Milling and Baking Test Results for Hard Winter Wheat Harvested in 2019



70th Report on Wheat Quality Hard Winter Wheat Technical Board of the Wheat Quality Council

A coordinated effort by wheat breeders, producers, millers and bakers to improve wheat quality

This program was carried out in cooperation with the Wheat Quality Council, Lenexa, KS, The United States Department of Agriculture (USDA) - ARS, The Agricultural Experiment Stations of Colorado, Kansas, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas, private wheat breeding companies including Syngenta (AgriPro Wheat), Baver (Monsanto, Westbred, LLC), Bayer, and laboratories from milling, baking, grain trade and other firms and research organizations. This annual technical report was prepared by the USDA-ARS, Hard Winter Wheat Quality Laboratory in Manhattan, KS. The Wheat Quality Council (WQC) provides funds for the program with great effort and support from collaborators who run bake tests. Trade names, if used, are used to identify products. No endorsement is intended, nor is criticism implied of similar products not mentioned.

Downloading or printing of this report is available through the Wheat Quality Council (http://www.wheatqualitycouncil.org), if you are member of WQC or a registered participant of the annual WQC meeting. Otherwise, please contact:

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2019

Milling and Baking Test Results for **Hard Winter Wheats**

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The MISSION of the WHEAT QUALITY COUNCIL:

ADVOCATE THE DEVELOPMENT OF NEW WHEAT VARIETIES THAT IMPROVE THE VALUE OF WHEAT TO ALL PARTIES IN THE UNITED STATES SUPPLY CHAIN.

The GOAL of the WHEAT QUALITY COUNCIL:

IMPROVE THE VALUE OF ALL U. S. WHEAT CLASSES FOR PRODUCERS, MILLERS, AND PROCESSORS OF WHEAT.

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Description of the 2019 Testing Program

Founded in 1949, this is the <u>70th</u> year for the Hard Winter Wheat Milling and Baking Evaluation Program. This program is sponsored by the Wheat Quality Council and coordinated by the USDA-ARS Hard Winter Wheat Quality Laboratory (HWWQL) and Kansas State University Department of Grain Science and Industry. Wheat experimental lines and check varieties (including common check and internal check) were submitted by public and private breeding programs in the Great Plains growing region. This technical report includes GIPSA wheat market classification, physical grain testing, milling, analytical, rheological, and bread baking results.

A total of 29 entries this year were grown in specific locations and submitted for small-scale testing by 11 wheat breeding programs. 6 of the entries were submitted as a set representing the new growout in the Northern States including NE, MT, SD and ND. Wheat samples were milled on the Miag Multomat mill in the Kansas State University Department of Grain Science and Industry (Methods, Appendix A). The flours were distributed to 18 cooperators (16 for bread baking, 1 for tortilla, and 1 for noodle) for end-product quality evaluation. The wheat physical and chemical tests, flour quality analysis, and dough rheological tests (Mixograph, Farinograph, Alveograph, and Extensigraph) were conducted by the HWWQL.

Also included in this report is alkaline noodle and protein analysis data generated by the HWWQL and Dr. Mike Tilley in Manhattan, KS, as well as tortilla data generated by Texas A&M University. Methods used to evaluate wheat lines are listed in Appendix A.

2019 WQC HWW Entries & Breeding Programs

Breeding Programs	Entry Number	Sample Identification
COLORADO	19-2401 19-2402 19-2403 19-2404 19-2405	Byrd Jagalene (CC01) CO13D0787 CO15SFD107 CO15D098R
TEXAS	19-2406 19-2407 19-2408	TAM 114 TX14A001035 TX14M7061
OKLAHOMA	19-2409 19-2410 19-2411 19-2412 19-2413 19-2414	Jagalene (CC02) Ruby Lee OK16D101089 OK168512 OCW04S717T-6W OK12912C-138407-2
LIMAGRAIN	19-2415 19-2416	Jagalene (CC03) ERYTHRO2420-2010
KANSAS-Hays	19-2417 19-2418 19-2419 19-2420	Jagalene (CC04) KS15H116-6-1 KS15H161-1-4 Danby
BAYER (Westbred)	19-2421 19-2422 19-2423	Jagalene (CC05) MODI4-5179 NEDI4-5304

NORTHERN STATES	19-2424 19-2425	Jagalene (CC06) NW13493
	19-2426	NE14691
	19-2427 19-2428	SD14113-3 MTCS1601R
	19-2429	MT1683

CC = Common Check

2019 Wheat Classification Results from GIPSA

ID	CL	DKG	TW	М	ODOR	HT	DKT	FM	SHBN	DEF	CCL	WOCL	GRADE	REMARKS
19-2401	HRW	0.0	60.5	11.0	ОК	0.0	0.0	0.0	1.9	1.9	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2402	HRW	0.0	60.7	11.0	ОК	0.0	0.0	0.0	1.9	1.9	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2403	HRW	0.0	61.7	11.2	ОК	0.0	0.0	0.0	1.3	1.3	0.0	0.3	U.S. NO. 1 HRW, DKG 0.0%	
19-2404	HRW	0.0	62.0	11.0	ОК	0.0	0.0	0.0	0.9	0.9	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2405	HRW	0.0	62.1	11.3	ОК	0.0	0.0	0.0	0.6	0.6	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2406	HRW	0.0	63.2	10.9	ОК	0.0	0.0	0.0	0.1	0.1	0.0	0.1	U.S. NO. 1 HRW, DKG 0.0%	
19-2407	HRW	0.0	64.8	9.9	ОК	0.0	0.1	0.0	1.0	1.1	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2408	HRW	0.0	62.9	10.1	ОК	0.0	0.0	0.0	0.9	0.9	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2409	HRW	0.0	57.4	12.9	ОК	0.0	1.0	0.0	0.4	1.4	0.0	4.4	U.S. NO. 3 HRW, DKG 0.0%	
19-2410	HRW	0.0	57.8	13.2	ОК	0.0	0.5	0.0	0.1	0.6	0.0	0.0	U.S. NO. 3 HRW, INFESTED, DKG 0.0%	58 LIVE WEEVILS
19-2411	HRW	0.0	58.8	13.2	ОК	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
19-2412	HRW	0.0	64.1	12.2	ОК	0.0	0.0	0.0	0.2	0.2	0.0	0.1	U.S. NO. 1 HRW, DKG 0.0%	
19-2413	HDWH	0.0	59.3	13.3	ОК	0.0	0.0	0.0	0.0	0.0	0.0	1.1	U.S. NO. 2 HDWH, DKG 0.0%	
19-2414	HRW	0.0	60.4	13.1	ОК	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2415	HRW	0.0	63.7	13.1	ОК	0.0	0.0	0.0	0.2	0.2	0.0	1.1	U.S. NO. 1 HRW, DKG 0.0%	
19-2416	HRW	0.0	62.8	13.1	ОК	0.0	0.3	0.0	0.1	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2417	HRW	0.0	58.4	11.8	ОК	0.0	0.3	0.0	0.6	0.9	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
19-2418	HRW	0.0	62.3	12.8	ОК	0.0	0.5	0.0	0.1	0.6	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2419	HRW	0.0	63.0	12.3	ОК	0.0	0.1	0.0	0.0	0.1	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2420	HDWH	0.0	64.3	12.3	ОК	0.0	0.0	0.0	0.0	0.0	0.0	0.1	U.S. NO. 1 HDWH, DKG 0.0%	
19-2421	HRW	0.0	64.8	9.3	ОК	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2422	HRW	0.0	64.2	9.5	ОК	0.0	0.0	0.0	0.3	0.3	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2423	HRW	0.0	64.2	9.4	ОК	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
19-2424	HRW	0.0	56.1	11.3	ОК	0.0	5.9	0.0	1.2	7.1	0.0	0.0	U.S. NO. 3 HRW, DKG 0.0%	
19-2425	HDWH	0.0	60.1	11.3	ОК	0.0	0.8	0.0	0.8	1.6	0.0	4.1	U.S. NO. 2 HDWH, DKG 0.0%	
19-2426	HRW	0.0	58.0	11.3	ОК	0.0	4.1	0.0	0.4	4.5	0.0	0.0	U.S. NO. 3 HRW, DKG 0.0%	
19-2427	HRW	0.0	58.5	11.2	ОК	0.0	1.6	0.0	0.9	2.5	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
19-2428	HRW	0.0	57.8	11.3	ОК	0.0	0.7	0.0	0.7	1.4	0.0	0.0	U.S. NO. 3 HRW, DKG 0.0%	
19-2429	HRW	0.0	52.5	11.3	ОК	0.0	4.7	0.0	1.2	5.9	0.0	0.0	U.S. NO. 5 HRW. DKG 0.0%	

GIPSA Wheat Market Classification

Cl = Wheat class, DKG = Dockage (%), TW = Test weight (lb/bushels), DKT = Damaged kernels total (%), FM = Foreign materials (%), SHBN = Shrunken and broken kernels (%), DEF = Defects (%), CCL = Contrasting classes (%), WOCL = wheat of other classes. XWHT = mixed wheat

Wheat Breeder Plot and Entry Descriptions, Wheat and Flour Analytical, Physical Dough, and Bread Baking Data

COLORADO

19-2401 19-2402 19-2403 19-2404 19-2405

Byrd Jagalene (CC01) C013D0787 C015SFD107 C015D098R



Congratulations on your retirement!

Thanks for your years of the dedication and hard work!

you deserve the best retirement ever, cherish every moment and have fun!

Description of Test Plots and Breeder Entries

Colorado – Scott Haley

Description of Test Plots and Breeder Entries - Colorado

Growing Location & Conditions

The Wheat Quality Council samples from Colorado originated from strip increases grown under dryland conditions at the USDA-ARS Central Great Plains Research Station at Akron, CO. The field with the strip increases, including adjacent breeding and extension trials, was fertilized with a pre-plant application of 70 lbs N (applied as 46-0-0). The planting date was 9/20/18 and the harvest date was 7/22/19.

Growing conditions included: planting into very dry soil ("dusted-in"), but plentiful moisture by early October allowed wheat to emerge; very good fall stand establishment; good winter snows; good early spring precipitation with below average temperatures; significant drought stress symptoms by early to mid-May; good precipitation later in May relieved drought stress to some degree; freeze damage occurred on May 21-22, did relatively minor damage due to lateness of the wheat; fourth coldest May on record slowed plant development; stripe rust present by early June, but at relatively low levels; development by mid-June about two weeks later than normal; final plant heights relatively short due to early season stress; very cool temperatures early during grain filling but later increased to more normal temperatures; significant rains after maturity reduced test weights; harvest about 10-12 days later than is typical for this location; some minor wheat stem sawfly cutting observed at harvest (first sawfly observation at Akron!).

Grain yields of the adjacent state extension variety trial (UVPT) were relatively high in spite of the early season stress, averaging 71.2 bu/acre with an average test weight of 59.1 lb/bushel. Average grain protein concentration of the group of 7 strips harvested for potential WQC submission was 12.6% with a range of 11.7% to 13.9% (12% moisture basis).

Jagalene (check) – common check

Byrd (check) – local check

Byrd is a hard red winter wheat (HRW) released by Colorado State University in 2011. Byrd was tested in the 2010 WQC sample set under experimental number CO06424 and has been included as our check since 2012. Byrd has shown good milling and bread baking quality characteristics, including particularly strong dough mixing properties, high loaf volume, and good crumb grain scores. Byrd is marketed by the Colorado Wheat Research Foundation (CWRF) under the *PlainsGold*[™] brand. In 2019, and for the fifth straight year, Byrd was the most widely grown wheat cultivar in Colorado (14.9% of total acreage).

CO13D0787 (released as 'Guardian')

CO13D0787 is a doubled-haploid HRW developed from the cross Antero/Snowmass//Byrd made in 2012. CO13D0787 was released as 'Guardian' in fall 2019 and will be marketed by the Colorado Wheat Research Foundation (CWRF) under the *PlainsGold*TM brand. CO13D0787 has medium height and medium maturity, medium coleoptile length, and average straw strength. CO13D0787 has good resistance to stripe, leaf, and stem rusts and excellent resistance to wheat streak mosaic virus due to resistance to the wheat curl mite vector (carries the *Cmc*_{TAM112}).

gene from Byrd) and the virus itself (carries *Wsm2* gene from Snowmass). CO13D0787 has very good test weight and very high grain protein deviation, averaging about 0.6% higher grain protein than expected for its respective yield level. CO13D0787 is susceptible to Hessian fly and all biotypes of Russian wheat aphid and moderately susceptible to wheat soilborne mosaic virus. The reaction of CO13D0787 to Fusarium head blight is not known.

Across 70 dryland site-years in the CSU Elite Trial (2016-19) and CSU Uniform Variety Performance Trial (2017-19), grain yield of CO13D0787 was similar to Byrd, Avery, and Canvas, and about 3 bu/acre (~4.0%) lower than Langin and Whistler. In the 2019 Southern Regional Performance Nursery (SRPN), CO13D0787 was slightly above trial average, or the 28th highest yielding entry in the trial.

CO13D0787 has shown very good overall milling and baking properties in tests conducted in the CSU Wheat Quality Lab. Compared to Byrd, CO13D0787 has similar SKCS kernel weight and slightly higher SKCS kernel hardness, similar Brabender quadrumat senior total flour yield and lower break flour yield, similar mixograph peak time and tolerance, higher SRC water absorption, and similar loaf volume and crumb grain scores.

CO15SFD107 (released as 'Fortify SF')

CO15SFD107 is a doubled-haploid HRW developed from the cross Byrd/Bearpaw//Byrd made in 2013. CO15SFD107 was released as 'Fortify SF' in fall 2019 and will be marketed by the Colorado Wheat Research Foundation (CWRF) under the *PlainsGold*TM brand. CO15SFD107 has medium height and medium maturity, medium coleoptile length, and less than average straw strength (i.e., lodging resistance). CO15SFD107 is similar to Byrd in its overall disease and insect reaction, being susceptible to stripe rust and resistant to the wheat curl mite (carries the *Cmc*_{TAM112} gene from Byrd) that vectors wheat streak mosaic virus. CO13D0787 has average test weight and below-average grain protein deviation. The reaction of CO13D0787 to Fusarium head blight is not known.

Across 44 dryland site-years in the CSU Elite Trial (2017-19) and CSU Uniform Variety Performance Trial (2018-19), grain yield of CO15SFD107 was similar to Byrd. In trials affected by wheat stem sawfly infestation (8 dryland site-years), however, grain yield of CO15SFD107 was in the upper tier of the trials. In these trials, the average wheat stem sawfly cutting score of CO15SFD107 was 2.1 (n=18; 1=no cutting, 9=severe cutting scale), with slightly more cutting than Bearpaw (1.4 score), and significantly less cutting than all of the hollow-stem checks (score average about 7 to 8). CO15SFD107 is categorized as "semi-solid" stem, with an average stem solidness score of 12.9 (n=28; 5=completely hollow to 25=completely solid scale), less solid than Bearpaw (18.1), and more solid than all of the hollow-stem checks (averaging ~5.5 to 6.5). In the 2019 Southern Regional Performance Nursery (SRPN), CO15SFD107 was well-below trial average, similar to the Jagalene check.

CO15SFD107 has shown average milling and baking properties in tests conducted in the CSU Wheat Quality Lab. Compared to Byrd, CO15SFD107 has shown very similar grain and milling properties and slightly lower pup loaf volume and crumb grain scores.

CO15D098R

CO15D098R is a doubled-haploid HRW line from the cross TAM 114/Antero//Byrd made in 2012. CO15D098R is on a limited foundation seed increase in 2020 with the potential to release as a new cultivar in fall 2020. CO15D098R is a tall wheat with medium-late maturity, has a medium-long coleoptile, and lower than average straw strength. CO13D0787 has good resistance to stripe, leaf, and stem rusts and good resistance to wheat streak mosaic virus due to resistance to the wheat curl mite vector (carries the Cmc_{TAM112} gene from Byrd). CO15D098R

has very high test weight and below average grain protein deviation. CO13D0787 shows a mixed reaction to Hessian fly, is susceptible to all biotypes of Russian wheat aphid, and is moderately susceptible to wheat soilborne mosaic virus. The reaction of CO15D098R to Fusarium head blight is not known.

Across 52 site-years in the CSU Elite Trial (2017-19) and CSU Uniform Variety Performance Trial (2018-19), grain yield of CO15D098R was similar to the highest yielding wheats in the trials (e.g., Langin and Whistler) with test weight among the top three entries in the trials (~2 lb/bu higher than Whistler, ~1 lb/bu higher than Langin). In the 2019 Southern Regional Performance Nursery (SRPN), CO15D098R was the 10th highest yielding entry in the trial.

CO15D098R has shown good overall milling and baking properties in tests conducted in the CSU Wheat Quality Lab. Compared to Byrd, CO15D098R has higher SKCS kernel weight and similar SKCS kernel hardness, lower Brabender quadrumat senior total and break flour yield, similar mixing time and tolerance, slightly higher SRC water absorption, and similar loaf volume and crumb grain scores.

Colorado: 2019 (Small-Scale) Samples

Test entry number	19-2401	19-2402	19-2403					
Sample identification	Byrd	Jagalene (CC01)	CO13D0787					
Wheat Data								
GIPSA classification	1 HRW	1 HRW	1 HRW					
Test weight (lb/bu)	60.5	60.7	61.7					
Hectoliter weight (kg/hl)	79.6	79.8	81.1					
1000 kernel weight (gm)	27.1	27.6	27.9					
Wheat kernel size (Rotap)								
Over 7 wire (%)	45.7	55.0	41.6					
Over 9 wire (%)	51.6	43.7	56.2					
I hrough 9 wire (%)	2.8	1.4	2.3					
Single kernel (skcs)*	62 0/49 4	60.0/00.0	66 2/40 2					
Hardness (avg /s.d)	62.9/18.1	69.0/20.0	66.3/19.3					
vveight (mg) (avg/s.d)	27.1/9.5	27.0/11.3	27.9/10.2					
Diameter (mm)(avg/s.d)	2.30/0.30	2.40/0.40	2.4 1/0.30					
Woisture (%) (avg/s.d)	01_13_26_58_01	04-08-20-68-01	04-11-20-65-01					
Classification	Hard	04-00-20-00-01 Hard	04-11-20-00-01 Hard					
Classification	Tiaru	Taru	Tiaru					
Wheat protein (12% mb) Wheat ash (12% mb)	12.2 1.46	14.1 1.48	14.0 1.48					
	Milling and Flour Q	uality Data						
Flour yield (%, str. grade)	•							
Miag Multomat Mill	77.2	79.2	77.2					
Quadrumat Sr. Mill	71.3	69.7	70.0					
Flour moisture (%)	12.3	12.6	12.4					
Flour protein (14% mb)	11.1	13.0	12.6					
Flour ash (14% mb)	0.47	0.54	0.46					
Rapid Visco-Analyser								
Peak time (min)	6.3	6.3	6.4					
Peak viscosity (RVU)	221.0	175.8	201.4					
Breakdown (RVU)	67.3	51.5	46.6					
Final viscosity at 13 min (RVU)	275.9	227.3	266.2					
Minolta color meter	04.55	04.00	04.0					
L*	91.55	91.03	91.3					
a*	-1.38	-1.36	-1.17					
^d	9.19	9.87	0.01					
PPO	0.450	0.354	0.649					
Falling number (sec)	440	407	450					
Damaged Starch								
(AI%)	98.1	98.3	98.2					
(AAĆC76-31)	8.0	8.2	8.1					

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Colorado: 2019	(Small-Scale)) Samples ((Continued))
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Test entry number	19-2404	19-2405					
Sample identification	CO15SFD107	CO15D098R					
Wheat Data							
GIPSA classification	1 HRW	1 HRW					
Test weight (lb/bu)	62.0	62.1					
Hectoliter weight (kg/hl)	81.5	81.7					
1000 kernel weight (gm)	24.2	30.3					
Wheat kernel size (Rotap)							
Over 7 wire (%)	46.1	60.5					
Over 9 wire (%)	51.9	38.4					
I hrough 9 wire (%)	2.1	1.1					
Single kernel (skcs) ^a Hardness (avg /s.d) Weight (mg) (avg/s.d) Diameter (mm)(avg/s.d) Moisture (%) (avg/s.d) SKCS distribution Classification	60.4/18.5 24.2/8.7 2.32/0.38 11.1/0.5 07-14-26-53-01 Hard	63.8/17.1 30.3/9.9 2.47/0.38 11.5/0.5 03-11-24-62-01 Hard					
Wheat protein (12% mb) Wheat ash (12% mb)	12.3 1.45	12.9 1.40					
Milling an	d Flour Quality Data						
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	77.0 71.8	78.4 70.2					
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.5 11.1 0.47	13.0 11.6 0.49					
Rapid Visco-Analyser Peak time (min) Peak viscosity (RVU) Breakdown (RVU) Final viscosity at 13 min (RVU)	6.2 217.3 64.2 277.7	6.3 236.0 88.5 253.2					
Minolta color meter	211.1	200.2					
L*	91.60	91.01					
a*	-1.44	-1.39					
b*	9.03	10.05					
PPO	0.477	0.433					
Falling number (sec)	420	408					
Damaged Starch (AI%) (AACC76-31)	98.2 8.1	97.8 7.8					

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Colorado: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples

Test Entry Number	19-2401	19-2402	19-2403					
Sample Identification	Byrd	Jagalene (CC01)	CO13D0787					
MIXOGRAPH								
Flour Abs (% as-is)	65.2	68.4	68.4					
Flour Abs (14% mb)	63.5	67.1	66.9					
Mix Time (min)	5.9	3.0	4.5					
Mix tolerance (0-6)	5	2	4					
	FARINOG	RAPH						
Flour Abs (% as-is)	61.0	66.7	65.4					
Flour Abs (14% mb)	59.3	65.4	63.9					
Peak time (min)	6.1	7.2	9.8					
Mix stability (min)	25.5	10.3	22.7					
Mix Tolerance Index (FU)	8	27	9					
Breakdown time (min)	27.1	12.9	26.8					
	ALVEOG	RAPH						
P(mm): Tenacity	100	114	126					
L(mm): Extensibility	83	89	99					
G(mm): Swelling index	20.3	21.0	22.3					
W(10 ⁻⁴ J): strength (curve area)	320	351	447					
P/L: curve configuration ratio	1.20	1.28	1.27					
le(P ₂₀₀ /P): elasticity index	63.9	57.9	63.2					
	EXTENSIO	GRAPH						
Resist (BU at 45/90/135 min)	570/906/1196	347/385/418	503/656/749					
Extensibility (mm at 45/90/135 min)	131/110/103	151/166/169	139/133/111					
Energy (cm ² at 45/90/135 min)	129/142/166	95/126/136	120/152/127					
Resist _{max} (BU at 45/90/135min)	787/1072/1400	483/601/629	687/924/947					
Ratio (at 45/90/135 min)	4.4/8.3/11.6	2.3/2.3/2.5	3.6/4.9/6.8					
	PROTEIN A	NALYSIS						
HMW-GS Composition	2*, 7+8, 5+10	1,2*, 17+18/7+9, 5+10	2*, 7+9, 5+10					
PP/MP	0.88	0.95	0.77					
	SEDIMENTAT	ION TEST						
Volume (ml)	63.9	65.1	67.0					

Test Entry Number	19-2404	19-2405									
Sample Identification	CO15SFD107	CO15D098R									
М	IXOGRAPH										
Flour Abs (% as-is)	65.5										
Flour Abs (14% mb)	64.4	64.7									
Mix Time (min)	3.1	4.4									
Mix tolerance (0-6)	1	4									
FAI	RINOGRAPH										
Flour Abs (% as-is) 62.1 61.7											
Flour Abs (14% mb)	60.6	60.9									
Peak time (min)	6.2	7.2									
Mix stability (min)	8.5	13.5									
Mix Tolerance Index (FU)	36	22									
Breakdown time (min)	10.4	14.1									
ALVEOGRAPH											
P(mm): Tenacity	91	106									
L(mm): Extensibility	108	83									
G(mm): Swelling index	23.1	20.3									
W(10 ⁻⁴ J): strength (curve area)	294	312									
P/L: curve configuration ratio	0.84	1.28									
le(P ₂₀₀ /P): elasticity index	52.3	58.4									
EXT	TENSIGRAPH										
Resist (BU at 45/90/135 min)	346/456/512	396/565/648									
Extensibility (mm at 45/90/135 min)	147/141/144	138/138/117									
Energy (cm ² at 45/90/135 min)	91/114/127	95/134/121									
Resist _{max} (BU at 45/90/135min)	466/629/681	531/780/858									
Ratio (at 45/90/135 min)	2.4/3.3/3.6	2.9/4.1/5.6									
PROT	EIN ANALYSIS										
HMW-GS Composition	2*, 7+8, 5+10	2*, 7+9. 5+10									
PP/MP	0.88	0.87									
SEDIMI	ENTATION TEST										
Volume (ml)	44.8	55.0									

Colorado: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples (continued)



P Personant P Personant

Water abs = 59.3%, Peak time = 6.1 min, Mix stab = 25.5 min, MTI = 8 FU

Farinograms

Water abs = 63.5% Mix time = 5.9 min

Mixograms

19-2401, Byrd











Farinograms



Mixograms



Water abs = 63.9%, Peak time = 9.8 min, Mix stab = 22.7 min, MTI = 9 FU

Water abs = 66.9% Mix time = 4.5 min

19-2403, CO13D0787





Water abs = 64.4%Mix time = 3.1 min

19-2404, CO15SFD107

Physical Dough Tests 2019 (Small Scale) Samples - Colorado

Farinograms

Mixograms





Water abs = 60.9%, Peak time = 7.2 min, Mix stab = 13.5 min, MTI = 22 FU Water abs = 64.7% Mix time = 4.4 min

19-2405, CO15D098R

Physical Dough Tests - Alveograph 2019 (Small Scale) Samples - Colorado



 $P(\text{mm H}_20) = 100, L(\text{mm}) = 83, W(10E^{-4} \text{ J}) = 320$





19-2403, CO13D0787 P(mm H₂0) =126, L(mm) = 99, W(10E⁻⁴ J) = 447

Physical Dough Tests - Alveograph 2019 (Small Scale) Samples - Colorado



19-2404, CO15SFD107 $P(mm H_20) = 91, L(mm) = 108, W(10E^{-4} J) = 294$

19-2405, CO15D098R $P(mm H_20) = 106, L(mm) = 83, W(10E^{-4} J) = 312$

Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Colorado





Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Colorado



Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Colorado: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)			
2401	6781	141	4050	0.447	2.068	1.262	1.835	-9.80			
2402	7091	138	4030	0.451	2.252	1.430	1.795	-11.20			



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)			
2403	7455	137 4126		0.461	2.290	5.633	1.760	-6.15			
2404	6520	146	3946	0.444	2.102	4.536	1.745	-11.40			

Colorado: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry	Slice Area	Slice	Number	Wall Thick	Cell Diameter	Non-	Avg. Cell	Cell Angle to
#	(mm ²)	Brightness	Cells	(mm)	(mm)	uniformity	Elongation	Vertical (⁰)
2405	6889	134	3827	0.459	2.314	4.390	1.795	-12.80



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Colorado Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2401	Byrd	65	64.4	62.7	62.2	59.3	64.6	63.7	63.6	57	63.5	65.2	59	63.5	59.9	57.3	61.3
19-2402	Jagalene (CC01)	67	66.7	65.7	67.8	65.4	66.6	67.1	69.2	59	68.4	67.0	65	67.1	64.4	61.7	67.4
19-2403	CO13D0787	66	66.6	65.1	66.6	63.9	65.1	66.8	68.4	59	67.2	65.2	63	66.9	62.6	61.5	65.9
19-2404	CO15SFD107	63	63.8	62.4	63.2	60.6	63.9	64.6	64.6	57	63.2	63.3	60	64.4	59.8	57.5	62.6
19-2405	CO15D098R	64	64.4	63.0	62.4	60.9	63.6	64.7	65.0	57	64.9	65.0	61	64.7	60.2	60.2	62.9

BAKE MIX TIME, ACTUAL (Small Scale) Colorado Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	М	Ν	ο	Ρ
19-2401	Byrd	4.3	5.0	5.3	5.0	18	9.5	5.9	4.5	11	7.3	6.4	25	5.4	8	8	20
19-2402	Jagalene (CC01)	2.8	3.3	3.3	3.5	10	4.8	3.0	4.5	6	4.1	4.4	9	2.5	8	4	11
19-2403	CO13D0787	3.7	4.5	5.0	5.0	18	6.5	4.5	7.5	10	6.0	5.6	22	4.0	8	6	20
19-2404	CO15SFD107	2.7	3.5	3.3	4.0	7	5.0	3.1	5.5	6	3.5	3.7	9	2.6	8	4	11
19-2405	CO15D098R	3.3	4.3	4.3	4.8	10	7.1	4.7	4.5	7	5.0	5.3	12	3.9	8	4	10



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DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Colorado

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2401	Byrd	0	2	4	9	1
19-2402	Jagalene (CC01)	2	1	3	9	1
19-2403	CO13D0787	4	1	3	7	1
19-2404	CO15SFD107	3	3	1	9	0
19-2405	CO15D098R	5	0	2	9	0



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Colorado

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2401	Byrd	0	1	4	10	1
19-2402	Jagalene (CC01)	1	1	4	8	2
19-2403	CO13D0787	1	3	1	7	3
19-2404	CO15SFD107	2	4	2	5	3
19-2405	CO15D098R	4	0	3	8	1

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CRUMB GRAIN, DESCRIBED (Small Scale) Colorado

IDCODE	ID	Open	Fine	Dense
19-2401	Byrd	8	8	0
19-2402	Jagalene (CC01)	9	7	0
19-2403	CO13D0787	7	8	0
19-2404	CO15SFD107	5	11	0
19-2405	CO15D098R	11	4	1

CELL SHAPE, DESCRIBED (Small Scale) Colorado

IDCODE	ID	Round	Irregular	Elongated
19-2401	Byrd	3	4	9
19-2402	Jagalene (CC01)	6	5	5
19-2403	CO13D0787	6	6	3
19-2404	CO15SFD107	6	4	6
19-2405	CO15D098R	5	5	6



CRUMB TEXTURE, DESCRIBED (Small Scale) Colorado

IDCODE	ID	Harsh	Smooth	Silky
19-2401	Byrd	2	10	4
19-2402	Jagalene (CC01)	1	11	4
19-2403	CO13D0787	2	9	4
19-2404	CO15SFD107	6	8	2
19-2405	CO15D098R	5	9	2



CRUMB COLOR, DESCRIBED (Small Scale) Colorado

IDCODE	ID	Gray	Dark_Yellow	Yellow	Dull	Creamy	White	Bright White
19-2401	Byrd	0	0	2	2	8	3	1
19-2402	Jagalene (CC01)	0	0	5	4	4	3	0
19-2403	CO13D0787	0	0	2	3	4	6	0
19-2404	CO15SFD107	0	0	3	4	5	3	1
19-2405	CO15D098R	0	0	7	5	3	1	0

LOAF WEIGHT, ACTUAL (Small Scale) Colorado Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Ι	J	к	L	М	Ν	0	Ρ
19-2401	Byrd	138.5	140.1	141.9	126.3	442.0	139.6	140.2	445.2	413	148.4	152.2	485	138.7	463.1	478.4	420.3
19-2402	Jagalene (CC01)	143.0	144.7	142.6	126.7	439.0	143.9	138.3	444.6	412	152.9	154.4	490	143.1	459.0	470.5	422.5
19-2403	CO13D0787	139.5	143.8	143.3	128.9	437.0	140.6	137.4	NA	413	149.6	151.2	487	140.1	458.8	473.3	427.7
19-2404	CO15SFD107	139.4	143.2	141.5	128.8	440.5	139.8	138.4	449.1	414	149.0	154.2	486	139.0	459.7	477.5	423.8
19-2405	CO15D098R	140.6	142.1	141.6	125.0	439.5	138.5	138.8	445.6	413	147.0	155.1	487	138.4	457.9	475.0	420.6

LOAF VOLUME, ACTUAL (Small Scale) Colorado Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	I	J	к	L	Μ	Ν	0	Р	
19-2401	Byrd	1025	985	855	980	2274	978	894	2142	3000	975	1025	2956	930	2532	2613	2550	
19-2402	Jagalene (CC01)	920	905	850	1025	2300	1046	890	2258	2925	1010	980	2750	890	2314	2575	2725	
19-2403	CO13D0787	935	1035	905	1075	2254	1050	935	NA	2900	1045	958	2839	990	2568	2600	2575	
19-2404	CO15SFD107	895	990	885	950	2269	961	847	2088	2800	905	968	2868	905	2474	2625	2575	
19-2405	CO15D098R	890	965	895	1020	2320	1039	902	2292	2925	960	963	2839	965	2474	2688	2750	



COOPERATOR'S COMMENTS (Small Scale) Colorado

COOP.

19-2401 Byrd

- A. No comment.
- B. Slight cap.
- C. Meets loaf volume target.
- D. No comment.
- E. Strong sponge with good height, could have used more mix, elastic during makeup.
- F. High Protein, High Water Abs, Very Long MT, Slight Sticky & Strong Dough, High Volume, Creamy Crumb, Slight Open Elongated Cells, Resilient & Very Smooth Texture.
- G. No comment.
- H. Good break and shred.
- I. Good dough, slightly open grain, good mix for protein, excellent volume.
- J. Long mix time and high tolerance, average absorption and grain, high volume.
- K. Very good dough character and volume performance for protein level.
- L. Fair absorption, very good mix strength and good loaf volume.
- M. No comment.
- N. No comment.
- O. Long mix time, very tolerant to mixing, low absorption, fine grain with creamy crumb, high volume.
- P. High mix time, average absorption, protein and volume, good for bread application.

COOP.

19-2402 Jagalene (CC01)

- A. Performed poorly for high protein.
- B. Nice loaf externals.
- C. Meets loaf volume target.
- D. Good volume, good dough handling characteristics.
- E. Slightly sticky sponge with good height, good dough out of mixer, elastic during makeup.
- F. Very High Protein, Very High Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Big break and shred.
- I. Good dough, short mix for protein, good volume.
- J. High absorption, nice grain, very high volume.
- K. Good overall performance.
- L. Very good absorption, slightly low mix strength, low loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption, tough dough at makeup, good grain and volume.
- P. High absorption and average mix time, good qualities and high protein, great volume. Recommend.

19-2403 CO13D0787

COOP.

- A. Very good protein.
- B. Slight cap.
- C. Meets loaf volume target.
- D. Good loaf volume and absorption.
- E. Strong sponge with good height, slightly elastic out of mixer, could have used more mix, dough was extensible during makeup.
- F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Dough could not be sheeted, too sticky and stuck in the roller.
- I. Good dough out of mixer and at makeup, good mix time, good volume.
- J. Long mix time, high absorption, good grain, very high volume.
- K. Good dough and bread volume, crumb grain somewhat lacking in development.
- L. Good absorption and mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Average mix time, very tolerant to mixing, good absorption, creamy crumb, high volume.
- P. High absorption and mix time, higher protein, good qualities all around, good for bread application.

COOP.

19-2404 CO15SFD107

- A. No comment.
- B. Nice loaf externals.
- C. Meets loaf volume target.
- D. No comment.
- E. Weakest sponge with some collapsing out of fermentation, extensible dough out of mixer and during makeup.
- F. High Protein, High Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Large break and shred, dough was too sticky and could not be sheeted.
- I. Slightly soft dough out of mixer, closed interior, average volume.
- J. Low tolerance for mixing, good volume.
- K. Good volume performance for protein, dough somewhat weak with weaker looking crumb grain.
- L. Fair absorption, slightly low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Low absorption, fine grain with creamy crumb, high volume.
- P. Average mix time and protein, above average absorption, sticky dough and below average final product qualities, could be good for bread application.

19-2405 CO15D098R

- COOP.
- A. No comment.
- B. Left and right side break.
- C. Meets loaf volume target.
- D. No comment.
- E. Slightly sticky sponge but had good height, good dough out of mixer and during makeup.
- F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Slight Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Large break and shred, loaf collapsed, light crust color.
- I. Average mix for protein, open grain, excellent volume.
- J. Good absorption, high volume.
- K. Very good dough and bread performance.
- L. Fair absorption and mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Fine grain and high volume.
- P. Above average absorption, average mix time, sticky and wet dough notes, good protein and great volume. Recommend.

Notes: E, H, I, L, O and P conducted sponge and dough bake tests



19-2406 19-2407 19-2408

TAM 114 TX14A001035 TX14M7061

Description of Test Plots and Breeder Entries

Texas – Jackie Rudd and Amir Ibrahim

Texas A&M AgriLife Research, Amarillo

The Wheat Quality Council samples submitted by Texas A&M AgriLife Research were harvested in June 2019 from strips planted adjacent to our intensively managed irrigated yield trials at Bushland (near Amarillo in the Texas Panhandle). We fertilized for a yield goal of 100 bu/a. The grain yields of TAM 114, TX14A001035, and TX14M7061from trials adjacent to the WQC strips, were 99, 107, and 94 bu/a respectively. The crop was irrigated with a linear at regular intervals from early March to early May. Crop development was normal for the Texas Panhandle and there were no significant abiotic or biotic stresses.

TX14A001035

This hard red winter wheat line was developed by the TAM Wheat Improvement Program in Amarillo from the cross Billings/TX03A0563. It is resistant to leaf rust, stripe rust, and stem rust and is well adapted to the High Plains of Texas and western Kansas. It was one of the top yielding varieties in 2019 regional and Texas trials and performs best under intensive management. It has good test weight, large seeds, and good bread-making quality.

TX14M7061

TX14M7061 hard red winter wheat was selected from TAM 113/TX03A0148 by the TAM Wheat Improvement Program in College Station. It has excellent foliar disease resistance; including leaf rust, stripe rust, and stem rust. It has good yield under a wide range of environments but is particularly suited for the more humid areas of the Central Plains. It has good test weight, large seeds, and very good bread-making quality.

TAM 114 (CHECK)

TAM 114 is our local check. Released in 2014, acreage is increasing and in 2019 it was planted on 6.9 % of the wheat acres in the Texas Panhandle and on 6.7% of the acres in Northwest Kansas. It has excellent bread-making properties and is sourced in the Texas Panhandle and western Kansas for it's extra strong dough properties.

Jagalene (CHECK) NOT EVALUATED

Jagalene was planted to be used as a standard check across the region, but common bunt was found in the harvested grain so samples were not submitted to WQC.

Texas: 2019 (Small-Scale) Samples

Test entry number	19-2406	19-2407	19-2408
Sample identification	TAM 114	TX14A001035	TX14M7061
	Wheat Data		
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	63.2	64.8	62.9
Hectoliter weight (kg/hl)	83.1	85.1	82.7
1000 kernel weight (gm)	30.3	31.9	34.9
Wheat kernel size (Rotap)	00.0	04.0	07.0
Over 7 wire (%)	66.U	61.0 27.4	67.9
Over 9 wire (%)	33.9	37.4 1 7	30.6
Single kornel (skcs) ^a	0.2	1.7	1.0
Hardness (avg /s d)	68.7/19.2	79.2/16.9	67.1/18.0
Weight (mg) (avg/s.d)	30.3/9.2	31.9/10.0	34.9/12.9
Diameter (mm)(avg/s.d)	2.62/0.34	2.62/0.35	2.68/0.46
Moisture (%) (avg/s.d)	11.0/0.5	9.7/0.5	9.8/0.6
SKCS distribution	02-10-20-68-01	01-02-10-87-01	03-09-21-67-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb) Wheat ash (12% mb)	11.5 1.43	12.0 1.52	12.4 1.55
Mil	ling and Flour Qu	ality Data	
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	78.4 68.7	77.0 67.2	75.4 66.7
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.8 10.2 0.47	12.7 10.6 0.49	12.9 11.1 0.50
Rapid Visco-Analyser			
Peak Time (min)	6.1	6.0	6.3
Peak Viscosity (RVU)	209.2	168.8	194.6
Breakdown (RVU)	//.8 2/3.2	57.4 216.5	00.0 236 4
Minolta color motor	240.2	210.0	200.4
	90.74	90.78	90.93
a*	-1.45	-0.93	-1.41
b*	10.49	8.49	10.01
DDO	0 370	0 271	0.260
FPU Falling number (sec)	/21	375	1200
Damaged Starch	401	515	422
(Al%)	98.3	99.2	98.1
(AACC76-31)	8.1	9.0	8.0

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Test Entry Number	19-2406	19-2407	19-2408
Sample Identification	TAM 114	TX14A001035	TX14M7061
	MIXOGRAPH	4	
Flour Abs (% as-is)	65.8	67.6	63.4
Flour Abs (14% mb)	64.6	66.4	62.4
Mix Time (min)	5.3	2.9	2.6
Mix tolerance (0-6)	4	1	2
	FARINOGRAF	РΗ	
Flour Abs (% as-is)	63.4	69.9	65.1
Flour Abs (14% mb)	62.2	68.6	64.1
Peak time (min)	4.6	4.5	4.7
Mix stability (min)	11.0	5.8	6.5
Mix Tolerance Index (FU)	22	32	32
Breakdown time (min)	11.0	8.1	9.2
	ALVEOGRAP	Н	
P(mm): Tenacity	129	146	112
L(mm): Extensibility	40	59	61
G(mm): Swelling index	14.1	17.1	17.4
W(10 ⁻⁴ J): strength (curve area)	225	292	220
P/L: curve configuration ratio	3.22	2.47	1.24
le(P ₂₀₀ /P): elasticity index	58.2	43.6	43.8
	EXTENSIGRA	PH	
Resist (BU at 45/90/135 min)	482/672/638	241/304/329	226/292/292
Extensibility (mm at 45/90/135 min)	135/125/125	142/137/134	141/130/141
Energy (cm ² at 45/90/135 min)	116/142/129	58/70/72	55/61/67
Resist _{max} (BU at 45/90/135 min)	672/931/840	286/366/388	269/335/341
Ratio (at 45/90/135 min)	3.6/5.4/5.1	1.7/2.2/2.5	1.6/2.3/2.1
	PROTEIN ANAL	YSIS	
HMW-GS Composition	2*, 7+9, 5+10	1, 7+9, 5+10	2*, 7+8, 5+10
PP/MP	1.01	0.98	0.83
	SEDIMENTATION	TEST	
Volume (ml)	48.4	49.4	38.6

Texas: Physical Dough Tests and Gluten Analysis For 2019 (Small-Scale) Samples

Physical Dough Tests 2019 (Small Scale) Samples – Texas

Farinograms

Water abs = 62.2%, Peak time = 4.6 min, Mix stab = 11.0 min, MTI = 22 FU













Mixograms

Physical Dough Tests 2019 (Small Scale) Samples – Texas

Farinograms



Water abs = 64.1%, Peak time = 4.7 min, Mix stab = 6.5 min, MTI = 32 FU Mixograms



Water abs = 62.4% Mix time = 2.6 min

19-2408, TX14M7061

Physical Dough Tests - Alveograph 2019 (Small Scale) Samples - Texas



P (mm H₂0) = 129, L (mm) = 40, W (10E⁻⁴J) = 225

 $P (mm H_20) = 146, L (mm) = 59, W (10E^{-4}J) = 292$



19-2408, TX14M7061 P (mm H₂0) = 112, L (mm) = 61, W (10E⁻⁴J) = 220

Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Texas





Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Texas: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2406	5588	135	3526	0.437	1.938	3.584	1.790	-9.15
2407	5694	138	3227	0.459	2.270	1.320	1.700	-5.30



Entry	Slice Area	Slice	Number	Wall Thick	Cell Diameter	Non-	Avg. Cell	Cell Angle to
#	(mm ²)	Brightness	Cells	(mm)	(mm)	uniformity	Elongation	Vertical (⁰)
2408	5998	140	3608	0.448	2.068	0.819	1.710	-8.50



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Texas Cooperators A – P

IDCODE	ID	Α	В	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Р
19-2406	TAM 114	65	67.0	61.0	64.3	62.2	62.1	64.4	65.7	56	68.5	65.8	61	64.6	62.5	58.8	64.2
19-2407	TX14A001035	66	67.1	61.3	71.0	68.6	63.5	66.5	73.3	57	65.5	63.6	67	66.4	69.6	59.8	70.6
19-2408	TX14M7061	63	63.8	62.6	65.9	64.1	64.1	62.3	67.8	57	62.7	63.3	64	62.4	63.7	60.0	66.1

BAKE MIX TIME, ACTUAL (Small Scale) Texas Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Ρ
19-2406	TAM 114	5.3	5.5	6	6.5	8	9.1	6.2	6.5	6	9.0	6.4	11	4.8	8	7	13
19-2407	TX14A001035	2.7	2.8	3	3.5	4	3.6	2.7	5.0	4	3.1	2.8	5	2.4	8	4	6
19-2408	TX14M7061	2.5	3.0	3	3.8	4	3.7	3.0	5.0	4	3.8	3.6	5	2.1	8	4	6





DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Texas

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2406	TAM 114	2	2	3	8	1
19-2407	TX14A001035	4	2	5	4	1
19-2408	TX14M7061	5	3	4	3	1



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Texas

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2406	TAM 114	1	2	4	7	2
19-2407	TX14A001035	3	2	2	5	4
19-2408	TX14M7061	5	2	2	6	1



CRUMB GRAIN, DESCRIBED (Small Scale) Texas

IDCODE	ID	Open	Fine	Dense
19-2406	TAM 114	6	4	6
19-2407	TX14A001035	11	3	2
19-2408	TX14M7061	7	5	4

CELL SHAPE, DESCRIBED (Small Scale) Texas

IDCODE	ID	Round	Irregular	Elongated
19-2406	TAM 114	5	6	5
19-2407	TX14A001035	8	7	1
19-2408	TX14M7061	11	3	2



CRUMB TEXTURE, DESCRIBED (Small Scale) Texas

IDCODE	ID	Harsh	Smooth	Silky
19-2406	TAM 114	6	6	4
19-2407	TX14A001035	7	7	2
19-2408	TX14M7061	7	7	2



CRUMB COLOR, DESCRIBED (Small Scale) Texas

IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White	
19-2406	TAM 114	0	1	7	4	3	1	0	
19-2407	TX14A001035	0	0	0	8	4	4	0	
19-2408	TX14M7061	0	2	4	6	3	1	0	

LOAF WEIGHT, ACTUAL (Small Scale) Texas Cooperators A – P

IDCODE	ID	Α	В	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2406	TAM 114	143.9	144.7	142.5	127.2	444	140.5	139.3	443.5	412	153.8	156.9	490	141.4	465.2	480.1	429.6
19-2407	TX14A001035	147.6	147.2	143.2	131.1	447	141.0	139.1	441.4	414	153.9	155.7	493	144.0	461.0	477.5	423.5
19-2408	TX14M7061	144.8	145.5	143.1	131.9	442	140.1	140.8	445.7	415	148.5	154.9	484	144.1	460.2	479.0	424.5

LOAF VOLUME, ACTUAL (Small Scale) Texas Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р	
19-2406	TAM 114	825	915	810	825	2078	799	744	2192	2925	745	825	2868	735	2028	2363	2550	
19-2407	TX14A001035	700	800	710	825	2099	869	755	2030	2750	780	770	2809	795	1874	2538	2575	
19-2408	TX14M7061	725	770	755	825	2119	855	740	2167	2650	805	758	2809	705	2196	2425	2575	



COOPERATOR'S COMMENTS (Small Scale) Texas

COOP.

19-2406 TAM 114

- A. Longer mix.
- B. Slight cap.
- C. Does not meet bake absorption target of 62%.
- D. High baking absorption, poor color.
- E. Slightly sticky sponge but had good height, very sloppy at the beginning of mix, the dough could have used more mix.
- F. Low Protein, Low Water Abs, Very Long MT, Slight Sticky & Weak Dough, Low Volume, Dull Crumb, Dense Elongated Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Loaf collapsed and puffed out the side of the pan, large break and shred, dark crust color.
- I. Good mix time, good dough out of mixer, excellent volume. Best overall in group.
- J. Long mix time, high absorption, but having tough dough at makeup, yielding bread with dense grain and very low volume.
- K. Good dough and bread performance for flour protein, this line has potential to be good at higher protein levels.
- L. Fair absorption and mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Long mix time, tough dough at makeup, average grain, low volume.
- P. Low protein but higher absorption, sticky dough and average mix time, lower volume.

COOP.

19-2407 TX14A001035

- A. No comment.
- B. No comment.
- C. Does not meet bake absorption target of 62%.
- D. No comment.
- E. Slightly sticky sponge but had good height, dough was sticky out of mixer.
- F. Normal Protein, Normal Water Abs, Short MT, Slight Sticky & Strong Dough, Fine Volume, Dull Crumb, Slight Open Round Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Break and shred.
- I. Good dough but short mix time, average volume, open grain.
- J. Good absorption but low tolerance for mixing, very tough dough, poor dense grain and very low volume.
- K. Very weak looking dough.
- L. Very good absorption, very low mix strength, low loaf volume.
- M. No comment.
- N. No comment.
- O. Average absorption but sticky doughs, open grain, creamy crumb, average volume.
- P. High absorption, lower protein and mix time, wet dough and unfavorable final product characteristics. Do not Recommend.

19-2408 TX14M7061

- A. Very poor loaf volume and color.
- B. No comment.

COOP.

- C. Absorption good, mixing properties poor, quantity not quality protein?
- D. No comment.
- E. Good sponge.
- F. High Protein, High Water Abs, Short MT, Slight Sticky & Strong Dough, Fine Volume, Yellow Crumb, Open Irregular Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Break and shred, loaf collapsed, dark crust color.
- I. Soft out of mixer but recovered at makeup, short mix time, lower volume, equal to 2407.
- J. Average mix time and absorption, very tough sticky dough, dense grain and low volume.
- K. Very weak dough at higher protein level with very poor bread.
- L. Good absorption, very low mix strength, low loaf volume.
- M. No comment.
- N. No comment.
- O. Average absorption but sticky doughs, open grain, dark yellow crumb.
- P. Average protein and high absorption, wet and sticky dough characteristics.

Notes: E, H, I, L, O and P conducted sponge and dough bake tests
OKLAHOMA

- 19-2409 19-2410
- 19-2411
- 19-2412
- 19-2413
- 13-2413
- 19-2414

- Jagalene (CC02)
- **Ruby Lee**
- **OK16D101089**
- **OK168512**
- **OCW04S717T-6W**
- OK12912C-138407-2

Description of Test Plots and Breeder Entries

Oklahoma – Brett Carver

With exception of one experimental line, OK168512, all samples were sourced predominately from the WQC growout at the North Central Agronomy Research Station at Lahoma (12 miles west of Enid). Mean grain yield in the growout was 45 bushels per acre, with the highest yielding entry coming in at 57 bushels per acre, or just under the yield goal of 60 bushels per acre on which fertilizer recommendations were based. With excessive rainfall during spring 2019, quite possibly the nitrogen tank ran dry in the rooting zone before nitrogen demand ever peaked during early grain fill. Mean wheat protein concentration in the growout was 11.6%.

Grain production in this nursery was largely influenced by severe Septoria triciti blotch, lasting almost the entire grain-filling period. A later infection of leaf rust negatively influenced yield and test weight. The experimental line with by far the greatest canopy hygiene under those disease conditions was the HW entry, OCW04S717T-6W (photo below, left). Likewise, in the photo below on the right, OK12912C-138407-2, a likely Doublestop CL Plus alternative, exhibited exceptional canopy hygiene (left of center dashed line) relative to its close relative, Doublestop CL Plus (right of center dashed line). The OK168512 sample was sourced in about 50:50 proportion from the Lahoma growout and from a seed production field near Guymon, OK, where OK168512 may be targeted for release.

Because of the excessive moisture in May and June, the WQC growout at Lahoma was harvested late on June 22, 2019, or about 10 to 14 days past harvest maturity. Differences in test weight reported herein largely reflect differences in the ability to retain test weight through multiple precipitation events past harvest maturity.

Once again, all samples were submitted on the blind, as no OSU WQL data were generated prior to sample submission. What is news to the reader is news to the breeder.



Both photographs taken May 23, 2019, during growth stage Feekes 11.2 (soft dough) – Lahoma WQC growout.

Ruby Lee (local check)

This 2011 release with pedigree KS94U275/Endurance is a proven winner in milling and baking performance and thus our gold standard against which other experimental lines are assessed for end-use quality. Acreage of Ruby Lee continues to drop from a peak of nearly 7% in 2016 to 1.2% in 2019. Ruby Lee is known to have excellent grazeability including grazing tolerance, but also high yield potential, cold tolerance, resilience to April freeze events, temperature-sensitive Hessian fly resistance, and the 2+12 glutenin subunit pair. It is quite susceptible to stripe rust, and often the reason cited for its decline in acreage even though the state has not endured a stripe rust epidemic since 2016. No new OSU variety is currently in sight having Ruby Lee as a parent.

OK16D101089

Visually not a distant fruit off the Bentley tree, OK16D101089 is a doubled haploid progeny of the cross, OK12621/Bentley. OK12621 was produced from the cross, P961341A3-2-2/Duster, the first parent a SRW experimental line carrying the Bdv2/3 gene from Herb Ohm's breeding program at Purdue University. The reason for the distinctly better leaf rust resistance of OK16D101089 than either of its susceptible parents remains a maddening mystery. Either something good is present in Bentley or OK12621 that we cannot see with current *Lr* molecular markers in OK16D101089, <u>or</u> something bad got switched off during its creation. What is not so mysterious is the stay-green ability of OK16D101089. Bentley has it, as does OK12621. Having two BYD-resistance genes to boot in one variety does not hurt.

OK16D101089 has the potential to do for Oklahoma's BYD problem as Duster did for its Hessian fly problem. Solutions to these problems in the field creates opportunities in the mill and beyond. In the absence of BYD in the 2019 OSU wheat variety trials, OK16D101089 placed in the top yielding group of varieties at seven of the 10 sites it was tested in downstate Oklahoma, while posting a mean wheat protein content of 12.0%, only 0.2 percentage points below the average of all varieties tested. Other than relatively low flour ash, but possibly a more yellow flour color, OK16D101089 has exhibited ordinary functionality, including water absorption. It is expected to enter the draft and play pro ball after this season.

OK168512

The pedigree of OK168512 is Overley (+Wsm1)/Fuller //CO050270 /3/CO050337-8. This wheat streak mosaic-resistant candidate carries a reduced *Thinopyrum* chromosome segment harboring the *Wsm1* resistance gene, courtesy of meticulous pre-breeding work and gene introgression performed at Kansas State University. Entering the fray was Colorado State University, where they injected High Plains yieldability into the pedigree, with parentage connected to Langin and Denali. Oklahoma State University joined the party and selected a progeny from this cross best fit for the Oklahoma panhandle. Fit is just a bit of an understatement, as OK168512 placed in the top yielding group across four panhandle wheat variety trials in 2019 (*http://wheat.okstate.edu/variety-testing/summary-of-all-regions/2018-19-panhandle-region-summary-yield-results*), with a leading test weight of 59.1 pounds per bushel. Its wheat protein concentration averaged 12.0%, equal to the panhandle trial average. Dough strength is above-average and kernel size is below-average or slightly below 30 mg

kernel weight and 2.5 mm kernel diameter. OK168512 is expected to go pro in fall 2020 and play for the High Plains.

OCW04S7171T-6W

Previously tested as 17-2431, OCW04S717T-6W did not perform in the 2017 WQC up to the level expected based on prior experience in the OSU WQL and with collaborators. Given the exceptional yield record this HW candidate has posted, and given that it has very few superiors for disease resistance on the HRW side of the OSU wheat breeding program, including leaf rust, stripe rust, powdery mildew, wheat soil-borne mosaic/wheat spindle streak mosaic complex, Septoria tritici blotch and tan spot, a second chance in the WQC seemed warranted. Sprout tolerance has been very good to average – not as consistent as Stardust but better in some environments. Even tolerance to nitrogen stress is exceptional. Its only notable weakness is shattering susceptibility, but for beardless wheat, we call that enhanced threshability for better test weight.

Protein content typically runs moderately high, or one-half percentage unit above the statewide variety trial mean in 2019. OCW04S7171T-6W produces a mixogram, possesses the dough strength, and exhibits baking characteristics most similar to Doublestop CL Plus. Flour ash content may be elevated, however, and test weight is ordinary.

The original cross for OCW04S7171T-6W was made by Art Klatt and included parents of CIMMYT and K-State origin, with the last parent in the complex cross being KS91W047. OCW04S7171T-6W was the highest yielding entry, red or white, in the OSU statewide elite trial in 2019, but it may not be our highest yielding experimental coming out of the pipeline. Such status may belong to another HW line, OK16729W, but it lacks end-use quality.

OK12912C-138407-2

In developing and evaluating this Clearfield Plus candidate, just one question ruled among all others: how close could we come to Doublestop CL Plus for test weight and end-use quality, yet extend the Doublestop yield ceiling ever so slightly? Check. Check. What really has this line in contention for release is something we don't see enough in this program [*hands cover eyes in mild show of embarrassment*]: high water absorption, with consistency; nice balance in P and L values, with elevated W; good dough strength but not necessarily excessive. That's like a triple-double – certainly achievable, but not very often. Exceeding 60% water absorption with a farinograph does not happen with regularity in this program, but when it does, we notice. That is what OK12912C-138407-2 does.

Watching P inch up to 100 or greater without L falling through the floor also catches eyes. Courtesy ARS HWWWQL-Manhattan, P/L values statewide for OK12912C-138407-2 were 102/95 in 2017 and 94/87 in 2018; mean farinograph absorption across both years was 61.3%. For comparison, P/L values for Smith's Gold were 93/95 and 77/70; mean farinograph absorption was 57.5%.

The parent line, OK12912C, from which OK12912C-138407-2 was single-plant selected was evaluated in the 2016 WQC as sample 16-2422. Reselection was mandated by segregation for kernel hardness in the original line. Agronomic improvements in the reselected experimental line over Doublestop CL+ include straw strength, earlier maturity, more aggressive canopy establishment, and higher yield potential in central Oklahoma, where the

Clearfield management system is most needed. It may be less than a one-half unit lower in wheat protein concentration and less than one-half pound lower in test weight than Doublestop CL Plus. Those numbers still keep OK12912C-138407-2 in the top-tier division for protein and test weight. This red-shirt senior is ready for prime time in 2020.

Oklahoma: 2019 (Small-Scale) Samples

Test entry number	19-2409	19-2410	19-2411
Sample identification	Jagalene (CC02)	Ruby Lee	OK16D101089
	Wheat Dat	а	
GIPSA classification	3 HRW	3 HRW	2 HRW
Test weight (lb/bu)	57.4	57.8	58.8
Hectoliter weight (kg/hl)	75.6	76.1	77.4
1000 kernel weight (gm)	29.9	34.3	29.4
Wheat kernel size (Rotap)			
Over 7 wire (%)	53.2	76.8	80.4
Over 9 wire (%)	45.0	22.9	19.4
I hrough 9 wire (%)	1.8	0.4	0.3
Hardness (avg /s.d)	70.0/19.9	48.3/13.3	50.9/13.7
Weight (mg) (avg/s.d)	29.9/10.2	34.3/9.2	29.4/8.9
Diameter (mm)(avg/s.d)	2.61/0.39	2.81/0.39	2.62/0.40
Moisture (%) (avg/s.d)	12.6/0.4	12.9/0.3	12.9/0.3
SKCS distribution	04-08-15-73-01	13-33-33-21-03	07-32-32-29-01
Classification	Hard	INIXED	Hard
Wheat protein (12% mb) Wheat ash (12% mb)	13.2 1.51	11.5 1.40	11.9 1.48
	Milling and Flour Q	uality Data	
Flour yield (%, str. grade)	-		
Miag Multomat Mill Quadrumat Sr. Mill	75.4 66.4	71.2* 69.6	77.6 70.9
Flour moisture (%)	13.1	13.2	12.8
Flour protein (14% mb)	11.9	10.6	10.7
Flour ash (14% mb)	0.56	0.48	0.44
Rapid Visco-Analyser			
Peak time (min)	6.1	6.0	6.2
Peak viscosity (RVU)	197.2	267.1	268.5
Breakdown (RVU)	83.1	110.6	102.7
Final viscosity at 13 min (RVU)	228.4	296.7	295.0
Minolta color meter			
L*	90.08	90.68	90.89
a*	-1.18	-1.15	-1.50
b*	9.20	7.98	9.33
РРО	0.483	0.569	0.481
Falling number (sec)	404	454	445
Damaged Starch			
(AI%)	97.8	96.6	97.0
(AACC76-31)	7.8	6.7	7.1

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

*the flour yield is not accurate due to an issue on the mill running and all the flour wasn't collected.

Oklahoma: 2019 (Small-Scale) Samples (Continued)

Test entry number	19-2412	19-2413	19-2414
Sample identification	OK168512	OCW04S717T-6W	OK12912C-138407-2
	Wheat Da	ata	
GIPSA classification	1 HRW	2 HDWH	1 HRW
Test weight (lb/bu)	64.1	59.3	60.4
Hectoliter weight (kg/hl)	84.2	78.0	79.5
1000 kernel weight (gm)	31.8	35.9	31.6
Wheat kernel size (Rotap)			
Over 7 wire (%)	64.3	90.0	72.3
Over 9 wire (%)	35.3	9.9	27.4
I nrough 9 wire (%)	0.5	0.1	0.4
Single kernel (skcs)"	75 0/17 0	67 2/14 2	64 0/17 5
Hardness (avg /s.d)	75.2/17.5	35 0/8 2	31 6/8 2
Diamatar (mm)(avg/s.d)	2 67/0 33	2 76/0 32	2 66/0 35
Moisture (%) (avg/s.d)	12 2/0 3	13 0/0 3	12 5/0 3
SKCS distribution	01-06-11-82-01	01-04-22-73-01	06-07-24-63-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb) Wheat ash (12% mb)	11.3 1.58	12.2 1.54	11.9 1.52
	Milling and Flour C	Quality Data	•
Flour yield (%, str. grade)			
Miag Multomat Mill Quadrumat Sr. Mill	76.2 66.9	76.7 66.5	76.4 66.7
Elour moisturo (%)	12.6	12 3	12.5
Flour protoin (14% mb)	97	10.7	10.7
Flour ash (14% mb)	0.52	0.59	0.54
Rapid Visco-Analyser			
Peak time (min)	6.1	6.1	6.2
Peak viscosity (RVU)	215.0	177.6	219.8
Breakdown (RVU)	76.6	62.1	75.9
Final viscosity at 13 min (RVU)	257.6	220.9	263.2
Minolta color meter	04.04	04.70	00.01
L*	91.31	91.73	90.91
a^ ►*	-1.28	-1.1/	-1.UZ 7.72
^d	0.43	0.04	1.13
РРО	0.396	0.464	0.487
Falling number (sec)	401	442	410
Damaged Starch			
(AI%)	98.5	99.0	98.4
(AACC76-31)	8.3	8.8	8.2

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Oklahoma: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples

Test Entry Number	19-2409 19-2410 19-2									
Sample Identification	Jagalene (CC02)	Ruby Lee	OK16D101089							
	MIXOGR	APH								
Flour Abs (% as-is)	66.0	63.9	64.3							
Flour Abs (14% mb)	65.3	63.2	63.2							
Mix Time (min)	4.4	5.5	3.6							
Mix tolerance (0-6)	3	5	2							
FARINOGRAPH										
Flour Abs (% as-is)	62.4	58.5	61.9							
Flour Abs (14% mb)	61.7	57.8	60.9							
Peak time (min)	5.0	3.6	5.0							
Mix stability (min)	12.3	10.4	10.6							
Mix Tolerance Index (FU)	16	30	20							
Breakdown time (min)	13.6	9.1	11.1							
	ALVEOGR	APH								
P(mm): Tenacity	99	85	93							
L(mm): Extensibility	83	89	91							
G(mm): Swelling index	20.3	21.0	21.2							
W(10 ⁻⁴ J): strength (curve area)	303	281	287							
P/L: curve configuration ratio	1.19	0.96	1.02							
le(P ₂₀₀ /P): elasticity index	60.0	61.3	56.6							
	EXTENSIG	RAPH								
Resist (BU at 45/90/135 min)	373/463/461	495/673/719	337/463/140							
Extensibility (mm at 45/90/135 min)	153/142/148	149/155/146	153/162/150							
Energy (cm ² at 45/90/135 min)	104/121/124	140/206/193	96/143/140							
Resist _{max} (BU at 45/90/135min)	520/671/667	744/1107/1096	476/690/748							
Ratio (at 45/90/135 min)	2.4/3.3/3.1	3.3/4.3/4.9	2.2/2.9/3.4							
PROTEIN ANALYSIS										
HMW-GS Composition	1,2*, 17+18/7+9, 5+10	2*, 7+8, 2+12	1, 7+8, 5+10							
PP/MP	1.03	1.17	0.95							
	SEDIMENTATI	ON TEST								
Volume (ml)	47.7	52.6	44.5							

Oklahoma: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples (continued)

Test Entry Number	19-2412	19-2413	19-2414							
Sample Identification	OK168512	OCW04S717T-6W	OK12912C-138407-2							
	MIXOGF	RAPH								
Flour Abs (% as-is)	64.6	67.8	68.3							
Flour Abs (14% mb)	63.3	65.8	66.8							
Mix Time (min)	4.1	5.4	5.1							
Mix tolerance (0-6)	3	4	4							
FARINOGRAPH										
Flour Abs (% as-is)	63.5	66.6	68.9							
Flour Abs (14% mb)	62.2	64.7	67.4							
Peak time (min)	4.9	4.1	4.6							
Mix stability (min)	10.7	9.5	9.9							
Mix Tolerance Index (FU)	19	27	22							
Breakdown time (min)	11.8	10.1	11.0							
	ALVEOG	RAPH								
P(mm): Tenacity	127	152	161							
L(mm): Extensibility	48	54	49							
G(mm): Swelling index	15.4	16.4	15.6							
W(10 ⁻⁴ J): strength (curve area)	235	325	316							
P/L: curve configuration ratio	2.65	2.81	3.29							
le(P ₂₀₀ /P): elasticity index	49.1	56.2	54.2							
	EXTENSIO	GRAPH								
Resist (BU at 45/90/135 min)	376/504/485	498/663/723	444/629/675							
Extensibility (mm at 45/90/135 min)	128/121/120	133/126/113	129/123/122							
Energy (cm ² at 45/90/135 min)	81/97/91	110/131/121	95/124/127							
Resist _{max} (BU at 45/90/135min)	467/616/587	639/816/871	577/835/871							
Ratio (at 45/90/135 min)	2.9/4.2/4.0	3.8/5.3/6.4	3.5/5.1/5.6							
PROTEIN ANALYSIS										
HMW-GS Composition	2*, 7+8, 5+10	2*, 7+9, 5+10	2*, 7+8, 5+10							
PP/MP	1.09	1.06	0.99							
	SEDIMENTAT	TION TEST								
Volume (ml)	41.5	41.2	50.2							

Physical Dough Tests 2019 (Small Scale) Samples - Oklahoma

Farinograms

Mixograms



Water abs = 61.7%, Peak time = 5.0 min, Mix stab = 12.3 min, MTI = 16 FU

Water abs = 65.3% Mix time = 4.4 min







Water abs = 63.2% Mix time = 5.5 min

19-2410, Ruby Lee



19-2411

Farinograms

Mixograms



Mix stab = 10.6 min, MTI = 20 FU















Farinograms

Mixograms



Water abs = 64.7%, Peak time = 4.1 min, Mix stab = 9.5 min, MTI = 27 FU Water abs = 65.8% Mix time = 5.4 min

19-2413, OCW04S717T-6W







19-2414, OK12912C-138407-2

Physical Dough Tests - Alveograph 2019 (Small Scale) Samples - Oklahoma



19-2409, Jagalene (CC02) P(mm H₂0) =99, L(mm) = 83, W(10E⁻⁴ J) = 303

19-2410, Ruby Lee $P(mm H_20) = 85, L(mm) = 89, W(10E^{-4} J) = 281$



19-2411, OK16D101089 P(mm H₂0) =93, L(mm) = 91, W(10E⁻⁴ J) = 287

Physical Dough Tests - Alveograph 2019 (Small Scale) Samples - Oklahoma



 $P(mm H_20) = 127, L(mm) = 48, W(10E^{-4} J) = 235$

19-2413, OCW04S717T-6W P(mm H₂0) = 152, L(mm) = 54, W(10E⁻⁴ J) = 325



19-2414 OK12912C-138407-2 $P(mm H_20) = 161, L(mm) = 49, W(10E^{-4} J) = 316$

Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Oklahoma





Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Oklahoma





Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Oklahoma: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2409	6875	137	4093	0.441	2.087	0.496	1.780	-9.50
2410	6860	142	4430	0.437	1.958	1.780	1.850	-13.10



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2411	6612	142	4094	0.441	2.098	1.005	1.795	-14.15
2412	5922	142	3701	0.445	1.948	1.719	1.735	-13.60

Oklahoma: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2413	5717	142	3677	0.434	1.899	2.990	1.785	-14.20
2414	5952	138	3609	0.447	2.044	1.999	1.775	-9.83



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Oklahoma Cooperators A – P

IDCODE	ID	Α	В	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Р
19-2409	Jagalene (CC02)	65.0	63.8	63.6	66.1	61.7	62.6	65.2	66.3	58	66.0	68.2	62	65.3	60.6	61.3	63.7
19-2410	Ruby Lee	64.0	64.4	61.7	61.0	57.8	62.1	63.1	61.7	57	63.0	65.8	58	63.2	57.1	57.3	59.8
19-2411	OK16D101089	63.5	64.2	61.7	62.8	60.9	63.4	63.4	65.2	57	63.1	60.7	61	63.2	60.6	59.9	62.9
19-2412	OK168512	64.7	64.0	60.2	64.5	62.2	62.7	63.5	66.1	56	63.4	65.1	62	63.3	61.9	58.7	64.2
19-2413	OCW04S717T-6W	67.5	67.8	61.9	70.0	64.7	64.1	65.8	69.6	57	67.7	62.7	64	65.8	64.2	61.0	66.7
19-2414	OK12912C-138407-2	68.0	67.6	61.8	70.1	67.4	64.1	66.7	71.2	57	70.2	69.8	67	66.8	66.8	63.5	69.4

BAKE MIX TIME, ACTUAL (Small Scale) Oklahoma Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	I	J	к	L	м	Ν	0	Ρ
19-2409	Jagalene (CC02)	3.7	4.3	4.3	4.5	9.0	6.5	4.4	5	4	5.0	5.6	11	3.9	8	4	10
19-2410	Ruby Lee	4.2	5.5	5.3	4.5	12.5	8.5	5.8	4	6	6.3	6.6	14	5.0	8	5	20
19-2411	OK16D101089	3.0	3.8	3.3	4.3	8.0	5.2	3.6	4	5	4.0	4.4	9	3.1	8	4	8
19-2412	OK168512	4.0	4.3	4.2	4.5	7.0	6.8	4.1	6	6	5.3	4.6	9	3.6	8	4	10
19-2413	OCW04S717T-6W	4.0	5.0	5.3	5.0	13.0	7.1	5.4	6	6	6.5	5.5	9	4.9	8	4	13
19-2414	OK12912C-138407-2	3.6	4.8	5.0	5.0	11.0	6.9	5.1	6	4	7.0	5.7	6	4.6	8	4	11





DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Oklahoma

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2409	Jagalene (CC02)	3	2	0	11	0
19-2410	Ruby Lee	1	2	1	9	3
19-2411	OK16D101089	2	3	3	7	1
19-2412	OK168512	2	2	5	7	0
19-2413	OCW04S717T-6W	3	2	3	8	0
19-2414	OK12912C-138407-2	1	3	4	7	1



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Oklahoma

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2409	Jagalene (CC02)	1	2	0	11	2
19-2410	Ruby Lee	0	2	3	9	2
19-2411	OK16D101089	1	3	0	10	2
19-2412	OK168512	1	3	5	7	0
19-2413	OCW04S717T-6W	2	2	2	9	1
19-2414	OK12912C-138407-2	3	0	7	6	0



CRUMB GRAIN, DESCRIBED (Small Scale) Oklahoma

IDCODE	ID	Open	Fine	Dense
19-2409	Jagalene (CC02)	10	6	0
19-2410	Ruby Lee	6	9	1
19-2411	OK16D101089	10	5	1
19-2412	OK168512	7	5	4
19-2413	OCW04S717T-6W	7	3	6
19-2414	OK12912C-138407-2	10	4	2

CELL SHAPE, DESCRIBED (Small Scale) Oklahoma

IDCODE	ID	Round	Irregular	Elongated
19-2409	Jagalene (CC02)	2	6	8
19-2410	Ruby Lee	5	2	9
19-2411	OK16D101089	4	4	8
19-2412	OK168512	4	6	6
19-2413	OCW04S717T-6W	9	2	5
19-2414	OK12912C-138407-2	5	5	6



CRUMB TEXTURE, DESCRIBED (Small Scale) Oklahoma

IDCODE	ID	Harsh	Smooth	Silky
19-2409	Jagalene (CC02)	1	10	5
19-2410	Ruby Lee	1	10	5
19-2411	OK16D101089	2	8	6
19-2412	OK168512	3	11	2
19-2413	OCW04S717T-6W	5	7	4
19-2414	OK12912C-138407-2	2	10	4



CRUMB COLOR, DESCRIBED (Small Scale) Oklahoma

IDCODE	ID	Gray	Dark_Yellow	Yellow	Dull	Creamy	White	Bright White
19-2409	Jagalene (CC02)	0	0	3	6	5	2	0
19-2410	Ruby Lee	1	0	0	5	3	6	1
19-2411	OK16D101089	0	0	2	5	8	1	0
19-2412	OK168512	0	0	6	1	7	2	0
19-2413	OCW04S717T-6W	0	0	4	6	5	1	0
19-2414	OK12912C-138407-2	0	0	0	4	7	4	1

LOAF WEIGHT, ACTUAL (Small Scale) Oklahoma Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Ρ
19-2409	Jagalene (CC02)	142.4	144.1	143.1	132.2	438.5	140.8	139.2	446.1	410	150.0	154.1	488	139.7	462.0	475.7	429.7
19-2410	Ruby Lee	141.6	141.7	140.5	131.4	447.5	139.3	139.4	450.7	412	146.9	150.3	480	136.3	465.1	481.2	431.3
19-2411	OK16D101089	139.9	142.0	141.6	129.3	436.5	141.0	139.2	446.6	409	149.1	152.0	486	139.2	466.0	477.3	423.3
19-2412	OK168512	143.3	144.5	141.9	131.9	438.5	139.2	139.8	448.0	412	150.5	155.4	483	141.6	465.8	482.1	423.7
19-2413	OCW04S717T-6W	147.5	146.0	143.5	130.0	438.0	142.3	141.5	451.0	413	153.2	154.4	488	141.9	465.6	484.0	430.2
19-2414	OK12912C-138407-2	142.9	144.8	141.9	133.6	441.0	142.6	139.8	447.9	411	154.1	160.5	492	143.2	460.7	482.4	423.3

LOAF VOLUME, ACTUAL (Small Scale) Oklahoma Cooperators A – P

IDCODE	ID	Α	В	С	D	Е	F	G	н	Т	J	К	L	Μ	Ν	0	Р
19-2409	Jagalene (CC02)	955	885	905	1135	2259	993	874	2391	3100	965	940	2927	920	2304	2600	2650
19-2410	Ruby Lee	1040	1000	950	1160	2089	904	874	2425	3000	935	995	2927	905	2753	2538	2675
19-2411	OK16D101089	945	960	950	920	2475	990	844	2375	3100	925	985	2897	910	2417	2650	2750
19-2412	OK168512	750	860	790	960	2320	819	762	2267	2800	795	820	2809	820	2240	2400	2650
19-2413	OCW04S717T-6W	730	835	745	700	2216	846	756	2067	3000	750	800	2691	790	2303	2400	2400
19-2414	OK12912C-138407-2	835	910	815	930	2416	908	798	2125	3000	795	870	2897	830	2420	2613	2525



COOPERATOR'S COMMENTS (Small Scale) Oklahoma

COOP.

19-2409 Jagalene (CC02)

- A. No comment.
- B. Yellow/brown dough.
- C. Meets loaf volume target.
- D. Good overall balance of absorption and loaf volume.
- E. Good sponge with good height, good dough out of mixer.
- F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, High Volume, Dull Crumb, Slight Open Round Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Big break and shred, dark crust color.
- I. Short mix for protein, slightly soft out of mixer, excellent volume.
- J. High absorption and wet dough at makeup, nice grain and high volume.
- K. Average performance and mix tolerance poor.
- L. Good absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption, average grain, high volume.
- P. Average mix time, higher protein and absorption, good final product qualities. Recommend for bread application.

COOP.

19-2410 Ruby Lee

- A. Excellent loaf volume.
- B. Long time to pick up, excellent loaf externals.
- C. Loaf volume better than protein predicted loaf volume.
- D. Good bread characteristics, overall lack of absorption.
- E. Good sponge with good height, could have used more mix, elastic out of mixer, dough was whiter than the other samples.
- F. Normal Protein, Normal Water Abs, Long MT, Slight Sticky & Strong Dough, High Volume, Gray Crumb, Slight Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Okay break and shred.
- I. Average mix for protein, slightly open grain, excellent volume.
- J. Long mix time and high tolerance, average absorption, very fine grain and good volume.
- K. Very good performance for protein level.
- L. Low absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Low absorption, nice grain with creamy crumb, average volume.
- P. Sponge wet and weak, average protein and absorption, high mix time and tolerance. Recommend.

19-2411 OK16D101089

- A. No comment.
- B. Cap.

COOP.

- C. Loaf volume better than protein predicted loaf volume.
- D. No comment.
- E. Good sponge with good height, good dough out of mixer.
- F. Normal Protein, Normal Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Creamy Crumb, Slight Open Elongated Cells, Resilient & Very Smooth Texture.
- G. No comment.
- H. Some break and shred.
- I. Slightly shorter mix time, slightly open grain, excellent volume.
- J. Average absorption and grain, good volume.
- K. Very good performance for protein level.
- L. Fair absorption, slightly low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Average absorption and grain, high volume.
- P. Average protein and mix time, higher absorption and volume, sticky notes on dough handling. Recommend.

COOP.

19-2412 OK168512

- A. Low protein.
- B. Left and right side break.
- C. Does not meet bake absorption target of 62%.
- D. Poor color, severe capping issues.
- E. Good sponge with good height, good dough out of mixer.
- F. Fine Protein, Normal Water Abs, Long MT, Slight Sticky & Weak Dough, Fair Volume, Yellow Crumb, Open Irregular Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Large break and shred, dark crust color, slight loaf collapse.
- I. Good out of mixer and makeup, lower protein in group, average volume.
- J. Low protein flour, average absorption but having tough dough, poor dense grain and very low volume.
- K. Good performance for low flour protein.
- L. Good absorption, slightly low mix strength, low loaf volume.
- M. No comment.
- N. No comment.
- O. Low protein flour, average grain.
- P. Low protein but high absorption, sticky dough and average mix time, good volume, good for bread application.

19-2413 OCW04S717T-6W

- A. Excellent absorption for protein.
- B. Rough break.

COOP.

- C. No comment.
- D. Small dense loaf.
- E. Good sponge with good height, slightly sticky sponge into fermentation, good dough out of mixer.
- F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, Fine Volume, Yellow Crumb, Dense Elongated Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Very good loaf structure.
- I. Average mix for protein, good out of mixer, good volume.
- J. Long mix time, high absorption, but having tough dough out of mixer, yielding bread with dense grain and very low volume.
- K. Dough strength shows promise if sample were viewed with more protein, bread performance good for protein level.
- L. Good absorption, slightly low mix strength, very low loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption and nice grain.
- P. Average HRW with higher absorption and lower volume. Do not recommend.

COOP.

19-2414 OK12912C-138407-2

- A. Excellent absorption for protein.
- B. Cap.
- C. No comment.
- D. No comment.
- E. Good sponge with good height, slightly sticky sponge, dough was whiter in color.
- F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, High Volume, Dull Crumb, Open Round Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Sponge did not form well, large break and shred, dark crust color, loaf collapsed.
- I. Soft out of mixer, short mix time, good volume, slightly open grain.
- J. Long mix time, very high (70%) absorption, but having tough dough at makeup, yielding bread with dense grain and very low volume.
- K. Dough strength shows promise if sample were viewed with more protein, bread performance good for protein level.
- L. Very good absorption, very low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. High absorption but tough dough at makeup, nice elongated grain with creamy crumb, high volume.
- P. High absorption; average mix time, protein and volume.

Notes: E, H, I, L, O and P conducted sponge and dough bake tests

LIMAGRAIN

19-2415 19-2416 Jagalene (CC03) ERYTHR02420-2010

Description of Test Plots and Breeder Entries

Limagrain – Maria Barnett

Growing Location & Conditions

The hard winter Wheat Quality Council samples from Limagrain Cereal Seeds originated from strip increases grown in Leoti, KS. The WQC strips were planted on September 25, 2018 into good soil moisture with good fall stands and decent growth. The field received 90 lbs actual N top-dressed in early December, a broadleaf herbicide in early March, and one foliar fungicide (tebuconazole and azoxystrobin) application in mid-May. Adjacent yield plots averaged 126 bushels/acre.

ERYTHRO2420-2010

ERYTHRO2420-2010 is a hard-red winter wheat originating from Ukraine, with mediumlate maturity. ERYTHRO2420-2010 has excellent straw strength and is moderately resistant to stripe rust, leaf rust, and Fusarium head blight. It is tolerant to acid soils but susceptible to stem rust. Winterhardiness is good to excellent in Nebraska and Kansas but marginal in the Dakotas to Canada. The line was tested in the 2019 Northern Regional Performance Nursery.

Milling and baking quality data from LCS show average protein, above average mixograph time, and above average loaf volume.

The line was ultimately discarded due to poor yield stability, susceptibility to stem rust and sub-par winterhardiness in the projected market region.

Jagalene – common check
Test entry number	19-2415	19-2416				
Sample identification	Jagalene (CC03)	ERYTHR02420-2010				
•	Wheat Data					
GIPSA classification	1 HRW	1 HRW				
Test weight (lb/bu)	63.7	62.8				
Hectoliter weight (kg/hl)	83.7	82.6				
1000 kernel weight (gm)	33.9	40.2				
Wheat kernel size (Rotap)						
Over 7 wire (%)	83.7	88.9				
Over 9 wire (%)	15.7	10.9				
I nrough 9 wire (%)	0.0	0.2				
Single kernel (SKCS) ^a	80 1/18 6	81 6/13 6				
Moight (mg) (avg/s.d)	33 9/11 5	40 2/10 7				
Diameter (mm)(avg/s.u)	2,75/0.46	2,93/0,39				
Moisture (%) (avg/s.d)	13.0/0.3	13.2/0.3				
SKCS distribution	01-03-10-86-01	00-01-04-95				
Classification	Hard	Hard				
Wheat protein (12% mb) Wheat ash (12% mb)	10.8 1.52	11.8 1.54				
Milling a	and Flour Quality	Data				
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	76.9 68.9	77.6 68.9				
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.3 9.7 0.59	12.2 10.7 0.55				
Rapid Visco-Analyser						
Peak Time (min)	6.1	6.3				
Peak Viscosity (RVU)	200.2	204.6				
Breakdown (RVU)	71.1	60.9				
Final Viscosity at 13 min (RVU)	237.7	257.3				
Minolta color meter	01.06	00.73				
L^	91.00	90.73				
a" b*	- 1.34 9 48	- 1.07 8.89				
U	0.40	0.00				
PPO	0.290	0.338				
Falling number (sec)	381	407				
Damaged Starch						
(AI%)	98.6	98.8				
(AAĆC76-31)	8.5	8.7				

Limagrain: 2019 (Small-Scale) Samples

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Limagrain: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples

Test Entry Number	19-2415	19-2416									
Sample Identification	Jagalene (CC03)	ERYTHR02420-2010									
N	IIXOGRAPH										
Flour Abs (% as-is)	65.3	72.0									
Flour Abs (14% mb)	63.6	70.4									
Mix Time (min)	4.8	6.1									
Mix tolerance (0-6)	4	3									
FA	RINOGRAPH										
Flour Abs (% as-is)	65.7	71.5									
Flour Abs (14% mb)	64.0	69.9									
Peak time (min)	5.1	10.7									
Mix stability (min)	12.7	23.3									
Mix Tolerance Index (FU)	7	8									
Breakdown time (min)	14.2	26.0									
AL	VEOGRAPH										
P(mm): Tenacity	133	210									
L(mm): Extensibility	48	40									
G(mm): Swelling index	15.4	14.1									
W(10 ⁻⁴ J): strength (curve area)	252	310									
P/L: curve configuration ratio	2.77	5.25									
le(P ₂₀₀ /P): elasticity index	51.0	21.2									
EX	TENSIGRAPH	-									
Resist (BU at 45/90/135 min)	363/608/745	533/926/914									
Extensibility (mm at 45/90/135 min)	117/97/97	118/101/88									
Energy (cm ² at 45/90/135 min)	67/80/91	98/127/98									
Resist _{max} (BU at 45/90/135 min)	438/647/781	658/1049/960									
Ratio (at 45/90/135 min)	3.1/6.2/7.7	4.5/9.2/10.4									
PROTEIN ANALYSIS											
HMW-GS Composition	1,2*, 17+18/7+9, 5+10	1, 7+8, 5+10									
PP/MP	1.03	0.97									
SEDIN	IENTATION TEST										
Volume (ml)	39.8	53.1									



Pi 19-2415 19-2415 19-2415 19-2415 19-2415 19-2415 19-2415 19-2415 19-2415 19-2415 19-2415 19-2415

Mixograms



Water abs = 64.0%, Peak time = 5.1 min Mix stab = 12.7 min, MTI = 7 FU

Farinograms

Water abs = 63.6%Mix time = 4.8 min









19-2416, ERYTHR02420-2010

Physical Dough Tests - Alveograph

2019 (Small Scale) Samples – Limagrain



19-2415, Jagalene (CC03) P (mm H₂0) = 133, L (mm) = 48, W (10E⁻⁴J) = 252



19-2416, ERYTHR02420-2010 P (mm H_20) = 210, L (mm) = 40, W (10E⁻⁴J) = 310

Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Limagrain



Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Limagrain: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2415	5998	138	3677	0.443	2.056	0.865	1.728	-13.35
2416	6212	137	3708	0.441	2.052	1.197	1.788	-11.78



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Limagrain Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2415	Jagalene (CC03)	65	65.6	59.9	69	64.0	62.4	63.7	68.1	56	64.0	64.1	64	63.6	63.1	61.3	66.0
19-2416	ERYTHRO2420-2010	71	70.7	62.0	73	69.9	64.1	70.4	74.5	57	73.1	68.6	67	70.4	68.6	63.4	71.9

BAKE MIX TIME, ACTUAL (Small Scale) Limagrain Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Ρ
19-2415	Jagalene (CC03)	4.0	4.3	5.0	5.5	7	5.8	4.8	4.5	6	5.0	5.8	10	4.3	8	4	11
19-2416	ERYTHRO2420-2010	4.4	5.0	5.3	5.0	10	7.0	6.1	4.0	10	8.4	5.8	11	5.6	8	7	14





DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Limagrain

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent	
19-2415	Jagalene (CC03)	3	3	2	8	0	
19-2416	ERYTHRO2420-2010	4	3	4	5	0	



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Limagrain

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent	
19-2415	Jagalene (CC03)	4	1	2	8	1	
19-2416	ERYTHRO2420-2010	3	2	5	5	1	



CRUMB GRAIN, DESCRIBED (Small Scale) Limagrain

IDCODE	ID	Open	Fine	Dense
19-2415	Jagalene (CC03)	7	6	3
19-2416	ERYTHRO2420-2010	11	4	1

CELL SHAPE, DESCRIBED (Small Scale) Limagrain

IDCODE	ID	Round	Irregular	Elongated
19-2415	Jagalene (CC03)	6	6	4
19-2416	ERYTHRO2420-2010	5	7	4



CRUMB TEXTURE, DESCRIBED (Small Scale) Limagrain

IDCODE	ID	Harsh	Smooth	Silky
19-2415	Jagalene (CC03)	3	8	5
19-2416	ERYTHRO2420-2010	2	10	4



CRUMB COLOR, DESCRIBED (Small Scale) Limagrain

IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
19-2415	Jagalene (CC03)	0	1	6	3	6	0	0
19-2416	ERYTHRO2420-2010	0	0	4	5	6	1	0

LOAF WEIGHT, ACTUAL (Small Scale) Limagrain Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2415	Jagalene (CC03)	144.7	142.9	142.0	130.2	442.5	141.1	141.0	450.7	413	150.8	156.8	489	143.5	459.7	479.0	423.7
19-2416	ERYTHRO2420-2010	146.8	146.4	143.6	134.3	441.5	141.5	139.7	438.5	417	156.7	156.7	488	145.6	450.6	479.2	423.3

LOAF VOLUME, ACTUAL (Small Scale) Limagrain Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2415	Jagalene (CC03)	760	850	690	850	2111	835	746	2191	3000	800	735	2927	755	2124	2450	2650
19-2416	ERYTHRO2420-2010	870	905	760	900	2303	849	751	2033	2850	885	833	2927	745	2262	2500	2575



COOPERATOR'S COMMENTS (Small Scale) Limagrain

COOP.

19-2415 Jagalene (CC03)

- A. Low protein.
- B. Slight cap.
- C. Does not meet bake absorption target of 62%.
- D. No comment.
- E. Good sponge with good height, dough was beige in color.
- F. Fine Protein, Normal Water Abs, Normal MT, Slight Sticky & Weak Dough, Fair Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Some break and shred, loaf collapsed.
- I. Good mix for protein, lower protein, good volume, open grain.
- J. Low protein flour, poor open grain and dark yellow crumb, low volume.
- K. Dough performance shows promise if protein were higher, bread very poor however.
- L. Good absorption, slightly low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Low protein flour, good absorption and fine grain.
- P. Low protein, average mix time, high absorption, unfavorable notes from mixing tolerance and dough handling characteristics, final product problems, good volume.

COOP.

19-2416 ERYTHRO2420-2010

- A. Excellent absorption for protein.
- B. Slight cap.
- C. No comment.
- D. High baking absorption, average loaf volume.
- E. Sponge slightly sticky, good sponge and height, good dough out of mixer.
- F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, Fine Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Big break and shred, collapsed loaf, dark crust color.
- I. Good mix time, open grain, average volume, creamy interior.
- J. Long mix time, very high (73%) absorption, tough dough at makeup, average grain and volume.
- K. Expected performance for protein level, dough strength shows promise at higher protein.
- L. Very good absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Long mix time and high absorption, very tolerant to mixing, average grain and volume.
- P. Average protein, good mix time but sticky and wet dough notes, high absorption, good volume (better than 2415).

Notes: E, H, I, L, O and P conducted sponge and dough bake tests

KANSAS-HAYS

19-2417 19-2418 19-2419 19-2420 Jagalene (CC04) KS15H116-6-1 KS15H161-1-4 Danby

Description of Test Plots and Breeder Entries

Kansas-Hays - Guorong Zhang

The samples submitted were grown at Hays experimental station in 2019. Jagalene, Danby, KS15H116-6-1, and KS15H161-1-4 were planted on Sept. 27, 2018 in a field with sandy-loam soil. Test plots were fertilized with 60 lb/a N before planting. Plots were not irrigated, and were not treated with fungicide. The field had good soil moisture at planting and the plots had good stands. The 2019 crop year was cooler than normal in both fall and spring, which delayed wheat development and our harvest was about two weeks later than normal. The plots grew very well and had above average yield because of the abundant precipitation in the spring. No lodging was observed in the plots. Both stripe rust and leaf rust infection occurred in the field. Jagalene was moderately susceptible to the rusts and Danby had intermediate reaction. Both KS15H116-6-1 and KS15H161-1-4 showed moderate resistance to the rusts.

Jagalene (common check)

Danby (local check)

KS15H116-6-1 (KS Dallas)

KS15H116-6-1 was released as KS Dallas in last August. It is a hard red winter wheat with medium maturity and medium height. It has very competitive yield in western Kansas, which is comparable to Joe. It has good grain shattering resistance and average straw strength. Its coleoptile length is medium long. It has good resistances to wheat streak mosaic virus, leaf rust, and stem rust. Its wheat streak mosaic virus resistance can hold up to 21°C, which is three degrees higher than those resistant varieties with *Wsm2*, such as RonL, Joe, Clara CL, and Oakley CL. It is intermediate to stripe rust, barley yellow dwarf virus, and *Triticum* mosaic virus. It is moderately susceptible to powdery mildew and Hessian fly, and susceptible to soilborne mosaic virus and acid soil. It has large kernels, average test weight, good flour yield, and good mixing tolerance.

KS15H161-1-4 (KS Western Star)

KS15H161-1-4 was released as KS Western Star in last August. It is a hard red winter wheat with medium maturity and medium height. It has very competitive yield in western Kansas, which is comparable to Joe. Its drought tolerance is very good. It also has very good grain shattering resistance and good straw strength. It has moderate resistances to stripe and leaf rust. It is resistant to wheat curl mite and soilborne mosaic virus. It is intermediate to stem rust, *Fusarium* head blight, and *Triticum* mosaic virus. It is moderately susceptible to wheat streak mosaic virus and susceptible to Hessian fly. KS15H161-1-4 has good test weight, mixing tolerance, and loaf volume; and very good flour yield.

Kansas-Hays: 2019 (Small-Scale) Samples

Test entry number	19-2417	19-2418	19-2419	19-2420
Sample identification	Jagalene (CC04)	KS15H116-6-1	KS15H161-1-4	Danby
	Whe	eat Data		
GIPSA classification	2 HRW	1 HRW	1 HRW	1 HDWH
Test weight (lb/bu)	588.4	62.3	63.0	64.3
Hectoliter weight (kg/hl)	76.9	81.9	82.8	84.5
1000 kernel weight (gm)	27.1	41.1	36.3	32.7
Wheat kernel size (Rotap)		00.0	00 7	770.0
Over 7 wire (%)	45.5	89.3	89.7 10.3	778.2
Over 9 wire (%)	31	0.0	0.5	0.1
Single kernel (skcs) ^a	0.1	0.2	0.1	0.1
Hardness (avg /s d)	79 8/19 2	70 3/14 2	66 2/17 3	72 7/15 3
Weight (mg) (avg/s.d)	27.1/10.8	41.4/10.8	36.3/10.0	32.7/8.6
Diameter (mm)(avg/s.d)	2.49/0.41	2.82/0.38	2.84/0.41	2.66/0.33
Moisture (%) (avg/s.d)	11.9/0.4	12.6/0.3	12.0/0.3	12.0/0.4
SKCS distribution	02-04-10-84-01	02-02-17-79-01	02-10-24-64-01	01-04-12-83-01
Classification	Hard	Hard	Hard	Hard
Wheat protein (12% mb) Wheat ash (12% mb)	12.7 1.65	12.1 1.50	11.5 1.54	10.9 1.50
	Milling and F	lour Quality Dat	а	
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	75.4 68.1	78.1 70.2	80.5 72.8	77.0 70.4
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.2 11.5 0.61	12.7 10.9 0.52	12.3 10.5 0.53	12.5 9.5 0.54
Rapid Visco-Analyser				
Peak Time (min)	6.0	6.1	6.1	6.1
Peak Viscosity (RVU)	195.5	252.6	225.9	260.3
Breakdown (RVU)	81.6	118.6	86.4	125.2
Final Viscosity at 13 min (RVU)	221.8	220.8	254.0	227.0
Minoita color meter	00.55	01.00	01 34	02.02
L	-1 23	-1 12	-1 32	92.03
a b*	9.71	8.53	8,91	7 93
	•			
РРО	0.407	0.477	0.102	0.482
Falling number (sec)	373	383	378	364
Damaged Starch (Al%) (AACC76-31)	98.5 8.4	97.5 7.5	98.5 8.3	97.7 7.6

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Kansas-Hays: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples

Test Entry Number	19-2417	19-2418	19-2419	19-2420
Sample Identification	Jagalene (CC04)	KS15H116-6-1	KS15H161-1-4	Danby
	MIXO	GRAPH		
Flour Abs (% as-is)	69.4	67.0	67.9	64.8
Flour Abs (14% mb)	67.6	65.8	66.3	63.4
Mix Time (min)	4.4	8.5	6.5	3.0
Mix tolerance (0-6)	4	4	4	2
	FARING	DGRAPH		
Flour Abs (% as-is)	66.7	64.4	65.8	64.3
Flour Abs (14% mb)	65.0	63.2	64.2	62.8
Peak time (min)	5.9	5.1	5.1	3.7
Mix stability (min)	11.2	10.4	9.7	6.5
Mix Tolerance Index (FU)	24	26	26	43
Breakdown time (min)	11.7	11.2	10.8	7.4
	ALVEC	GRAPH		
P(mm): Tenacity	133	130	119	98
L(mm): Extensibility	57	30	70	69
G(mm): Swelling index	16.8	12.2	18.6	18.5
W(10 ⁻⁴ J): strength (curve area)	296	179	321	227
P/L: curve configuration ratio	2.33	4.33	1.70	1.42
le(P ₂₀₀ /P): elasticity index	56.4	0.0	59.8	48.0
	EXTENS	SIGRAPH		
Resist (BU at 45/90/135 min)	395/466/512	589/909/1172	467/666/749	253/272/299
Extensibility (mm at 45/90/135 min)	144/143/141	128/104/99	136/127/123	151/160/141
Energy (cm² at 45/90/135 min)	100/121/132	125/130/150	115/143/144	70/81/74
Resist _{max} (BU at 45/90/135 min)	536/672/764	793/1046/1366	692/932/982	340/369/396
Ratio (at 45/90/135 min)	2.8/3.3/3.6	4.6/8.8/11.9	3.4/5.2/6.1	1.7/1.7/2.1
	PROTEIN	ANALYSIS		
HMW-GS Composition	1,2*, 17+18/7+9, 5+10	1, 7+8, 5+10	2*, 7+9, 5+10	2*, 7+9, 5+10
PP/MP	1.01	0.88	0.98	0.97
	SEDIMENT	ATION TEST		
Volume (ml)	57.0	51.4	52.1	46.3

Physical Dough Tests 2019 (Small Scale) Samples – Kansas-Hays

Farinograms

Mixograms





Water abs = 65.0%, Peak time = 5.9 min Mix stab = 11.2 min, MTI = 24 FU

Water abs = 67.6% Mix time = 4.4 min

19-2417, Jagalene (CC04)



Water abs = 63.2%, Peak time = 5.1 min, Mix stab = 10.4 min, MTI = 26 FU



19-2418, KS15H116-6-1

Physical Dough Tests 2019 (Small Scale) Samples – Kansas-Hays (continued)

R1 19-2419 Faitspan

Farinograms

Mixograms



Water abs. = 64.2%, Peak time = 5.1 min, Mix stab = 9.7 min, MTI = 26 FU



19-2419, KS15H161-1-4









Physical Dough Tests - Alveograph

2019 (Small Scale) Samples – Kansas-Hays





19-2419, KS15H161-1-4 P (mm H_20) = 119, L (mm) = 70, W (10E⁻⁴J) = 321

19-2420, Danby P (mm H₂0) = 98, L (mm) = 69, W (10E⁻⁴J) = 227

Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Kansas-Hays





Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Kansas-Hays: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2417	6820	134	3992	0.444	2.113	0.988	1.743	-11.10
2418	6186	139	3618	0.448	2.116	3.188	1.820	-6.15



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2419	6083	138	3837	0.436	1.917	2.624	1.758	-11.33
2420	6400	144	3619	0.459	2.283	0.918	1.700	-14.80



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Kansas-Hays Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р	
19-2417	Jagalene (CC04)	68	67.6	63.1	70.1	65.0	64.4	67.4	68.4	58	70.9	64.5	65	67.6	64.2	61.2	67.0	
19-2418	KS15H116-6-1	67	67.9	62.5	65.4	63.2	64.1	66.0	65.2	57	69.5	67.2	63	65.8	60.6	60.8	65.2	
19-2419	KS15H161-1-4	70	66.5	61.4	67.1	64.2	63.0	66.3	67.0	57	66.1	62.6	64	66.3	63.8	60.4	66.2	
19-2420	Danby	65	63.6	60.1	65.4	62.8	62.5	63.6	66.5	56	64.3	61.5	62	63.4	63.1	58.6	64.8	

BAKE MIX TIME, ACTUAL (Small Scale) Kansas-Hays Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Ρ
19-2417	Jagalene (CC04)	3.5	4.3	5.0	6.0	15	5.0	4.4	6.5	6	6.8	6.2	13	3.9	8	4	11
19-2418	KS15H116-6-1	5.7	7.3	8.0	8.0	15	13.1	7.8	4.5	9	12.3	10.0	25	8.0	8	7	20
19-2419	KS15H161-1-4	4.9	5.5	5.3	7.3	14	10.1	6.7	8.5	8	9.0	5.9	12	6.0	8	8	19
19-2420	Danby	2.9	3.5	3.2	4.5	5	4.3	3.1	7.5	4	4.0	4.7	5	2.5	8	4	8





DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Kansas-Hays

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2417	Jagalene (CC04)	2	1	1	11	1
19-2418	KS15H116-6-1	2	3	3	7	1
19-2419	KS15H161-1-4	3	1	6	5	1
19-2420	Danby	7	2	2	4	1



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Kansas-Hays

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2417	Jagalene (CC04)	2	0	3	11	0
19-2418	KS15H116-6-1	2	1	5	7	1
19-2419	KS15H161-1-4	1	2	5	7	1
19-2420	Danby	6	4	0	5	1



CRUMB GRAIN, DESCRIBED (Small Scale) Kansas-Hays

IDCODE	ID	Open	Fine	Dense
19-2417	Jagalene (CC04)	9	4	3
19-2418	KS15H116-6-1	10	5	1
19-2419	KS15H161-1-4	7	7	2
19-2420	Danby	10	4	2
CELL SHAPE, DESCRIBED (Small Scale) Kansas-Hays

IDCODE	ID	Round	Irregular	Elongated
19-2417	Jagalene (CC04)	3	8	5
19-2418	KS15H116-6-1	5	5	6
19-2419	KS15H161-1-4	6	5	5
19-2420	Danby	11	4	1



CRUMB TEXTURE, DESCRIBED (Small Scale) Kansas-Hays

IDCODE	ID	Harsh	Smooth	Silky
19-2417	Jagalene (CC04)	2	11	3
19-2418	KS15H116-6-1	1	8	7
19-2419	KS15H161-1-4	3	8	5
19-2420	Danby	7	5	4



CRUMB COLOR, DESCRIBED (Small Scale) Kansas-Hays

IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White	
19-2417	Jagalene (CC04)	0	1	6	4	5	0	0	
19-2418	KS15H116-6-1	0	0	2	3	9	2	0	
19-2419	KS15H161-1-4	0	0	2	3	6	5	0	
19-2420	Danby	0	0	4	2	7	2	1	

LOAF WEIGHT, ACTUAL (Small Scale) Kansas-Hays Cooperators A – P

IDCODE	ID	Α	В	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Р
19-2417	Jagalene (CC04)	148.8	146.0	142.6	129.1	448.5	140.8	134.5	443.8	410	152.3	156.5	488	144.6	461.3	476.3	424.4
19-2418	KS15H116-6-1	144.2	143.2	142.4	130.4	450.0	138.3	139.1	445.8	414	153.0	154.5	483	141.1	459.3	477.3	428.1
19-2419	KS15H161-1-4	146.1	144.2	142.1	128.9	451.5	139.6	139.3	446.9	414	151.1	156.2	483	145.1	459.9	478.2	429.0
19-2420	Danby	147.5	146.0	142.3	128.7	438.0	140.1	138.8	444.0	418	150.0	149.2	480	142.5	463.2	481.5	428.6

LOAF VOLUME, ACTUAL (Small Scale) Kansas-Hays Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	κ	L	Μ	Ν	0	Р
19-2417	Jagalene (CC04)	855	875	860	1040	2374	963	922	2208	2850	945	870	2956	875	2470	2563	2700
19-2418	KS15H116-6-1	965	940	745	925	2269	900	878	2267	2925	865	880	2927	720	2324	2363	2850
19-2419	KS15H161-1-4	875	945	740	885	2346	915	845	2092	3000	830	878	2956	710	2277	2588	2800
19-2420	Danby	730	710	620	900	2193	936	816	2325	2550	870	843	2868	855	2033	2338	2350



COOPERATOR'S COMMENTS (Small Scale) Kansas-Hays

COOP.

19-2417 Jagalene (CC04)

- A. No comment.
- B. Yellow?
- C. Meets loaf volume target.
- D. Good loaf volume and absorption.
- E. Good sponge with good height, good dough out of mixer and at makeup.
- F. High Protein, High Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Break and shred, loaf collapsed, dark crust color.
- I. Highest protein in group, sticky sponge but recovered at makeup, average volume, open grain.
- J. Long mix time, very high (71%) absorption, average grain but good volume.
- K. Expected performance for protein level, dough strength shows promise at higher protein.
- L. Very good absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption and nice grain, good volume but very yellow crumb.
- P. Good protein and mix time, high absorption, some sticky and wet dough notes, good volume and fair final product characteristics, good for bread application.

19-2418 KS15H116-6-1

- A. Long mix.
- B. Cap.

COOP.

- C. Mix too long (8 minutes).
- D. Long mixer.
- E. Good sponge, dough could have used more mix, good dough during makeup.
- F. High Protein, High Water Abs, Very Long MT, Slight Sticky & Strong Dough, Very High Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
- G. No comment.
- H. Nice loaf structure and crust color.
- I. Good dough, good mix time and volume, open grain, creamy interior.
- J. Longest mix time of the set, high absorption, good grain, but average volume.
- K. Expected performance for protein level, dough strength shows promise at higher protein.
- L. Good absorption, very good mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Long mix time, good absorption, nice grain but low volume.
- P. Good protein and dough notes; high absorption, mix time and volume. Recommend.

19-2419 KS15H161-1-4

- A. Excellent absorption for protein and very good overall.
- B. Nice loaf externals.
- C. Does not meet bake absorption target of 62%.
- D. No comment.

COOP.

- E. Good sponge with good height, good dough out of mixer and at makeup.
- F. Normal Protein, Normal Water Abs, Very Long MT, Slight Sticky & Strong Dough, High Volume, Creamy Crumb, Slight Open Elongated Cells, Resilient & Very Smooth Texture.
- G. No comment.
- H. Break and shred, loaf collapsed, slightly dark crust.
- I. Good dough, good mix time and volume, open grain, creamy interior.
- J. Long mix time, high absorption, average grain.
- K. Expected performance for protein level, dough strength shows promise at higher protein.
- L. Very good absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Long mix time, average absorption and grain, good volume.
- P. Average protein, wet and sticky dough notes; high volume, mix time and absorption. Recommend.

COOP.

19-2420 Danby

- A. No comment.
- B. Lifeless dough.
- C. Does not meet bake absorption target of 62%.
- D. No comment.
- E. Good sponge with good height, good dough out of mixer and at makeup.
- F. Fine Protein, Fine Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Slight Yellow Crumb, Open Irregular Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Little break and shred.
- I. Sticky sponge, very soft dough, low volume and short mix, squatty loaf, worst of group.
- J. Low protein flour, average grain and volume, very yellow crumb.
- K. Expected performance for protein level, dough strength shows promise at higher protein.
- L. Good absorption, very low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Low protein flour having sticky wet doughs, poor dense grain and low volume.
- P. Higher absorption, low protein, low mix time and volume, unfavorable dough mixing qualities and dough handling characteristics, final product not very desirable. Do not recommend.

Notes: E, H, I, L, O and P conducted sponge and dough bake tests

BAYER (MONSANTO, WESTBRED)

19-2421
19-2422
19-2423

Jagalene (CC05) MODI4-5179 NEDI4-5304



Description of Test Plots and Breeder Entries

Bayer (Monsanto, Westbred) - Sid Perry

The test samples were grown in Filer, Idaho. The plots were planted on October 10, 2018. Pre-plant N was applied via manure application targeting 125 bushel per acre yields. Liquid 32 was applied at a rate of 100 units/acre. The growth regulator Palisade was applied at jointing. Caramba was applied at flowering to reduce stripe rust and head scab infections. Full irrigation was provided and produced a yield level of 170 bushels per acre.

JAGALENE (Common Check)

MODI4-5179

MODI4-5179 is a hard red winter wheat, with medium maturity, average straw strength, and above average test weight. It has good winterhardiness and is well adapted to the northern plains and Montana. It is moderately resistant to stripe rust, and has above average tolerance to Wheat Streak Mosaic Virus. It is susceptible to wheat stem sawfly and fusarium head blight. Internal quality testing indicates MODI4-5179 to have below average protein, but good functionality. MODI4-5179 will be marketed as WB4505, targeting non-sawfly acres of Montana and the western Dakotas.

NEDI4-5304

NEDI4-5304 is a hard red winter wheat, with early-medium maturity, above average straw strength, and above average test weight. It has good winterhardiness and is well adapted to the Dakotas and western regions of the central plains. It is moderately resistant to stripe rust and leaf rust. It has good tolerance to hessian fly. It is susceptible to wheat stem sawfly, soil borne mosaic and is moderately susceptible to fusarium head blight. Internal quality testing indicates NEDI4-5304 to have above average protein content and very good functionality. NEDI4-5304 will be marketed as WB4309, targeting the Dakotas, and into areas of the central plains north of I-70.

Test entry number	19-2421	19-2422	19-2423
Sample identification	Jagalene (CC05)	MODI4-5179	NEDI4-5304
	Wheat Data	1	
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	64.8	64.2	64.2
Hectoliter weight (kg/hl)	85.1	84.4	84.4
1000 kernel weight (gm)	41.7	38.3	35.8
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	91.5 8.5 0.0	88.5 11.3 0.3	87.9 12.1 0.1
Single kernel (skcs) ^a Hardness (avg /s.d) Weight (mg) (avg/s.d) Diameter (mm)(avg/s.d) Moisture (%) (avg/s.d) SKCS distribution Classification	69.6/14.2 41.7/9.2 3.05/0.34 8.7/0.8 01-05-16-78-01 Hard	64.5/16.7 38.3/10.0 2.72/0.39 9.1/0.9 04-08-28-60-01 Hard	76.9/15.1 35.8/8.8 2.77/0.38 8.8/0.8 01-02-08-89-01 Hard
Wheat protein (12% mb) Wheat ash (12% mb)	12.6 1.46	11.0 1.49	12.5 1.56

Milling and Flour Quality Data

76.2

68.9

12.7

9.6

0.50

6.2

197.0

69.9

226.3

91.25

-1.22

8.44

0.160

388

98.8

76.8

68.2

12.1

11.0

0.50

6.1

160.3

56.3

197.7

90.83

-1.52

10.14

0.197

380

99.4

9.2

78.1

70.1

12.3

11.4

0.52

6.1

157.7

53.0

195.5

91.35

-1.24

8.69

0.238

381

99.4

Flour yield (%, str. grade)

Miag Multomat Mill

Quadrumat Sr. Mill

Flour moisture (%)

Flour protein (14% mb)

Flour ash (14% mb)

Rapid Visco-Analyser

Peak Time (min)

Peak Viscosity (RVU)

Breakdown (RVU) Final Viscosity at 13 min (RVU)

Minolta color meter

L*

a*

b*

PPO

Falling number (sec)

Damaged Starch

(AI%)

Bayer (Westbred): 2019 (Small-Scale) Samples

(AAĆC76-31)9.18.6as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Test Entry Number	19-2421	19-2422	19-2423			
Sample Identification	Jagalene (CC05)	MODI4-5179	NEDI4-5304			
	MIXOGRAPH	1				
Flour Abs (% as-is)	69.7	67.1	72.6			
Flour Abs (14% mb)	68.0	65.9	70.7			
Mix Time (min)	3.0	3.1	3.8			
Mix tolerance (0-6)	2	2	2			
	FARINOGRAP	ΡH				
Flour Abs (% as-is)	71.5	71.1	73.4			
Flour Abs (14% mb)	69.8	69.8	71.5			
Peak time (min)	5.3	4.2	6.0			
Mix stability (min)	6.5	5.7	7.9			
Mix Tolerance Index (FU)	39	41	38			
Breakdown time (min)	8.6	7.6	10.0			
	ALVEOGRAP	Н				
P(mm): Tenacity	145	152	172			
L(mm): Extensibility	66	54	60			
G(mm): Swelling index	18.1	16.4	17.2			
W(10 ⁻⁴ J): strength (curve area)	345	293	394			
P/L: curve configuration ratio	2.20	2.81	2.39			
le(P ₂₀₀ /P): elasticity index	52.8	44.4	54.6			
	EXTENSIGRA	РН				
Resist (BU at 45/90/135 min)	283/346/336	226/284/325	337/421/460			
Extensibility (mm at 45/90/135 min)	140/153/156	137/137/128	137/137/127			
Energy (cm ² at 45/90/135 min)	71/101/100	53/68/69	79/98/97			
Resist _{max} (BU at 45/90/135 min)	382/512/504	268/363/411	430/556/632			
Ratio (at 45/90/135 min)	2.0/2.3/2.2	1.7/2.1/2.5	2.5/3.1/3.6			
	PROTEIN ANAL	YSIS				
HMW-GS Composition	1,2*, 17+18/7+9, 5+10	1, 7+9, 5+10	1, 7+8, 5+10			
PP/MP	0.98	0.99	0.99			
	SEDIMENTATION	TEST				
Volume (ml)	50.6	41.0	56.4			

Bayer: Physical Dough Tests and Gluten Analysis For 2019 (Small-Scale) Samples

Physical Dough Tests 2019 (Small Scale) Samples – Bayer

Farinograms

Mixograms





Water abs = 69.8%, Peak time = 5.3 min, Mix stab = 6.5 min, MTI = 39 FU

Water abs = 68.0% Mix time = 3.0 min











Physical Dough Tests 2019 (Small Scale) Samples – Bayer

19-2423

Farinograms

Water abs = 71.5%, Peak time = 6.0 min, Mix stab = 7.9 min, MTI = 38 FU

Water abs = 70.7% Mix time = 3.8 min

19-2423, NEDI4-5304

Mixograms

Physical Dough Tests - Alveograph 2019 (Small Scale) Samples - Bayer



19-2421, Jagalene (CC05) P (mm H₂0) = 145, L (mm) = 66, W (10E⁻⁴J) = 345

19-2422, MODI4-5179 P (mm H₂0) = 152, L (mm) = 54, W (10E⁻⁴J) = 293



19-2423, NEDI4-5304 P (mm H₂0) = 172, L (mm) = 60, W (10E⁻⁴J) = 394

Physical Dough Tests - Extensigraph 2019 (Small Scale) Samples - Bayer





Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Bayer: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2421	6518	140	3442	0.466	2.491	1.540	1.760	-12.05
2422	6040	138	3464	0.456	2.268	1.135	1.665	-12.05



Entry	Slice Area	Slice	Number	Wall Thick	Cell Diameter	Non-	Avg. Cell	Cell Angle to
#	(mm ²)	Brightness	Cells	(mm)	(mm)	uniformity	Elongation	Vertical (⁰)
2423	6503	135	3270	0.473	2.527	4.664	1.765	-11.40



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Bayer Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Ρ
19-2421	Jagalene (CC05)	66	67.5	62.9	72.9	69.8	64.5	67.9	73.9	57	69.0	66.1	67	68.0	70.3	59.3	71.8
19-2422	MODI4-5179	67	66.0	60.1	72.2	69.8	62.2	66.0	72.8	56	64.5	63.7	67	65.9	69.9	61.8	71.8
19-2423	NEDI4-5304	68	69.2	62.3	75.0	71.5	65.1	70.6	75.6	57	70.8	67.9	68	70.7	72.0	62.1	73.5

BAKE MIX TIME, ACTUAL (Small Scale) Bayer Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	М	Ν	ο	Ρ
19-2421	Jagalene (CC05)	2.4	3.0	3.2	4.0	7	4.0	3.0	5.0	4	3.5	3.6	7	2.5	8	4	6
19-2422	MODI4-5179	2.6	3.0	3.2	3.5	5	3.5	3.1	5.0	4	3.1	3.6	4	2.6	8	4	8
19-2423	NEDI4-5304	3.0	3.5	3.5	5.0	7	4.4	3.8	4.5	6	4.0	3.9	7	3.3	8	4	8





DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Bayer

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2421	Jagalene (CC05)	3	2	5	6	0
19-2422	MODI4-5179	6	4	2	4	0
19-2423	NEDI4-5304	3	4	3	5	1



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Bayer

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2421	Jagalene (CC05)	5	1	2	7	1
19-2422	MODI4-5179	4	3	2	7	0
19-2423	NEDI4-5304	3	1	3	6	3



CRUMB GRAIN, DESCRIBED (Small Scale) Bayer

IDCODE	ID	Open	Fine	Dense
19-2421	Jagalene (CC05)	11	3	2
19-2422	MODI4-5179	13	3	0
19-2423	NEDI4-5304	11	5	0

CELL SHAPE, DESCRIBED (Small Scale) Bayer

IDCODE	ID	Round	Irregular	Elongated
19-2421	Jagalene (CC05)	7	5	4
19-2422	MODI4-5179	8	5	3
19-2423	NEDI4-5304	7	5	4



CRUMB TEXTURE, DESCRIBED (Small Scale) Bayer

IDCODE	ID	Harsh	Smooth	Silky
19-2421	Jagalene (CC05)	3	9	4
19-2422	MODI4-5179	9	4	3
19-2423	NEDI4-5304	3	10	3



CRUMB COLOR, DESCRIBED (Small Scale) Bayer

IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
19-2421	Jagalene (CC05)	0	0	4	2	5	5	0
19-2422	MODI4-5179	0	1	2	6	6	1	0
19-2423	NEDI4-5304	0	1	5	3	5	2	0

LOAF WEIGHT, ACTUAL (Small Scale) Bayer Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Р
19-2421	Jagalene (CC05)	144.0	146.2	143.1	134.0	438.5	141.1	139.4	440.7	418	153.8	156.6	489	143.2	454.3	482.2	424.5
19-2422	MODI4-5179	147.6	146.8	142.3	131.7	442.5	143.4	140.7	441.4	418	150.6	155.1	493	144.1	447.3	475.2	413.8
19-2423	NEDI4-5304	146.1	147.8	144.1	137.0	445.0	144.2	138.6	442.6	417	154.8	157.2	489	145.8	454.4	477.4	423.1

LOAF VOLUME, ACTUAL (Small Scale) Bayer Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Ρ
19-2421	Jagalene (CC05)	685	850	860	980	1994	1025	782	2017	2650	910	810	2897	960	2011	2625	2425
19-2422	MODI4-5179	695	785	655	830	2169	865	708	1991	2350	810	735	2839	785	2005	2400	2325
19-2423	NEDI4-5304	750	890	750	1015	2138	993	802	1917	2550	905	850	2839	860	2192	2463	2350



COOPERATOR'S COMMENTS (Small Scale) Bayer

COOP.

19-2421 Jagalene (CC05)

- A. Short mix, very poor loaf volume.
- B. Nice loaf externals.
- C. Meets loaf volume target.
- D. No comment.
- E. Very sticky sponge with good height, good dough during makeup.
- F. High Protein, High Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Sponge did not form well at all, very difficult to work with, some break and shred, loaf collapsed, dark crust color.
- I. Soft dough, short mix, lower volume, open grain, creamy interior.
- J. High absorption, tough dough out of mixer, poor open grain and very yellow crumb, but good volume.
- K. Poor performance for protein in sample.
- L. Very good absorption, low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Poor open grain but high volume.
- P. High absorption, great protein, low mix time and volume, some undesirable dough handling characteristics. Recommend.

COOP.

19-2422 MOD14-5179

- A. Excellent absorption for protein.
- B. Dry?
- C. Does not meet bake absorption target of 62%.
- D. Small loaf, high absorption.
- E. Very sticky sponge with good height, slightly sticky dough during makeup.
- F. Low Protein, Low Water Abs, Short MT, Slight Sticky & Weak Dough, Fine Volume, Dark Yellow Crumb, Open Round Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Some break and shred, loaf collapsed considerably, slightly dark crust color.
- I. Soft dough, short mix, low volume, open grain, slightly dull crumb color, lowest protein in group, squatty loaf.
- J. Low protein flour, very tough dough out of mixer but wet at makeup, very poor open grain, low volume.
- K. Dough shows promise at higher protein, bread performance low but as expected for protein.
- L. Very good absorption, very low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Low protein flour with good absorption, poor open grain.
- P. High absorption, low protein, low mix time and volume, undesirable dough handling and final product characteristics. Do not recommend.

COOP.

19-2423 NED14-5304

- A. Excellent absorption for protein.
- B. Rough break.
- C. No comment.
- D. Poor color.
- E. Sticky yellow sponge, good height of sponge out of fermentation, beige color of dough, good dough at makeup.
- F. High Protein, High Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Yellow Crumb, Slight Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Little break and shred, loaf collapsed considerably, dark crust color.
- I. Good dough out of mixer and at makeup, slightly dull crumb, low volume, open grain.
- J. Very high (71%) absorption, very tough dough out of mixer but good at makeup, very poor open grain and dark yellow crumb but good volume.
- K. Dough shows promise at higher protein, bread performance low but as expected for protein.
- L. Very good absorption, low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption, poor open grain having very yellow crumb.
- P. High absorption, good protein, low mix time, sticky and wet dough handling notes. Recommend.

Notes: E, H, I, L, O and P conducted sponge and dough bake tests

NORTHERN STATES

- 19-2424 19-2425 19-2426 19-2427 19-2428 19-2429
- Jagalene (CC06) NW13493 NE14691 SD14113-3 MTCS1601R MT1683

Description of Test Plots and Breeder Entries

Northern States (NE, MT, SD and ND)

NEBRASKA by Stephen Baenziger

Wheat Quality Samples from Nebraska:

Growing Conditions:

In 2019, we used a multistate grow out system. For Nebraska and for convenience we did our grow out at Lincoln, NE. There were a total of 13 lines (3 per state and the check Jagalene). Before submission, one line per state was dropped. For Nebraska, NW13493 and NE14691 were retained. The grow outs were planted a little later than desired due to rain. The winter was mild and winter killing was minimal. The crop progressed normally during the winter and spring with adequate to above average (especially in May during flowering) rainfall. Due to rainfall, plots not sprayed with fungicides were infected with leaf rust and Fusarium head blight (FHB, syn. scab). To provide a realistic (or worse case) sample, the wheat quality grow-outs were not sprayed with fungicide.

Nama	Courses	Viala	Ductoin	Test Meisht	11	1000 Karrad M/T	Dauli
Name	Source	Yield	Protein	lest weight	Height	1000 Kernel W I	капк
		Bu/a	%	lbs/bu	in	g	
WB4303	Westbred	118.2	13.9	57.5	33.5	42.2	1
LCS Valiant	LCS	111.6	13.8	60.0	37.2	42.8	2
NW13493	UNL	97.6	13.6	59.3	38.8	41.8	7
NHH144913-3	UNL	97.6	13.2	52.0	38.0	32.2	9
Siege	NuPride Genetics	96.1	13.7	60.6	39.5	40.4	11
Scout 66	UNL	58.0	14.9	56.8	46.8	45.0	23
2019 entry							
Before 2019							

Yield of some lines at the grow-out site in Lincoln, NE (Lancaster Country) from the State Variety Trial in 2019 are (note NE14691 was not grown in Lincoln as it is a more western wheat):

Note: Siege (NE12561), LCS Valiant (NE10478-1) and NHH144913-3 were previously tested by the Wheat Quality Council. Data from the 2019 Nebraska Elite Yield Trial having two reps sprayed with fungicide and two reps not sprayed with fungicide are:

	Linc.Int	Linc.	Reduction
	Yield	Yield	Due to Disease
Name	Bu/a	Bu/a	%
	Fungicide	Unsprayed	
NW13493	88.2	76.2	0.14
NH144913-3	71.5	67.5	0.06
NE14691	84.0	72.7	0.13
Ruth	89.3	52.6	0.41
OVERLAND	75.0	70.0	0.07
Valiant	88.0	66.2	0.25
Freeman	77.8	74.7	0.04
Robidoux	92.6	46.1	0.50
SCOUT66	50.2	45.3	0.10
Siege	80.2	71.5	0.11

NW13493: In 2019, NW13493 was tested in parts of the Kansas and in Nebraska State Variety Trials. It has done well across Nebraska in areas to our west based upon data from the USDA regional performance nurseries (SRPN16 and 17). NW13493 (derived from the cross SD98W175-1/NW03666) is a potential new hard white winter wheat. The pedigree of SD98W175-1 is KS84273BB-10/KSSB110-9//KS831374-141B/YE1110/3/KS82W418/SPN and the pedigree of NW03666 is N94S097KS/NE93459. White wheat varieties always have to find a market before they can be released because without a known buyer there is a concern on marketability which puts growers at risk. However, there is little doubt that if NW13493 were a hard red winter wheat, it would be released. It is a very high yielding, early, semi-dwarf with good winterhardiness and disease resistance (leaf [possibly containing Lr34, Lr68, and Lr16], stem [possibly containing Sr38], and stripe rust [possibly containing Yr17]; wheat soilborne mosaic virus). However, it is susceptible to wheat streak mosaic virus, wheat stem sawfly, and Hessian fly. While it has good test weight, it tends to be slightly below average for grain protein content. It seems to be above average for sprouting tolerance among white wheat genotypes. It has very good end-use quality. Note the sample provided from the grow-out was non-sorted to remove red kernels (expected to be about 6%). After sorting, red kernel contaminants were 0.6% or less in our seed increase.

NW13493 is superior to very susceptible FHB lines such as Overley, but inferior to moderately resistant FHB lines such as Overland. In 2019, its average FHB rating in state variety trials was 5.7 on a scale of 1 to 9 where 1 = resistant and 9 = susceptible, and severity in the greenhouse was 64%, indicating it is moderately susceptible.

NE14691: In 2019, NE14691 was tested in the Nebraska State Variety Trials. It has done well across Nebraska and in areas to our north based upon data from the USDA regional performance nurseries (NRPN18 and 19). NE14691 (derived from the cross SD05W138/Camelot) is a potential new hard red wheat. The pedigree of SD05W138 is SD98416/SD98W331. NE14691 is a high yielding, moderately late, semi-dwarf with good disease and pest resistance (leaf [Lr37, Lr11+], stem [possibly containing Sr38], and stripe rust [possibly containing Yr17]; wheat soilborne mosaic virus; and Hessian fly and possibly wheat curl mite). However, it is susceptible to wheat streak mosaic virus, and wheat stem sawfly. It has good test weight and tends to be average for grain protein content. It has good end-use quality.
NE14691 is superior to very susceptible FHB lines such as Overley, but inferior to moderately resistant FHB lines such as Overland. In 2019, its FHB severity was 51%, 56%, and 51% in the greenhouse, NIN, and state variety trial, respectively, indicating it is moderately susceptible.

Jagalene was the quality control line.

Note: Of the lines tested last year, NE10478-1 was released as LCS Valiant and NHH144913-3 is looking for a soft wheat home.

MONTANA by Phil Buckner/Jim Berg

Growing Location & Conditions

The Northern WQC Grow Out, from which the Montana samples were submitted, was planted at the Post Agronomy Farm, west of Bozeman. Strips (6' x 96') were planted on September 22, 2018 into average fall moisture. There was above normal snow cover during winter months and no winterkill was observed. Temperatures from February to August were below average, except for average in April, June and August. The 2019 crop year had slightly above average precipitation. Above average moisture was recorded in April and July, while below average moisture occurred in May and June. Stripe rust, which is often a major factor in yield and test weight reduction, was minimal and late in occurrence. Harvest of all WQC lines, for the 2019 submitted samples, occurred on Aug 30 (see table below).

2019	Bozeman M	IT WQC	Growout ·	- Lines Ha	rvested	
	Pounds	Yield	Test Wt	Heading	Falling	Protein
Entry Name	harvested	bu/a	lb/bu	date	no.	%
		approx.				
Jagalene	82	118	63.3	172	335	12.3
NW13493 NE14691	79 87	103 113	61.6 61.7	171 168	372 343	12.2 12.7
SD14113-3	88	114	61.3	169	340	12.2
MTCS1601R MT1683	85 101	111 131	62.2 61.1	178 179	367 364	12.2 11.8

The Montana Intrastate Winter Wheat Test (varieties and elite lines, planted nearby), which includes Montana lines grown in the WQC drill strips, had yields (average = 129 bu/a, range 103 – 153 bu/a) and test weights (average = 63.0 lb/bu, range 61.1 - 64.7 lb/bu) which were slightly below the 2018 records for Bozeman. Proteins were 12.0% (range 10.7 - 13.8%).

MTCS1601 – a semi-solid stemmed, 2-gene herbicide resistant Clearfield hard red winter wheat line. MTCS1601 is derived from the cross <u>MTS0531</u> /7/ MTS0532 /6/ 96X17E69 /3/ <u>MTCL0309</u> / <u>CDC Teal 11A</u> // MTW01143 /4/ MTCL0510 /5/ MTS0531. MTS0531 (= (L'Govskaya 167 / Rampart /6/ (MT9409, Tiber/5/ (MT8030, TAM W-103/ Froid /4/ Yogo // Turkey Red / Oro /3/ Centurk)), a hard white experimental line with intermediate stem solidness was crossed to a herbicide resistant plant selection. The herbicide resistant trait donors for this cross are MTCL0309 (als1) (= (Tiber /5/ (MT8030, TAM W-103 / Froid /4/ Yogo // Turkey Red / Oro /3/ Centurk), MT9409)*2 /6/ IMI Fidel) and CDC Teal 11A (als2).

MTCS1601 is a high yielding line similar to both Bobcat and SY Clearstone 2CL and higher than Warhorse and Brawl CL Plus. MTCS1601 test weight is high (comparable to Judee and 2lb/bu higher than SY Clearstone 2CL) and has above average protein (similar to Judee). MTCS1601 has above average winter hardiness (similar to Yellowstone and significantly higher than Judee and Brawl CL Plus) in limited testing in eastern Montana. MTCS1601 has medium heading date (similar to Judee, earlier than Loma, Bobcat, Warhorse, and SY Clearstone 2CL and later than

Brawl CL Plus). MTCS1601 is a medium height line, shorter than SY Clearstone and taller than Loma, Bobcat, Warhorse, and Brawl CL Plus. MTCS1601 is moderately susceptible to stem rust and moderately resistant to stripe rust. MTCS1601 had low dwarf bunt % infection in Utah tests.

Stem solidness of MTCS1601, scoring 19 on the 5-25 scale (5 = hollow at all internodes, 25 = completely solid at all internodes), is lower than predominant solid-stem cultivars Judee (21), Loma (21), and Warhorse (22). Cutting of MTCS1601 has been relatively high, significantly greater than Bobcat and Warhorse, but significantly lower than SY Clearstone 2CL. MTCS1601 yield under sawfly pressure (test averages greater than 10% cutting) is greater than Judee, Warhorse, and SY Clearstone 2CL, similar to Brawl CL Plus, and less than Loma and Bobcat.

MTCS1601 is a high PPO line with high flour yield and flour protein in MSU tests. Ash is good and lower than Yellowstone. Mix times are shorter than most Montana varieties. Mixing tolerance is good. Mix and bake absorption is average. Loaf volume is good (similar to Yellowstone).

Currently, no solid-stem 2 gene Clearfield winter wheat cultivars are available in Montana. MTCS1601 was approved for licensed release by the Montana Agricultural Experiment Station in 2019.

<u>MT1683</u> – a medium to late heading, tall (similar to Yellowstone), hollow stemmed hard red winter wheat line the pedigree Yellowstone(L)*2/CDC Buteo. Yellowstone(L) is a low PPO selection from Yellowstone. MT1683 has above average yield, average test weight and protein. Over 31 location-years, yield of MT1683 was similar to high yielding varieties Keldin, Northern, and LCS Jet and higher yielding than Yellowstone and Decade. MT1683 has above average winter hardiness (similar to Decade) in limited testing in eastern Montana. MT1683 has medium-late heading date (0.5d earlier than Yellowstone) and is similar in height to Yellowstone. MT1683 is moderately susceptible to stem rust (Yellowstone is susceptible) and resistant to stripe rust. MT1683 had low dwarf bunt % infection in Utah tests.

MT1683 is a medium PPO line with average flour yield and flour protein, very similar to Yellowstone, in MSU tests. Ash is good and similar to Yellowstone. Mix times are medium-long, similar to most Montana varieties. Mixing tolerance is good. Mix and bake absorption is above average (greater than Yellowstone). Loaf volume is above average and similar to Yellowstone.

NORTH DAKOTA by Frans Gideon

Growing Location & Conditions

The NDSU WQC grow-outs were located at the NDSU Agronomy Seed Farm (ASF) in Casselton, ND, approximately 20 miles west of Fargo. The grow-out strips (4' x 230') were seeded on Sept. 18th, 2018. Moisture was adequate prior to planting and there was approximately 2 inches of rainfall the week following seeding. The fall season in general was cool and wet. The winter brought significant snow amounts (especially in Feb. & Mar.), as well as very cold temperatures at times. There was some plant death on the southern edge of the strips, however we can attribute this to overland flooding during the spring thaw and not necessarily due to cold winter weather. The 2019 growing season was relatively cool and wet compared to previous seasons, especially at harvest. Urea was applied at a rate of 260 lbs/A (120 lbs N) by the ASF on May 17th, 2019. The pesticide, Wolverine Advanced, was sprayed on May 30th at the wheat jointing stage, to control weed growth. The WQC strips were harvested on August 8th and 9th, 2019, and were quite weathered since they were not able to be harvested earlier (rain). Harvest was a challenge in ND in general, due to the consistent rainfall and cool temperatures. Below are the yields, moistures, and test weights for the harvested strips at Casselton.

2019 Cass	elton ND WQ	C Growou	ts - Selected	Lines
Entry Name	Harvest Wt.	Yield	Moisture	Test Wt.
	(lbs)	(bu/A)	(%)	(lb/bu)
Jagalene	72.1	56.9	11.2	53.7
NW13493	93.4	73.7	11.6	58.0
NE14691	85.8	67.7	11.1	55.3
SD14113-3	98.0	77.3	11.4	57.2
MTCS1601R	56.6	44.7	12.2	55.3
MT1683	66.3	52.3	11.0	51.5

SOUTH DAKOTA by Sunish Sehgal

Growing Location and Conditions: A total of 12 entries were evaluated under the 2019 Northern Wheat Quality Council (WQC) grow outs. At Brookings, SD all entries and Jagalene (check) were timely planted on September 23, 2018, as 200' long and 5' wide strips (7-rows) in oat stubble (no-till). A starter fertilizer 10-34-0 (10 gal/ac) was applied at seeding. All entries had uniform emergence and good growth going into winter. No visible winter kill was observed. In spring, 28-0-0 (42 gal/acre) fertilizer was stream-bar applied at Feekes 5-6 and the strips were also sprayed with 13 oz Bromac + 13 oz Puma. The heading was delayed by 2-3 days due to the cooler spring season. Leaf rust and FHB were observed in the trial and the entries were sprayed with Prosaro at anthesis. Several rain events further delayed the harvest and the grow outs were harvested on August 6th, 2019. The grain protein content ranged from 11.5% to 15.1% and the test weight ranged from 46.6 lb/bu -59.2 lb/bu among the 13 entries.

SD14113-3

SD14113-3 was developed from the cross T154/SD06069 and has medium height and medium maturity, similar to Wesley. It has very good winter hardiness and straw strength. SD14113-3 has demonstrated an excellent yield potential (ranked 2^{nd}) in the 2018 and 2019 USDA Northern Regional Performance Nursery. In South Dakota Crop Performance Trials across 41 environments over 3 years, SD14113-3 ranked 3^{rd} in central SD and 1^{st} in western SD locations. It has moderate test weight and protein concentration. SD14113-3 is moderately resistant to resistant to soil-borne mosaic virus and shows an intermediate response to FHB, stripe, and leaf rust. Marker data indicated it possibly has *Lr46*, however, gene postulation has suggested *Lr14a*.

SD14113-3 showed an overall acceptable milling and baking qualities. Across multiple trial locations (2016-2018), its milling quality parameters (average flour yield 68.3 %) and baking quality parameters (average loaf volume 960 cm³ and specific volume 6.4 cc/g) were comparable to Alice (average flour yield 69.0%, average loaf volume 975 cm³, and specific volume 6.5 cc/g) and Lyman (average flour yield 68.1%, average loaf volume 959 cm³, and specific loaf volume 6.3 cc/g) and better than Overland (average flour yield 68.4%, average loaf volume 868 cm³, and specific volume 5.8 cc/g).

		2019			2-year			3-year	
Variety	Yield (bu/a)	Test Wt (Ibs)	Protein %	Yield (bu/a)	Test Wt (Ibs)	Protein %	Yield (bu/a)	Test Wt (Ibs)	Protein %
Draper (SD14113-3)	64.0	56.5	13.1	63.1	57.2	13.0	57.2	58.0	13.1
Keldin	62.2	55.9	12.7	64.8	56.5	12.7	56.0	57.5	13.1
Ideal	60.9	55.5	12.5	61.3	56.6	12.7	55.8	57.7	13.0
SY Monument	61.0	53.9	12.5	61.7	55.2	12.6	54.8	56.7	12.7
Winner	66.7	55.8	12.9	59.7	56.4	13.1	54.4	57.6	13.3
Cowboy	57.5	54.8	12.3	61.7	56.6	12.1	54.1	57.7	12.3
SY Wolf	56.0	53.3	13.2	58.4	55.3	13.2	53.7	57.1	13.3
Redfield	62.8	56.1	12.9	62.6	57.4	12.9	53.5	58.2	13.2
Trial Average	57.7	55.5	12.8	58.7	56.5	12.9	52.3	57.7	13.1
LSD(0.05)	4.0	1.4	0.8	2.7	1.0	0.4	2.5	0.7	0.4
C.V.%	9.9	3.5	8.3	9.7	3.5	7.0	12.2	2.9	7.2

Table 1. Yield, test weight, and grain protein content of some of the lines tested in South Dakota winter wheat variety performance trial (western South Dakota, 2017-2019).

N=39; Location x years = 13; varieties ranking in the top 1/3 of each trial category are shaded.

Northern States: 2019 (Small-Scale) Samples

Test entry number	19-2424	19-2425	19-2426
Sample identification	Jagalene (CC06)	NW13493	NE14691
	Wheat Data		
GIPSA classification	3 HRW	2 HDWH	3 HRW
Test weight (lb/bu)	56.1	60.1	58.0
Hectoliter weight (kg/hl)	73.9	79.1	76.4
1000 kernel weight (gm)	27.7	30.7	32.5
Wheat kernel size (Rotap)			- / -
Over 7 wire (%)	50.7	54.4	74.7
Over 9 wire (%)	47.2	44.0	25.2
Single kernel (%)	Z. I	1.7	0.2
Hardness (avg /s.d) Weight (mg) (avg/s.d) Diameter (mm)(avg/s.d) Moisture (%) (avg/s.d) SKCS distribution Classification	57.9/21.8 27.7/11.7 2.44/0.42 11.2/0.5 14-15-23-48-03 Mixed	58.6/15.9 30.7/9.9 2.53/0.35 11.1/0.4 06-16-27-51-01 Hard	61.8/17.6 32.5/10.9 2.66/0.38 11.0/0.4 05-14-24-57-01 Hard
Wheat protein (12% mb) Wheat ash (12% mb)	12.9 1.81	13.1 1.69	13.7 1.72
Milling	and Flour Qua	lity Data	
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	74.4 65.5	73.7 65.4	75.2 65.8
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.1 11.6 0.65	12.4 11.6 0.59	11.9 12.2 0.58
Rapid Visco-Analyser Peak time (min) Peak viscosity (RVU) Breakdown (RVU) Final viscosity at 13 min (RVU)	6.1 202.8 78.2 245.7	6.3 209.8 69.7 259.3	6.2 188.6 62.2 238.2
Minolta color meter L* a* b*	90.04 -1.21 9.68	91.14 -1.33 8.80	90.73 -0.99 7.67
РРО	0.435	0.570	0.445
Falling number (sec)	402	418	411
Damaged Starch (AI%) (AACC76-31)	98.5 8.3	98.1 8.0	97.7 7.6

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Northern States: 2019 (Small-Scale) Samples (continued)

Test entry number	19-2427	19-2428	19-2429
Sample identification	SD14113-3	MTCS1601R	MT1683
	Wheat Data		
GIPSA classification	2 HRW	3 HRW	5 HRW
Test weight (lb/bu)	58.5	57.8	52.5
Hectoliter weight (kg/hl)	77.0	76.1	69.2
1000 kernel weight (gm)	26.9	31.4	31.5
Wheat kernel size (Rotap)			
Over 7 wire (%)	44.4	46.5	62.4
Over 9 Wire (%)	52.9	51.9	36.4
Single kernel (skes) ^a	2.0	1.0	1.4
Hardness (avg /s.d) Weight (mg) (avg/s.d) Diameter (mm)(avg/s.d) Moisture (%) (avg/s.d) SKCS distribution Classification	54.5/19.8 26.9/10.9 2.31/0.36 11.2/0.5 12-22-27-39-03 Mixed	57.7/19.1 31.4/11.9 2.47/0.34 11.0/0.5 10-16-28-46-01 Hard	62.3/17.6 31.5/12.0 2.54/0.41 11.5/0.4 06-11-22-61-01 Hard
Wheat protein (12% mb) Wheat ash (12% mb)	12.9 1.82	14.0 1.80	13.4 1.76
Milling	g and Flour Qua	lity Data	1
Miag Multomat Mill Quadrumat Sr. Mill	75.0 67.1	74.9 66.4	71.4 63.2
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.3 11.7 0.62	12.3 12.8 0.62	11.8 12.4 0.60
Rapid Visco-Analyser			
Peak time (min)	6.1	6.2	6.3
Peak viscosity (RVU)	189.7	198.3	212.4
Breakdown (RVU) Final viscosity at 13 min (RVU)	226.9	250.4	249.6
Minolta color meter	220.0	200.1	210.0
L*	90.81	90.43	90.41
a*	-1.27	-1.44	-1.36
b*	8.51	9.82	9.53
PPO	0.555	0.799	0.508
Falling number (sec)	393	385	416
Damaged Starch			
(AI%) (AACC76-31)	97.6 7.6	98.0 7.9	98.1 8.0

^as.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Test Entry Number	10 2424	40 2425	40.2426
Test Entry Number	19-2424	19-2425	19-2420
Sample Identification	Jagalene (CC06)	NW13493	NE14691
	MIXOGRAPH		
Flour Abs (% as-is)	68.5	67.9	69.6
Flour Abs (14% mb)	66.6	66.3	67.3
Mix Time (min)	3.9	4.9	3.5
Mix tolerance (0-6)	4	5	3
	FARINOGRAPI	4	
Flour Abs (% as-is)	66.8	65.4	66.3
Flour Abs (14% mb)	64.9	63.8	64.0
Peak time (min)	5.8	6.1	6.2
Mix stability (min)	9.3	11.0	8.8
Mix Tolerance Index (FU)	25	22	29
Breakdown time (min)	11.4	13.1	11.2
	ALVEOGRAPH	1	
P(mm): Tenacity	108	105	91
L(mm): Extensibility	89	106	110
G(mm): Swelling index	21.0	22.9	23.3
W(10 ⁻⁴ J): strength (curve area)	321	369	303
P/L: curve configuration ratio	1.21	0.99	0.83
le(P ₂₀₀ /P): elasticity index	55.4	58.4	53.9
	EXTENSIGRAP	Η	
Resist (BU at 45/90/135 min)	311/371/360	352/429/443	262/278/276
Extensibility (mm at 45/90/135 min)	159/155/146	167/171/160	166/190/182
Energy (cm ² at 45/90/135 min)	92/106/97	116/148/143	82/113/96
Resist _{max} (BU at 45/90/135min)	437/525/530	529/678/719	370/454/395
Ratio (at 45/90/135 min)	2.0/2.4/2.5	2.1/2.5/2.8	1.6/1.5/1.5
F	ROTEIN ANALY	SIS	
HMW-GS Composition	1,2*, 17+18/7+9, 5+10	1, 7+9, 5+10	2*, 7+9, 5+10
PP/MP	1.01	1.00	0.93
SE	DIMENTATION 1	ſEST	
Volume (ml)	57.9	59.1	57.7

Northern States: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples

Test Entry Nu	Imber	19-2427	19-24	428	19-2429
Sample Identif	ication	SD14113-3	MTCS	601R	MT1683
	MIX	OGRAPH			
Flour Abs (% a	as-is)	68.1	69.	5	69.4
Flour Abs (14%	່ mb)	66.4	67.	8	67.2
Mix Time (m	in)	2.6	3.4	4	4.5
Mix tolerance	(0-6)	1	3		4
	FAR	INOGRAPI	4		
Flour Abs (% a	as-is)	63.8	66.	9	67.0
Flour Abs (14%	ն mb)	62.1	65.	3	64.7
Peak time (m	nin)	4.5	6.3	3	5.4
Mix stability (r	min)	4.3	8.	1	8.7
Mix Tolerance Inc	lex (FU)	49	33	;	28
Breakdown time	e (min)	7.2	11.1		
	ALV	EOGRAPH			
P(mm): Tena	city	64	11	5	107
L(mm): Extens	ibility	126	10	3	95
G(mm): Swelling	j index	25.0	22.	6	21.7
W(10 ⁻⁴ J): strength (d	curve area)	196	36	3	346
P/L: curve configura	ation ratio	0.51	1.1	2	1.13
le(P ₂₀₀ /P): elastici	ty index	44.8	54.	1	57.7
	EXTE	NSIGRAP	Η		
Resist (BU at 45/90	/135 min)	173/205/232	290/35	1/389	388/440/455
Extensibility (mm at 45/	/90/135 min)	185/174/188	167/16	0/157	171/157/159
Energy (cm ² at 45/9	0/135 min)	61/67/83	91/110)/114	137/136/134
Resist _{max} (BU at 45/	90/135min)	227/273/319	403/53	2/544	619/697/655
Ratio (at 45/90/1	35 min)	0.9/1.2/1.2	1.7/2.2	2/2.5	2.3/2.8/2.9
	PROTE	IN ANALY	SIS		
HMW-GS Comp	osition	2*, 6+8, 3+12	2*, 7+8,	, 5+10	1, 7+8, 5+10
PP/MP		0.93	1.0	2	0.96
	SEDIME	NTATION 1	EST		
Volume (m	I)	46.7	64.	9	67.5

Northern States: Physical Dough Tests and Gluten Analysis 2019 (Small-Scale) Samples (continued)



19-2424

Farinograms

Water abs = 64.9%, Peak time = 5.8 min, Mix stab = 9.3 min, MTI = 25 FU

Mix time $= 3.9 \min$

19-2424, Jagalene (CC06)





19-2425, NW13493



Mixograms



Physical Dough Tests 2019 (Small Scale) Samples – Northern States

19-2426

Farinograms

Pin 19-2426 Fairogen

Water abs = 64.0%, Peak time = 6.2 min, Mix stab = 8.8 min, MTI = 29 FU Water abs = 67.3%Mix time = 3.5 min

Mixograms









Water abs = 66.4% Mix time = 2.6 min

19-2427, SD14113-3



Farinograms

Mixograms



Water abs = 65.3%, Peak time = 6.3 min, Mix stab = 8.1 min, MTI = 33 FU

Water abs = 67.8%Mix time = 3.4 min







Water abs = 67.2% Mix time = 4.5 min



Physical Dough Tests - Alveograph 2019 (Small Scale) Samples – Northern States



19-2424, Jagalene (CC06) $P(mm H_20) = 108, L(mm) = 89, W(10E^{-4} J) = 321$

19-2425, NW13493 P(mm H₂0) =105, L(mm) = 106, W(10E⁻⁴ J) = 368



19-2426, NE14691 $P(mm H_20) = 91, L(mm) = 110, W(10E^{-4} J) = 303$

Physical Dough Tests - Alveograph 2019 (Small Scale) Samples - Northern States



 $P(mm H_20) = 61, L(mm) = 126, W(10E^{-4} J) = 196$

 $P(mm H_20) = 115, L(mm) = 103, W(10E^{-4} J) = 363$



19-2429, MT1683 $P(mm H_20) = 107, L(mm) = 95, W(10E^{-4} J) = 346$

Physical Dough Tests - Extensigraph

2019 (Small Scale) Samples – Northern States





Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigraph

2019 (Small Scale) Samples – Northern States





Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm²) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Northern States: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2424	7290	132	4357	0.450	2.154	11.221	1.730	=16.80
2425	6813	140	4007	0.449	2.148	1.103	1.805	-8.95



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2426	6905	139	3859	0.456	2.270	0.963	1.760	-8.30
2427	6984	137	4220	0.446	2.218	0.652	1.740	-13.35

Northern States: C-Cell Bread Images and Analysis 2019 (Small-Scale) Samples



Entry #	Slice Area (mm ²)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non- uniformity	Avg. Cell Elongation	Cell Angle to Vertical (⁰)
2428	6629	133	3755	0.453	2.236	1.119	1.795	-8.65
2429	7229	133	4236	0.448	2.129	0.926	1.760	-14.45



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Northern States Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2424	Jagalene (CC06)	67	68.1	63.4	70.3	64.9	66.1	66.5	68.5	58	67.8	64.9	64	66.6	64.1	58.1	66.9
19-2425	NW13493	67	67.5	63.3	66.6	63.8	65.1	66.2	66.7	58	66.1	68.2	63	66.3	62.9	59.4	65.8
19-2426	NE14691	66	67.6	64.2	71.0	64.0	64.1	67.1	68.7	58	67.4	63.8	64	67.3	65.0	58.7	66.0
19-2427	SD14113-3	64	65.5	63.3	68.1	62.1	64.0	66.3	65.9	58	65.0	65.2	62	66.4	62.2	56.3	64.1
19-2428	MTCS1601R	66	68.4	65.1	68.2	65.3	66.6	67.8	68.8	59	70.0	70.2	65	67.8	65.3	61.3	67.3
19-2429	MT1683	69	67.8	64.6	70.8	64.7	66.6	67.2	68.8	58	67.5	69.0	64	67.2	64.6	60.8	66.7

BAKE MIX TIME, ACTUAL (Small Scale) Northern States Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	I	J	к	L	М	Ν	0	Ρ
19-2424	Jagalene (CC06)	3.4	4.3	3.5	5.0	7	6.5	3.9	4.5	4	5.0	5.5	8	3.4	8	4	8
19-2425	NW13493	4.0	4.5	5.0	5.0	14	8.9	4.9	4.5	6	6.5	5.8	14	4.4	8	5	18
19-2426	NE14691	3.1	3.5	3.3	3.5	9	5.5	3.5	4.5	3	4.3	4.4	8	3.0	8	4	8
19-2427	SD14113-3	2.3	2.8	2.3	3.0	5	3.7	2.6	4.0	3	3.0	3.3	5	2.1	8	4	8
19-2428	MTCS1601R	3.0	3.5	3.3	4.5	14	4.9	3.4	4.5	4	4.3	2.9	7	2.9	8	5	12
19-2429	MT1683	3.9	4.5	4.3	6.5	13	8.0	5.0	6.0	6	7.3	5.7	10	4.0	8	6	20





DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Northern States

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2424	Jagalene (CC06)	3	4	3	5	1
19-2425	NW13493	3	2	3	7	1
19-2426	NE14691	4	3	1	7	1
19-2427	SD14113-3	5	4	1	5	1
19-2428	MTCS1601R	3	0	2	10	1
19-2429	MT1683	2	2	3	8	1



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Northern States

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2424	Jagalene (CC06)	8	1	1	4	2
19-2425	NW13493	2	2	3	9	0
19-2426	NE14691	4	4	0	6	2
19-2427	SD14113-3	8	3	1	3	1
19-2428	MTCS1601R	4	2	0	8	2
19-2429	MT1683	1	2	2	7	4



CRUMB GRAIN, DESCRIBED (Small Scale) Northern States

IDCODE	ID	Open	Fine	Dense
19-2424	Jagalene (CC06)	11	4	1
19-2425	NW13493	4	10	2
19-2426	NE14691	8	7	1
19-2427	SD14113-3	8	3	5
19-2428	MTCS1601R	8	7	1
19-2429	MT1683	8	7	1

CELL SHAPE, DESCRIBED (Small Scale) Northern States

IDCODE	ID	Round	Irregular	Elongated
19-2424	Jagalene (CC06)	6	5	5
19-2425	NW13493	3	7	6
19-2426	NE14691	5	5	6
19-2427	SD14113-3	8	5	3
19-2428	MTCS1601R	5	5	6
19-2429	MT1683	6	4	6



CRUMB TEXTURE, DESCRIBED (Small Scale) Northern States

IDCODE	ID	Harsh	Smooth	Silky
19-2424	Jagalene (CC06)	5	8	3
19-2425	NW13493	3	11	2
19-2426	NE14691	3	10	3
19-2427	SD14113-3	8	5	3
19-2428	MTCS1601R	3	9	4
19-2429	MT1683	3	10	3



CRUMB COLOR, DESCRIBED (Small Scale) Northern States

IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
19-2424	Jagalene (CC06)	0	1	6	7	1	1	0
19-2425	NW13493	0	0	3	4	4	4	1
19-2426	NE14691	0	0	1	1	8	5	1
19-2427	SD14113-3	1	2	3	8	1	1	0
19-2428	MTCS1601R	0	1	4	7	4	0	0
19-2429	MT1683	0	0	2	9	5	0	0

LOAF WEIGHT, ACTUAL (Small Scale) Northern States Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Р
19-2424	Jagalene (CC06)	144.8	145.3	143.1	129.5	444.0	138.5	137.4	444.4	413	151.6	153.8	482	142.2	459.3	483.6	430.5
19-2425	NW13493	147.8	145.6	142.5	131.1	461.0	136.9	138.6	445.2	414	150.9	156.5	485	143.1	465.0	484.7	433.1
19-2426	NE14691	142.8	146.1	144.1	129.2	444.5	141.8	138.4	439.9	412	151.2	155.1	486	143.0	459.5	479.5	430.6
19-2427	SD14113-3	148.2	144.9	145.4	131.1	441.0	140.8	140.2	446.0	412	150.2	158.0	489	142.8	464.3	483.6	437.1
19-2428	MTCS1601R	146.0	147.8	144.9	128.3	448.0	141.9	138.4	444.1	413	154.3	159.7	487	143.4	462.6	476.1	436.0
19-2429	MT1683	145.9	147.2	144.8	131.1	451.0	139.7	137.8	445.9	410	149.0	154.6	490	143.8	463.7	479.9	432.4

LOAF VOLUME, ACTUAL (Small Scale) Northern States Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2424	Jagalene (CC06)	880	925	840	1025	2470	1050	906	2475	2850	970	848	2986	890	2374	2538	2475
19-2425	NW13493	870	860	765	985	1840	1040	898	2317	2875	975	978	2927	855	2436	2363	2700
19-2426	NE14691	855	850	730	975	2238	1050	875	2333	2800	975	930	2868	935	2341	2463	2475
19-2427	SD14113-3	730	795	720	950	2301	1050	860	2358	2750	975	845	2927	940	2196	2363	2400
19-2428	MTCS1601R	890	910	910	900	2154	1015	907	2317	2750	970	988	2927	965	2504	2563	2600
19-2429	MT1683	855	915	895	1040	2235	1050	919	2288	3000	1025	940	2897	925	2484	2575	2425



COOPERATOR'S COMMENTS (Small Scale) Northern States

COOP.

19-2424 Jagalene (CC06)

- A. No comment.
- B. Nice loaf externals.
- C. Close to meeting loaf volume target, good crumb and color.
- D. No comment.
- E. Sticky beige sponge, dough was sticky out of mixer, extensible during makeup.
- F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Dull Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Break and shred, dark crust color, overall good loaf structure.
- I. Sticky sponge, short mix time, soft dough, average volume, dull color.
- J. High absorption, good grain, high volume.
- K. Poor performance for protein in sample.
- L. Good absorption, slightly low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Lower absorption but having wet doughs, average grain with very yellow crumb, average volume.
- P. Good protein and high absorption, low mix time, sticky and wet dough handling notes, unfavorable final product characteristics. Do not recommend.

COOP.

19-2425 NW13493

- A. No comment.
- B. Nice loaf externals.
- C. No comment.
- D. No comment.
- E. Good sponge, slightly white in color, dry in bowl during mixing, dough was very stiff and tough, proofed for 80 minutes and did not come up to template.
- F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
- G. No comment.
- H. Some collapse of loaf on one side, good crust color, overall good loaf structure.
- I. Good dough, average loaf volume, very creamy and slightly dull color, open grain.
- J. Long mix time and high tolerance, high absorption, tough dough out of mixer, good grain, high volume.
- K. Good dough strength and volume performance.
- L. Good absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Average grain and low volume.
- P. Higher protein, absorption, mix time and volume; good quality final product. Recommend.

19-2426 NE14691

COOP.

- A. No comment.
- B. No comment.
- C. No comment.
- D. No comment.
- E. Slightly sticky sponge with good height.
- F. High Protein, High Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Creamy Crumb, Slight Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Very good break and shred, good loaf structure.
- I. Sticky sponge, very short mix for protein, weak dough.
- J. High absorption, average grain, creamy crumb, high volume.
- K. Bread performed as expected for protein level, dough somewhat weak mix tolerance.
- L. Good absorption, slightly low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Wet sticky dough, average grain with creamy crumb.
- P. Higher protein and absorption, low mix time and volume.

COOP. 19-2427 SD14113-3

- A. Short mix, very poor color and loaf volume.
- B. No comment.
- C. Bad at 1st punch.
- D. Short mixer, average loaf volume.
- E. Good sponge with good height, extensible out of mixer.
- F. High Protein, High Water Abs, Short MT, Slight Sticky & Weak Dough, Very High Volume, Dark Yellow Crumb, Open Irregular Cells, Resilient & Slight Harsh Texture.
- G. No comment.
- H. Minimal break and shred, very slight loaf collapse, overall good loaf structure.
- I. Sticky sponge, very short mix for protein, weak dough, squatty loaf, slightly dull color.
- J. Low tolerance for mixing, good absorption, average grain, high volume.
- K. Bread performed lower than expected for protein level, dough somewhat weak.
- L. Good absorption, very low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Very low absorption but having good dough character, poor dense grain, low volume.
- P. Higher protein and absorption, low mix time and volume, unfavorable final product.

19-2428 MTCS1601R

COOP.

- A. Very good protein.
- B. Nice loaf externals.
- C. Meets loaf volume target.
- D. No comment.
- E. Good sponge with good height, extensible out of mixer.
- F. Very High Protein, Very High Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Slight Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Collapsed loaf with some break and shred.
- I. Good out of mixer but short mix for protein, good volume, slightly dull crumb color.
- J. Very high (70%) absorption, average grain and very yellow crumb, high volume.
- K. Short mix time but overall good dough strength and good bread performance.
- L. Very good absorption, low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption, poor open grain, good volume.
- P. Higher protein and absorption, good mix time and dough notes, favorable final product. Recommend.

COOP.

19-2429 MT1683

- A. No comment.
- B. No comment.
- C. Meets loaf volume target.
- D. Good bread characteristics overall.
- E. Good sponge with good height, could have used more mix, slightly elastic out of mixer.
- F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Dull Crumb, Slight Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Slightly dark crust color, some break and shred, some collapse of loaf.
- I. Good out of mixer but short mix for protein, good volume, open grain, creamy interior.
- J. Long mix time, high absorption, tough dough, fine grain and creamy crumb, very high volume.
- K. Average performance.
- L. Good absorption, slightly low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Average mix time and good absorption, average grain, good volume.
- P. Higher absorption, protein and mix time; lower volume might be due to overall elasticity of the dough.

Notes: E, H, I, L, O and P conducted sponge and dough bake tests

MICRO-QUALITY ANALYSIS

1. SKCS SINGLE KERNEL INFORMATION

A. Kernel Hardness

SKCS Wheat Kernel Hardness												
	LOCATIONS											
Sample ID	NE	MT	ND	SD	Avg	Std						
Jagalene	60.3	63.7	61.4	61.1	61.6	1.46						
NW13493	58.9	67.9	54.9	57.6	59.8	5.64						
NE14691	66.7	70.4	59.1	52.1	62.1	8.15						
SD14113-3	58.8	59.7	55.0	70.9	61.1	6.84						
MTCS1601 R	54.0	60.6	59.2		57.9	3.48						
MT1683	60.4	63.3	69.3	60.4	63.4	4.20						
Avg.	59.9	64.3	59.8	60.4								
Std	4.09	4.16	5.30	6.85								



B. Kernel Weight (mg)

SKCS Wheat Kernel Weight (mg)											
		1004	TIONS								
Sample ID	NE	Avg	Std								
Jagalene	25.5	35.0	26.1	32.9	29.9	4.79					
NW13493	26.5	33.6	26.8	32.6	29.9	3.75					
NE14691	31.1	39.7	30.9	35.7	34.4	4.20					
SD14113-3	24.8	32.2	27.0	33.0	29.3	3.98					
MTCS1601 R	26.9	37.8	29.3		31.3	5.73					
MT1683	24.3	39.6	27.1	28.5	29.9	6.71					
Avg.	26.5	36.3	27.9	32.5							
Std	2.45	3.18	1.84	2.58							


C. Kernel Size

	SKC	S Wheat	Kernel S	Size (mm	ı)					
		LOCA	TIONS							
Sample ID	ample ID NE MT ND SD									
Jagalene	2.32	2.68	2.42	2.74	2.54	0.20				
NW13493	2.36	2.67	2.39	2.66	2.52	0.17				
NE14691	2.65	2.94	2.66	2.83	2.77	0.14				
SD14113-3	2.27	2.50	2.43	2.71	2.48	0.18				
MTCS1601 R	2.25	2.69	2.48		2.47	0.22				
MT1683	2.29	2.69	2.50	2.49	2.49	0.16				
Avg.	2.36	2.70	2.48	2.69						
Std	0.15	0.14	0.10	0.13						



2. Protein Content

A. Wheat Protein

	Whea	t Protei	n Conter	nt (12%n	nb)	
Sample ID	NE	MT	SD	Avg	Std	
Jagalene	12.7	13.1	13.8	13.7	13.3	0.52
NW13493	13.9	12.0	13.4	13.5	13.2	0.83
NE14691	14.0	13.0	13.7	12.2	13.2	0.80
SD14113-3	13.2	12.6	12.9	13.0	12.9	0.25
MTCS1601 R	14.4	12.5	15.2		14.0	1.39
MT1683	14.3	12.9	13.9	13.5	13.7	0.60
Avg.	13.8	12.7	13.8	13.2		
Std	0.7	0.4	0.8	0.6		



B. Flour Protein

	Flo	ur Protei	in Conte	nt (14%)							
	LOCATIONS										
Sample ID	NE	Avg	Std								
Jagalene	11.3	11.7	12.2	12.3	11.9	0.46					
NW13493	12.0	10.4	11.9	11.6	11.5	0.74					
NE14691	12.0	11.6	12.1	10.5	11.6	0.73					
SD14113-3	11.9	11.4	11.7	11.7	11.7	0.21					
MTCS1601 R	13.0	11.3	13.5		12.6	1.15					
MT1683	12.6	11.4	12.5	11.8	12.1	0.57					
Avg.	12.1	11.3	12.3	11.6							
Std	0.59	0.46	0.64	0.66							



3. Mixograph Test Information

A. Mixograph Water Absorption

N	Лixogra	oh Wate	r Absorp	tion (14	%mb)	
Sample ID	NE	Avg	Std			
Jagalene	62.2	64.1	65.0	65.2	64.1	1.37
NW13493	65.3	63.6	65.1	64.4	64.6	0.77
NE14691	63.7	64.9	64.8	60.9	63.6	1.86
SD14113-3	64.0	63.8	63.5	64.1	63.9	0.26
MTCS1601 R	64.2	63.9	65.9		64.7	1.08
MT1683	64.5	64.3	65.4	63.5	64.4	0.78
Avg.	64.0	64.1	65.0	63.6		
Std	1.03	0.46	0.81	1.64		



B. Mixograph Mix Time

	Mi	xograph	Mix Tin	ne (min)							
		LOCA	TIONS								
Sample ID	Sample ID NE MT ND SD										
Jagalene	4.0	3.8	6.8	7.3	5.5	1.83					
NW13493	5.8	4.5	10.8	13.3	8.6	4.15					
NE14691	3.9	3.5	6.3	7.9	5.4	2.08					
SD14113-3	2.5	2.3	4.0	3.0	3.0	0.76					
MTCS1601 R	3.0	3.0	4.3		3.4	0.75					
MT1683	6.5	5.8	11.6	12.6	9.1	3.47					
Avg.	4.3	3.8	7.3	8.8							
Std	1.57	1.22	3.22	4.22							



C. Mixograph Mix Tolerance

	М	ixograpł	n Mix To	lerance							
	LOCATIONS										
Sample ID	Sample ID NE MT ND SD										
Jagalene	3.0	2.0	4.0	3.0	3.0	0.82					
NW13493	3.0	4.0	5.0	4.0	4.0	0.82					
NE14691	2.0	2.0	5.0	2.0	2.8	1.50					
SD14113-3	1.0	1.0	2.0	2.0	1.5	0.58					
MTCS1601 R	3.0	2.0	4.0		3.0	1.00					
MT1683	4.0	4.0	6.0	3.0	4.3	1.26					
Avg.	2.7	2.5	4.3	2.8							
Std	1.03	1.22	1.37	0.84							



4. FALLING NUMBER TEST

	Falli	ng Numb	oer on M	eals (se	c)						
Sample ID	Sample ID NE MT ND SD										
Jagalene	380	352	409	378	380	23					
NW13493	439	372	396	390	399	28					
NE14691	405	379	405	381	393	14					
SD14113-3	361	375	366	383	371	10					
MTCS1601 R	380	374	449		401	42					
MT1683	436	377	403	320	384	49					
Avg.	400	372	405	370							
Std	32	10	27	29							



5. SEDIMENTATION TEST

	Sedim	nentatio	n Test (1	.4%mb, ı	ml)						
	LOCATIONS										
Sample ID	NE	Avg	Std								
Jagalene	39.0	62.2	66.2	62.0	57.4	12.4					
NW13493	54.6	62.2	69.2	58.6	61.2	6.2					
NE14691	44.2	67.2	67.2	40.3	54.7	14.5					
SD14113-3	38.0	45.2	52.6	55.2	47.8	7.8					
MTCS1601 R	52.1	61.1	70.1		61.1	9.0					
MT1683	66.7	71.5	71.2	64.9	68.6	3.3					
Avg.	49.1	61.6	66.1	56.2							
Std	10.9	8.9	6.9	9.6							



JAGALENE CHECK

- Jagalene (CC01)
- **Jagalene (CC02)**
- Jagalene (CC03)
- **Jagalene (CC04)**
- **Jagalene (CC05)**
- **Jagalene (CC06)**

- 19-2402 19-2409 19-2415 19-2417
- 19-2421
- 19-2424

End-use Quality of the **Common Check**

Jagalene Check – Jagalene

General Information

A Hard Red Winter Wheat variety, Jagalene, was selected as a common check for each of breeding programs in 2019. Six breeding programs submitted the common check with their breeding lines for WQC baking evaluation. They were:

19-2402	Jagalene (CC01)	Colorado
19-2409	Jagalene (CC02)	Oklahoma
19-2415	Jagalene (CC03)	Limagrain
19-2417	Jagalene (CC04)	Kansas-Hays
19-2421	Jagalene (CC05)	Bayer
19-2424	Jagalene (CC06)	Northern States

In order to facilitate relational database output of statistical data in the same manner as breeding lines contained with the WQC annual report, the common checks were treated as a breeding program for baking data analysis and their comparisons in order to see how different they are in terms of baking performance quality characteristics.

Entry No.	19-2402	19-2409	19-2415	19-2417	19-2421	19-2424
Breeding Programs	Colorado	Oklahoma	Limagrain	Kansas-Hays	Bayer	North States
Wheat Protein (12%mb)	14.1	13.2	10.8	12.7	12.6	12.9
Flour Protein (14%mb)	13.0	11.9	9.7	11.5	11.4	11.6
Flour Ash (14%mb)	0.54	0.56	0.59	0.61	0.52	0.65
PP/MP*	0.95	1.03	1.03	1.01	0.98	1.01
Sedimentation (ml 14%mc)	65.1	47.7	39.8	57.0	50.6	57.9
Mixograph Abs (14%mb)	67.1	65.3	63.6	67.6	68.0	66.6
Mix Time (min)	3.0	4.4	4.8	4.4	3.0	3.9
Tolerance	2	3	4	4	2	4
Farinograph Abs (14%mb)	65.4	61.7	64.0	65.0	69.8	64.9
Peak time (min)	7.2	5.0	5.1	5.9	5.3	5.8
Stability (min)	10.3	12.3	12.7	11.2	6.5	9.3
MTI (FU)	27	16	7	24	39	25
Bake Abs (14%mb)	67.0	65.1	64.1	67.1	67.2	66.7
Bake Mix Time (min)	3.5	4.7	4.9	5.0	3.2	4.5
Loaf Volume (cc)	946	952	780	912	874	926
Crumb Color Rating (0-5)	3.4	3.5	3.1	2.8	3.5	2.8
Crumb Grain Rating (0-5)	3.5	3.8	3.3	3.6	3.2	3.4
Crumb Texture Rating (0-5)	4.0	3.8	3.7	3.6	3.3	3.4
Over All Bake Performance	4.0	4.1	2.8	4.1	3.5	3.8

Wheat and Flour Quality Characteristics of the Common Checks

Bake data average based on 9 cooperators' pup loaf straight grade dough method

¹ CC = Common Check.

* PP/MP= total polymeric protein/total monomeric protein.

⁺ The bake data is an average on 7 cooperators who conducted pup-loaf straight dough bake tests.

Brief Conclusions

Six of 16 cooperators conducted the sponge-and-dough baking test and didn't find any statistically significant differences in the sponge dough characteristics. Bake absorption, bake mix time, and mixing tolerance of the common checks showed significant difference based on data from 16 cooperators while the crumb grain and crumb didn't show such significant difference at the 5% level of significance. However, other baking performance quality characteristics such as crumb color, loaf volume and overall baking quality evaluated by the cooperators were found to be significantly different (at the 0.5% level) among the common checks.



BAKE ABSORPTION, ACTUAL (14% MB) (Small Scale) Jagalene Checks Cooperators A – P

IDCODE	ID	Α	В	С	D	Е	F	G	н	Т	J	к	L	М	Ν	0	Р
19-2402	Jagalene (CC01)	67	66.7	65.7	67.8	65.4	66.6	67.1	69.2	59	68.4	67.0	65	67.1	64.4	61.7	67.4
19-2409	Jagalene (CC02)	65	63.8	63.6	66.1	61.7	62.6	65.2	66.3	58	66.0	68.2	62	65.3	60.6	61.3	63.7
19-2415	Jagalene (CC03)	65	65.6	59.9	69.0	64.0	62.4	63.7	68.1	56	64.0	64.1	64	63.6	63.1	61.3	66.0
19-2417	Jagalene (CC04)	68	67.6	63.1	70.1	65.0	64.4	67.4	68.4	58	70.9	64.5	65	67.6	64.2	61.2	67.0
19-2421	Jagalene (CC05)	66	67.5	62.9	72.9	69.8	64.5	67.9	73.9	57	69.0	66.1	67	68.0	70.3	59.3	71.8
19-2424	Jagalene (CC06)	67	68.1	63.4	70.3	64.9	66.1	66.5	68.5	58	67.8	64.9	64	66.6	64.1	58.1	66.9

BAKE MIX TIME, ACTUAL (Small Scale) Jagalene Checks Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Ρ
19-2402	Jagalene (CC01)	2.8	3.3	3.3	3.5	10	4.8	3.0	4.5	6	4.1	4.4	9	2.5	8	4	11
19-2409	Jagalene (CC02)	3.7	4.3	4.3	4.5	9	6.5	4.4	5.0	4	5.0	5.6	11	3.9	8	4	10
19-2415	Jagalene (CC03)	4.0	4.3	5.0	5.5	7	5.8	4.8	4.5	6	5.0	5.8	10	4.3	8	4	11
19-2417	Jagalene (CC04)	3.5	4.3	5.0	6.0	15	5.0	4.4	6.5	6	6.8	6.2	13	3.9	8	4	11
19-2421	Jagalene (CC05)	2.4	3.0	3.2	4.0	7	4.0	3.0	5.0	4	3.5	3.6	7	2.5	8	4	6
19-2424	Jagalene (CC06)	3.4	4.3	3.5	5.0	7	6.5	3.9	4.5	4	5.0	5.5	8	3.4	8	4	8





DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Jagalene Checks

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2402	Jagalene (CC01)	2	1	3	9	1
19-2409	Jagalene (CC02)	3	2	0	11	0
19-2415	Jagalene (CC03)	3	3	2	8	0
19-2417	Jagalene (CC04)	2	1	1	11	1
19-2421	Jagalene (CC05)	3	2	5	6	0
19-2424	Jagalene (CC06)	3	4	3	5	1



DOUGH CHAR. 'AT MAKE UP', DESCRIBED (Small Scale) Jagalene Checks

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
19-2402	Jagalene (CC01)	1	1	4	8	2
19-2409	Jagalene (CC02)	1	2	0	11	2
19-2415	Jagalene (CC03)	4	1	2	8	1
19-2417	Jagalene (CC04)	2	0	3	11	0
19-2421	Jagalene (CC05)	5	1	2	7	1
19-2424	Jagalene (CC06)	8	1	1	4	2



CRUMB GRAIN, DESCRIBED (Small Scale) Jagalene Checks

IDCODE	ID	Open	Fine	Dense
19-2402	Jagalene (CC01)	9	7	0
19-2409	Jagalene (CC02)	10	6	0
19-2415	Jagalene (CC03)	7	6	3
19-2417	Jagalene (CC04)	9	4	3
19-2421	Jagalene (CC05)	11	3	2
19-2424	Jagalene (CC06)	11	4	1

CELL SHAPE, DESCRIBED (Small Scale) Jagalene Checks

IDCODE	ID	Round	Irregular	Elongated
19-2402	Jagalene (CC01)	6	5	5
19-2409	Jagalene (CC02)	2	6	8
19-2415	Jagalene (CC03)	6	6	4
19-2417	Jagalene (CC04)	3	8	5
19-2421	Jagalene (CC05)	7	5	4
19-2424	Jagalene (CC06)	6	5	5



CRUMB TEXTURE, DESCRIBED (Small Scale) Jagalene Checks

IDCODE	ID	Harsh	Smooth	Silky
19-2402	Jagalene (CC01)	1	11	4
19-2409	Jagalene (CC02)	1	10	5
19-2415	Jagalene (CC03)	3	8	5
19-2417	Jagalene (CC04)	2	11	3
19-2421	Jagalene (CC05)	3	9	4
19-2424	Jagalene (CC06)	5	8	3



CRUMB COLOR, DESCRIBED (Small Scale) Jagalene Checks

IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
19-2402	Jagalene (CC01)	0	0	5	4	4	3	0
19-2409	Jagalene (CC02)	0	0	3	6	5	2	0
19-2415	Jagalene (CC03)	0	1	6	3	6	0	0
19-2417	Jagalene (CC04)	0	1	6	4	5	0	0
19-2421	Jagalene (CC05)	0	0	4	2	5	5	0
19-2424	Jagalene (CC06)	0	1	6	7	1	1	0

LOAF WEIGHT, ACTUAL (Small Scale) Jagalene Checks Cooperators A – P

IDCODE	ID	Α	в	С	D	Е	F	G	н	Т	J	к	L	м	Ν	0	Р
19-2402	Jagalene (CC01)	143.0	144.7	142.6	126.7	439.0	143.9	138.3	444.6	412	152.9	154.4	490	143.1	459.0	470.5	422.5
19-2409	Jagalene (CC02)	142.4	144.1	143.1	132.2	438.5	140.8	139.2	446.1	410	150.0	154.1	488	139.7	462.0	475.7	429.7
19-2415	Jagalene (CC03)	144.7	142.9	142.0	130.2	442.5	141.1	141.0	450.7	413	150.8	156.8	489	143.5	459.7	479.0	423.7
19-2417	Jagalene (CC04)	148.8	146.0	142.6	129.1	448.5	140.8	134.5	443.8	410	152.3	156.5	488	144.6	461.3	476.3	424.4
19-2421	Jagalene (CC05)	144.0	146.2	143.1	134.0	438.5	141.1	139.4	440.7	418	153.8	156.6	489	143.2	454.3	482.2	424.5
19-2424	Jagalene (CC06)	144.8	145.3	143.1	129.5	444.0	138.5	137.4	444.4	413	151.6	153.8	482	142.2	459.3	483.6	430.5

LOAF VOLUME, ACTUAL (Small Scale) Jagalene Checks Cooperators A – P

IDCODE	ID	Α	В	С	D	Е	F	G	н	Т	J	κ	L	М	Ν	0	Р
19-2402	Jagalene (CC01)	920	905	850	1025	2300	1046	890	2258	2925	1010	980	2750	890	2314	2575	2725
19-2409	Jagalene (CC02)	955	885	905	1135	2259	993	874	2391	3100	965	940	2927	920	2304	2600	2650
19-2415	Jagalene (CC03)	760	850	690	850	2111	835	746	2191	3000	800	735	2927	755	2124	2450	2650
19-2417	Jagalene (CC04)	855	875	860	1040	2374	963	922	2208	2850	945	870	2956	875	2470	2563	2700
19-2421	Jagalene (CC05)	685	850	860	980	1994	1025	782	2017	2650	910	810	2897	960	2011	2625	2425
19-2424	Jagalene (CC06)	880	925	840	1025	2470	1050	906	2475	2850	970	848	2986	890	2374	2538	2475



COOPERATOR'S COMMENTS (Small Scale) Common Checks

COOP.

19-2430 Jagalene (CC01)

- A. Performed poorly for high protein.
- B. Nice loaf externals.
- C. Meets loaf volume target.
- D. Good volume, good dough handling characteristics.
- E. Slightly sticky sponge with good height, good dough out of mixer, elastic during makeup.
- F. Very High Protein, Very High Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Big break and shred.
- I. Good dough, short mix for protein, good volume.
- J. High absorption, nice grain, very high volume.
- K. Good overall performance.
- L. Very good absorption, slightly low mix strength, low loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption, tough dough at makeup, good grain and volume.
- P. High absorption and average mix time, good qualities and high protein, great volume. Recommend.

COOP.

19-2431 Jagalene (CC02)

- A. No comment.
- B. Yellow/brown dough.
- C. Meets loaf volume target.
- D. Good overall balance of absorption and loaf volume.
- E. Good sponge with good height, good dough out of mixer.
- F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, High Volume, Dull Crumb, Slight Open Round Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Big break and shred, dark crust color.
- I. Short mix for protein, slightly soft out of mixer, excellent volume.
- J. High absorption and wet dough at makeup, nice grain and high volume.
- K. Average performance and mix tolerance poor.
- L. Good absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption, average grain, high volume.
- P. Average mix time, higher protein and absorption, good final product qualities. Recommend for bread application.

19-2432 Jagalene (CC03)

A. Low protein.

COOP.

- B. Slight cap.
- C. Does not meet bake absorption target of 62%.
- D. No comment.
- E. Good sponge with good height, dough was beige in color.
- F. Fine Protein, Normal Water Abs, Normal MT, Slight Sticky & Weak Dough, Fair Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Some break and shred, loaf collapsed.
- I. Good mix for protein, lower protein, good volume, open grain.
- J. Low protein flour, poor open grain and dark yellow crumb, low volume.
- K. Dough performance shows promise if protein were higher, bread very poor however.
- L. Good absorption, slightly low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Low protein flour, good absorption and fine grain.
- P. Low protein, average mix time, high absorption, unfavorable notes from mixing tolerance and dough handling characteristics, final product problems, good volume.

COOP.

19-2433 Jagalene (CC04)

- A. No comment.
- B. Yellow?
- C. Meets loaf volume target.
- D. Good loaf volume and absorption.
- E. Good sponge with good height, good dough out of mixer and at makeup.
- F. High Protein, High Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Break and shred, loaf collapsed, dark crust color.
- I. Highest protein in group, sticky sponge but recovered at makeup, average volume, open grain.
- J. Long mix time, very high (71%) absorption, average grain but good volume.
- K. Expected performance for protein level, dough strength shows promise at higher protein.
- L. Very good absorption, fair mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Good absorption and nice grain, good volume but very yellow crumb.
- P. Good protein and mix time, high absorption, some sticky and wet dough notes, good volume and fair final product characteristics, good for bread application.

19-2434 Jagalene (CC05)

COOP.

- A. Short mix, very poor loaf volume.
- B. Nice loaf externals.
- C. Meets loaf volume target.
- D. No comment.
- E. Very sticky sponge with good height, good dough during makeup.
- F. High Protein, High Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Sponge did not form well at all, very difficult to work with, some break and shred, loaf collapsed, dark crust color.
- I. Soft dough, short mix, lower volume, open grain, creamy interior.
- J. High absorption, tough dough out of mixer, poor open grain and very yellow crumb, but good volume.
- K. Poor performance for protein in sample.
- L. Very good absorption, low mix strength, average loaf volume.
- M. No comment.
- N. No comment.
- O. Poor open grain but high volume.
- P. High absorption, great protein, low mix time and volume, some undesirable dough handling characteristics. Recommend.

COOP.

19-2435 Jagalene (CC06)

- A. No comment.
- B. Nice loaf externals.
- C. Close to meeting loaf volume target, good crumb and color.
- D. No comment.
- E. Sticky beige sponge, dough was sticky out of mixer, extensible during makeup.
- F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Dull Crumb, Open Elongated Cells, Resilient & Smooth Texture.
- G. No comment.
- H. Break and shred, dark crust color, overall good loaf structure.
- I. Sticky sponge, short mix time, soft dough, average volume, dull color.
- J. High absorption, good grain, high volume.
- K. Poor performance for protein in sample.
- L. Good absorption, slightly low mix strength, good loaf volume.
- M. No comment.
- N. No comment.
- O. Lower absorption but having wet doughs, average grain with very yellow crumb, average volume.
- P. Good protein and high absorption, low mix time, sticky and wet dough handling notes, unfavorable final product characteristics. Do not recommend.

Notes: E, H, I, L, O and P conducted sponge and dough bake tests

2019 WQC Milling and Baking Marketing Scores

2019 WQC Milling & Baking Marketing Scores (Based upon HWWQL Quality Data and KSU Milling Data)





2019 WQC Milling & Baking Marketing Scores (Based upon HWWQL Quality Data and KSU Milling Data)



2019 WQC Baking Marketing Scores

(Based upon Average Baking Data of Collaborators Pup-Loaf Straight Dough)



Marketing Scores

Achieving acceptable end-use (milling and baking) quality is a fundamental objective of wheat breeding programs throughout the U.S. hard winter wheat region. Numerous statistical methods have been developed to measure quality. Several years ago, Dr. Scott Haley (Colorado State University), in conjunction with the USDA-ARS Hard Winter Wheat Quality Laboratory (HWWQL), developed a relational database for summarization and interpretation of regional performance nursery wheat end-use quality data generated annually by the HWWQL (Scott D. Haley, Rod D. May, Bradford W. Seabourn, and Okkyung K. Chung. 1999. Relational database system for summarization and interpretation of Hard Winter Wheat regional quality data. Crop Sci. 39:309-315). Until that time, few tools were available to assist in the decision-making process when faced with a large number of parameters from comprehensive milling and baking tests. The database system uses a graphical interface that requires input from the user. The database system provides simultaneous assessment of multiple quality traits on a standardized scale, user-specified prioritization of end-use quality traits for numerical and qualitative ratings of genotypes, tabulation of major quality deficiencies of genotypes, and summarization of quality ratings for a genotype across multiple nurseries.

As an extension of this relational database, and in keeping with the precedent set by Dr. Gary Hareland and the Hard Spring wheat region with the introduction of a 'marketing score' into their 2004 annual crop report to the Wheat Quality Council, the HWWQL developed (using the HRS system as a guide) a similar marketing score for both milling and baking for the Hard Winter Wheat Region, as shown below.

Variation(+/-) from SCORE		TW lbs/bu	Kernel Size % Large	Kernel Weight g/1000	Wheat Protein 12%mb	Kernel Hardness NIR	Str Grd Flour Yield %	Wheat Ash 14%mb	Wheat Falling Number Seconds
Target Value:	6	63	39	45	15.0	100	76	1.30	375
	5	62	36	40	14.0	90	74	1.40	350
	4	61	33	35	13.0	80	72	1.50	325
TARGET VALUE:	3	60	30	30	12.0	70	70	1.60	300
	2	59	26	25	11.0	60	68	1.70	275
	1	58	22	20	10.0	50	66	1.80	250
	0	57	18	15	9.0	40	64	1.90	225

Milling Marketing Score = (TW*1.5) + (largeK*1) + (1000KWT*0.5) + + (protein*2.5) + (NIRHS*1) + (YLD*1.5) + (ash*1) + (FN*1)/10 (where TW = test weight, largeK = large kernel size %, 1000KWT = thousand kernel weight, protein = protein content %, NIRHS = NIR hardness score, YLD = flour yield, ash = wheat ash content %, and FN = falling number value).

		Absorption	Volume	Color	Grain	Texture		Mix Time
		Actual	Actual	Rating	Rating	Rating		Actual
Variation(+/-) from	SCORE	(%)	(cc)	Score	Score	Score	SCORE	(min)
Target Value:								
-	6	65	1050	6.0	6.0	6.0	0	5.00
	5	64	1000	5.4	5.4	5.4	2	4.50
	4	63	950	4.7	4.7	4.7	4	4.00
TARGET VALUE:	3	62	900	4.0	4.0	4.0	6	3.50
	2	61	850	3.3	3.3	3.3	4	3.00
	1	60	800	1.6	1.6	1.6	2	2.50
	0	59	750	1.0	1.0	1.0	0	2.00

Bake Marketing Score = (Abs*3) + (Lvol*2) + (color*1) + (grain*1.5) + (texture*1) + (MT*1.5)/10 (where Abs = mixograph water absorption %, Lvol = loaf volume [cc], color = crumb color [0-6 scale], grain = crumb grain [0-6 scale], texture = crumb texture [0-6 scale], and MT = mixograph mix time).

Alkaline Noodle Quality Tests of 2019 WQC Hard Winter Wheat Entries



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Alkaline Noodle Quality Report

Objectives: Evaluate alkaline noodle color and cooking characteristics.

Materials: 29 WQC hard winter wheat samples harvested in 2019.

Methods:

PPO (Polyphenol Oxidase) Test:

The PPO level in wheat meal was determined using a method modified from AACCI Approved Method 22-85.

- 1. Grind wheat using a Udy Mill and blend the sample thoroughly on tumbling equipment.
- 2. Weigh 75 mg of wheat meal in a 2 mL microfuge tube.
- 3. Dispense 1.5 mL of 5 mM L-DOPA in 50 mM MOPS (pH 6.5) solution.
- 4. Vortex 10 min.
- 5. Centrifuge 4 min at 10,000 rpm.
- 6. Read absorbance at 475 nm.

Noodle Making:

<u>Formulation:</u> Alkaline Noodle was made with 100 g flour, 1 g Na₂CO₃, and 35 mL of water (fixed).

Procedure:



Cutting

Measurement of Noodle Dough Color:

Noodle dough color (L^* , lightness; a^* , redness-greenness; b^* , yellowness-blueness) was measured by Minolta Colorimeter (Model CR-410) at 0 and 24 hr.

Cooking Noodles:

- 1. After cutting noodles, rest noodles in plastic bags for 2 hr at 21°C.
- 2. Put the noodles (25 g) in the boiling distilled water (300 mL).
- 3. Cook continuously with gentle stirring for 4 min 30 sec or until the core of noodle disappears.
- 4. Pour noodles and hot water through colander and collect the cooking water for calculation of cooking loss.
- 5. Immerse the cooked noodles in a bowl with distilled water (100 mL) for 1 min.
- 6. Drain water by shaking the colander 10 times.
 - Measure the cooked noodle weight for calculation of water uptake.
- 7. Test noodle texture immediately.

Measurement of Cooking Loss and Water Uptake:

Cooking Loss:

- 1. Pre-weigh 500 mL beaker to 0.01 g.
- 2. Quantitatively transfer cooking/rinse water to beaker.
- 3. Evaporate to dryness (constant weight) in air oven at 95 ±5°C. Drying time is about 20 hr.
- 4. Cool beakers and weigh to 0.01 g.
 For 25 g sample, multiply by 4 → % cooking loss.

Water Uptake:

Water Uptake (%) = (Cooked noodle weight-Raw noodle weight)/Raw noodle weight x 100

Texture Profile Analysis (TPA) of Noodle:

Immediately after cooking, noodle TPA was conducted using a TA-XTplus (Texture Technologies, NY) on 3 strings of noodle with 1-mm flat Perspex Knife Blade (A/LKB-F). TPA provides objective sensory results on various parameters as follows:

- Hardness (N): maximum peak force during the first compression cycle (first bite) and often substituted by the term "firmness".
- **Springiness (elasticity, ratio):** ratio related to the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite.
- Chewiness: hardness x cohesiveness x springiness.

- **Resilience (ratio):** measurement of how the sample recovers from deformation both in terms of speed and forces derived.
- **Cohesiveness (ratio):** ratio of the positive force area during the second compression to that during the first compression.

Results:

Top 3 samples showing desirable properties were selected in each category.

Table I shows the following:

Noodle Color (*L* value, Higher is better.) *at 0 hr*: 2422 (81.39), 2420(81.27), 2413 (80.59)

Noodle Color (*L* value, Higher is better.) *at 24 hr*: 2413 (69.17), 2422 (68.70), 2420 (68.30)

Delta L (Change of *L* value, Lower absolute value is better.) 2413 (-11.42), 2414 (-12.18), 2422(-12.69)

PPO (Lower is better.): 2419 (0.102), 2422 (0.160), 2423 (0.197)

Table II shows the following:

Hardness: 2429(2.797), 2414 (2.728), 2425 (2.708)

Springiness: 2403 (0.913), 2411 (0.907), 2421 (0.905)

Chewiness: 2429 (1.652), 2428 (1.635), 2411 (1.620)

Resilience: 2402 (0.420), 2421 (0.420), 2423 (0.419)

Cohesiveness: 2403 (0.694), 2421 (0.686), 2423 (0.684)

Water Uptake: 2404 (92.72), 2424 (90.08), 2420 (89.56)

Cooking Loss: 2426 (6.12), 2428 (6.16), 2402 (6.24)

Discussion

Sample 2413 had third highest L-value (brightness) at 0 hrs, the highest L-value (brightness) at 24 hrs and the lowest delta L^* value. This sample also had relatively high hardness and chewiness in texture after cooking. Bright noodle color 24 hr after production and a firmer texture following
cooking are considered desirable characteristics for alkaline noodles. Thus, sample 2413 would be considered the most favorable variety overall for alkaline noodle quality.

Sample 2422 had the highest L-value (brightness) at 0 hrs, second highest L-value (brightness) at 24 hrs, and had third lowest delta L^* value, second lowest PPO value. This sample also had the lowest hardness and chewiness after cooking. Therefore, sample 2422 would be considered the most favorable variety overall for white salted noodles quality (Japanese Udon-type), which are preferred to have a bright, creamy white color, and smooth, soft texture.

Sample 2420 had second highest L-value (brightness) at 0 hrs, third highest L-value (brightness) at 24 hrs and third water uptake.

Sample ID	L*@0	L* @ 24	a* @ 0	a* @ 24	b*@0	b*@ 24	delta L*	delta a*	delta b*	PPO
2401	78.73	62.81	-0.59	1.72	19.89	23.14	-15.92	2.31	3.25	0.450
2402	75.82	59.58	-0.64	1.65	23.82	23.94	-16.24	2.29	0.12	0.354
2403	76.63	58.12	-0.76	1.89	19.09	21.35	-18.51	2.65	2.26	0.649
2404	79.66	63.51	-1.10	1.03	20.12	21.85	-16.15	2.13	1.73	0.477
2405	74.78	57.90	-0.31	2.59	23.06	24.12	-16.89	2.90	1.06	0.433
2406	76.76	62.81	-0.51	2.29	23.03	26.60	-13.95	2.80	3.58	0.370
2407	76.99	60.97	-0.43	1.89	20.66	21.63	-16.02	2.31	0.97	0.271
2408	76.37	62.24	-0.56	2.29	24.27	27.15	-14.13	2.84	2.88	0.260
2409	74.18	59.78	-0.39	2.19	21.54	24.11	-14.40	2.58	2.57	0.483
2410	75.37	61.47	-0.21	2.04	18.56	22.58	-13.90	2.25	4.02	0.569
2411	75.97	63.15	-0.47	1.74	21.31	25.14	-12.82	2.21	3.84	0.481
2412	79.37	66.16	-1.07	0.88	20.39	24.49	-13.22	1.95	4.11	0.396
2413	80.59	69.17	-1.25	0.56	19.37	23.95	-11.42	1.81	4.58	0.464
2414	79.43	67.25	-0.77	0.85	18.61	22.90	-12.18	1.62	4.29	0.487
2415	80.56	67.44	-1.17	1.01	19.84	23.34	-13.12	2.18	3.50	0.290
2416	78.89	65.55	-0.67	1.40	19.80	21.68	-13.35	2.07	1.89	0.338
2417	78.67	63.74	-0.81	1.82	21.33	23.73	-14.94	2.63	2.40	0.407
2418	79.57	64.16	-0.77	2.02	18.87	24.48	-15.41	2.79	5.61	0.477
2419	79.50	64.83	-0.83	1.19	20.49	25.08	-14.67	2.01	4.60	0.102
2420	81.27	68.30	-1.70	0.54	20.55	26.25	-12.97	2.24	5.70	0.482
2421	80.59	65.54	-1.28	0.65	19.92	21.72	-15.06	1.93	1.80	0.238
2422	81.39	68.70	-1.08	0.67	19.51	23.91	-12.69	1.75	4.40	0.160
2423	78.83	65.76	-0.85	1.16	22.30	23.65	-13.07	2.01	1.35	0.197
2424	76.02	57.56	-0.39	2.86	21.59	22.76	-18.46	3.25	1.18	0.435
2425	77.82	62.07	-0.86	1.74	22.01	25.22	-15.75	2.60	3.21	0.570
2426	74.83	59.46	-0.12	2.57	21.49	23.41	-15.37	2.69	1.92	0.445
2427	73.42	57.40	0.48	3.18	22.22	23.72	-16.03	2.70	1.50	0.555
2428	72.73	56.00	-0.30	2.88	24.21	25.22	-16.73	3.18	1.01	0.799
2429	74.63	57.71	-0.18	2.77	21.81	23.86	-16.93	2.95	2.06	0.508
Avg	77.56	62.73	-0.67	1.72	21.02	23.83	-14.83	2.40	2.80	0.419

 Table I. Noodle Color and PPO Level

Sample	Hardness	Springiness	Chewiness	Resilience	Cohesiveness	Water Uptake	cooking
2401	2.476	0.892	1.498	0.417	0.678	81.88	7.56
2402	2.479	0.878	1.484	0.420	0.682	86.68	6.24
2403	2.502	0.913	1.586	0.415	0.694	86.48	6.40
2404	2.682	0.898	1.583	0.376	0.657	92.72	6.60
2405	2.463	0.900	1.506	0.418	0.679	84.60	6.64
2406	2.336	0.894	1.390	0.409	0.665	82.32	7.88
2407	2.293	0.894	1.360	0.398	0.663	85.60	7.52
2408	2.554	0.878	1.465	0.394	0.654	82.60	7.32
2409	2.512	0.884	1.499	0.403	0.675	84.08	6.64
2410	2.611	0.853	1.479	0.407	0.664	80.52	6.84
2411	2.712	0.907	1.620	0.383	0.659	86.00	6.84
2412	2.668	0.888	1.547	0.393	0.653	84.20	7.88
2413	2.638	0.881	1.520	0.390	0.654	85.96	7.40
2414	2.728	0.828	1.446	0.378	0.640	85.24	7.72
2415	2.376	0.884	1.357	0.387	0.646	82.96	8.08
2416	2.362	0.867	1.362	0.407	0.665	83.88	7.28
2417	2.449	0.869	1.411	0.388	0.663	86.28	6.96
2418	2.585	0.888	1.549	0.412	0.675	80.40	7.36
2419	2.590	0.865	1.495	0.403	0.667	84.28	7.68
2420	2.640	0.867	1.426	0.361	0.623	89.56	7.76
2421	2.246	0.905	1.393	0.420	0.686	87.24	7.16
2422	2.188	0.898	1.303	0.401	0.663	85.76	8.00
2423	2.385	0.898	1.466	0.419	0.684	86.12	6.84
2424	2.686	0.873	1.534	0.381	0.654	90.08	6.48
2425	2.708	0.886	1.603	0.389	0.668	82.20	6.44
2426	2.630	0.871	1.534	0.393	0.669	86.72	6.12
2427	2.652	0.849	1.440	0.366	0.640	84.24	7.08
2428	2.680	0.905	1.635	0.398	0.674	85.00	6.16
2429	2.797	0.876	1.652	0.397	0.675	80.92	6.48

Table II. Texture Profile Analysis of Cooked Noodle and Water Uptake and Cooking Loss

Avg2.5390.8821.4880.3970.66484.98	7.08
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TORTILLA BAKING TEST RESULTS of 2019 WQC SAMPLES

Audrey L. Girard and Joseph M. Awika Cereal Quality Lab, Department of Soil and Crop Sciences Texas A&M University, College Station, TX (December 2019)

SUMMARY

This report includes the methods for production and evaluation of wheat flour tortillas and data of the 2019 WQC samples. The data was collected over 17 days, including baking and shelf stability.

Samples 2426 and 2428 created tortillas that were ranked as "good", based on their final diameter (≥ 160 mm) and subjective rollability (v. little cracking when rolled 16 days after baking) as seen in Table 2. These samples also had good dough handling properties (Table 1). Higher diameter and rollability scores suggest flour that is moderately strong with good extensibility characteristics. Samples 2403 was ranked as "fair-good" because it had a diameter that just missed the cutoff for good (158 mm) and had great rollability (4.25 = signs of cracking, but no breaking) over 16 days of storage.

Samples 2402, 2409, 2425, and 2429 ranked as "fair", based on their diameter (150-160 mm), though they had good rollability. This suggests these flours were strong and caused shrinkage to the tortilla dough when hot-pressed.

Sample 2416 created hard and rough dough evidenced by its extreme ratings in all subjective dough parameters (Table 1). This resulted in tortillas with inferior diameter (127 mm) that had reduced rollability over 16 days of storage; it was ranked as "v. poor". This is indicative of very strong gluten proteins, which often increase shrinkage after hot-press, an undesirable dough trait in tortillas. Samples 2401, 2413, 2414, 2415, and 2424 also created stiff doughs, which were not highly extensible, and led to poor quality tortillas.

Samples 2404, 2405, 2408, 2410, 2411, and 2427 had good diameters (161-174 mm) but low rollability scores (<3), indicative of weak flours.

RESULTS

Test #	Abs	Mix Time	Smoothness	Softness	Extensibility	Force to	Press
1001 //	[%]	[min]	emeetiness	Contricos	Extensionity	Extend	Rating
2401	54.2	15	4.0	4.0	2.0	4.0	4.5
2402	57.2	8	2.5	3.0	3.0	2.5	2.5
2403	56.6	12	2.5	2.5	3.0	3.0	3.0
2404	54.2	8	2.0	2.0	3.0	2.5	2.5
2405	55.0	10	2.5	3.0	2.5	2.5	3.0
2406	52.8	17	3.0	3.0	2.5	3.0	3.0
2407	53.4	15	3.0	2.5	2.0	2.5	3.5
2408	54.2	12	3.0	3.0	2.5	2.5	2.5
2409	55.4	13	2.5	2.5	2.5	2.5	2.5
2410	53.4	12	2.5	2.5	2.5	2.5	2.5
2411	53.6	8	3.0	3.0	2.5	3.0	3.0
2412	52.2	15	4.0	4.0	2.0	3.5	3.5
2413	53.6	19	3.5	4.0	2.0	4.0	3.5
2414	53.6	19	4.0	4.0	2.0	4.5	4.0
2415	52.0	14	4.5	4.0	2.0	4.5	4.5
2416	53.6	19	5.0	5.0	1.5	5.0	5.0
2417	54.8	12	3.0	3.5	2.0	3.0	3.0
2418	54.0	12	3.0	3.0	2.0	3.0	3.0
2419	53.4	12	3.0	3.5	2.0	3.5	3.0
2420	51.8	12	2.5	3.0	2.0	3.0	3.0
2421	54.8	12	2.5	2.5	2.5	2.5	2.5
2422	52.0	16	3.5	3.5	2.0	3.5	3.5
2423	54.2	15	3.0	3.0	2.0	3.0	3.5
2424	55.0	14	4.0	4.0	2.0	4.0	4.0
2425	55.0	14	2.5	2.5	3.0	2.5	2.5
2426	55.4	12	3.0	3.0	1.5	3.0	3.5
2427	55.2	8	2.5	2.5	3.0	2.5	2.5
2428	56.8	8	2.5	2.5	2.0	2.5	3.0
2429	56.2	12	3.0	3.0	3.5	3.0	3.5

Table 1 – Subjectively evaluated dough properties.

Smoothness: 1 = satin smooth, **2 = preferred**, 5 = very rough

Softness: 1 = very soft, **2** = **preferred**, 5 = very hard Extensibility: 1 = breaks immediately, **3** = **preferred**, 5 = extends readily

Force to extend: 1 = less force, **2** = **preferred**, 5 = extreme force

Press rating: 1 = less force, **2 = preferred**, 5 = extreme force

Methodology listed on subsequent pages.

Table 2 – Physical and textural properties of tortillas.

	Finished Tortilla Physical Properties					Finished Tortilla Texture							
Test #	Moisture [%]	Weight [g]	Thickness [mm]	Diameter [mm]	Sp. Vol [cm³/g]	Lightness [L*-value]	Force Day 8 [N]	Distance Day 8 [mm]	Force Day 16 [N]	Distance Day 16 [mm]	Rollability Day 8	Rollability Day 16	Rating*
2401	32.1	42.8	3.7	143	1.4	71.0	6.92	14.5	5.44	12.3	3.75	3.50	Poor
2402	33.8	41.3	3.4	159	1.6	70.9	5.04	14.7	4.78	12.7	4.25	3.00	Fair
2403	34.3	41.4	3.2	158	1.5	70.1	5.38	14.7	5.17	13.8	4.50	4.25	Fair-Good
2404	33.2	40.4	3.0	166	1.6	72.2	4.93	12.4	4.25	12.0	3.25	2.75	Poor
2405	32.6	40.6	3.4	167	1.8	70.9	6.18	14.0	3.79	11.8	3.50	2.50	Poor
2406	32.9	41.6	3.8	149	1.6	70.8	4.59	11.8	4.46	9.9	4.00	2.75	Poor
2407	31.8	40.8	3.1	157	1.5	71.8	4.30	11.2	3.38	10.4	2.75	2.00	Poor
2408	31.3	40.6	3.6	166	1.9	73.6	4.07	11.8	2.87	10.5	3.25	2.00	Poor
2409	34.3	42.0	3.4	159	1.6	70.5	5.82	13.3	5.08	12.8	4.50	3.25	Fair
2410	33.4	41.5	4.1	161	2.0	72.9	5.26	11.4	4.74	11.0	2.75	1.75	Poor
2411	32.9	41.4	3.1	165	1.6	71.7	5.18	11.4	3.29	10.6	3.50	2.00	Poor
2412	31.4	40.6	3.5	157	1.7	73.9	4.37	10.4	3.06	8.5	2.00	1.00	V. Poor
2413	31.6	41.8	3.7	146	1.5	73.0	6.30	13.8	6.21	12.2	4.00	2.50	Poor
2414	32.5	41.4	3.5	145	1.4	72.0	6.55	12.0	5.67	11.9	3.25	2.50	Poor
2415	31.8	41.8	3.7	144	1.4	72.2	5.78	11.4	5.14	10.5	2.75	1.75	Poor
2416	31.9	42.3	3.8	127	1.1	70.2	6.96	12.8	8.65	12.1	3.50	2.75	V. Poor
2417	32.7	41.9	3.5	154	1.6	71.9	6.63	14.5	4.44	10.9	3.25	2.75	Poor
2418	32.8	42.0	3.3	148	1.4	69.7	4.41	11.5	6.31	12.6	4.00	2.75	Poor
2419	32.7	41.1	3.3	146	1.4	72.3	5.69	13.2	6.13	12.6	3.00	2.00	Poor
2420	30.8	41.0	3.6	157	1.7	76.3	3.59	10.0	3.14	9.8	1.75	1.00	V. Poor
2421	32.8	42.1	3.5	158	1.6	74.0	5.65	14.1	4.63	12.1	3.50	2.25	Poor
2422	30.2	41.7	3.4	150	1.4	74.4	4.39	10.9	3.58	10.9	2.50	1.25	V. Poor
2423	32.2	41.4	3.6	146	1.5	72.4	6.63	13.6	6.38	13.2	4.25	2.75	Poor
2424	32.3	41.7	3.8	152	1.7	72.3	6.37	14.4	5.38	13.4	4.00	2.50	Poor
2425	32.7	41.4	3.5	159	1.7	73.4	5.99	15.2	4.92	14.3	4.50	3.50	Fair
2426	33.6	40.9	3.4	162	1.7	72.5	4.98	13.7	5.39	13.4	4.25	3.50	Good
2427	32.0	40.5	3.1	174	1.8	70.3	4.24	12.3	3.17	11.3	2.50	2.00	Poor
2428	33.6	41.2	3.1	165	1.6	67.4	5.75	15.9	5.92	14.9	4.50	3.75	Good
2429	33.8	41.3	3.3	151	1.4	68.3	7.24	16.3	6.92	16.2	4.00	4.00	Fair

*Subjective rating based primarily on diameter and rollability. Good: rollability score >3.0 on day 16, \geq 160 mm diameter. Fair: rollability score >3.0 on day 16, 150-160 mm diameter. Poor: rollability score <3.0 on day 16, any diameter.

**Descriptors or scales for other parameters listed on subsequent pages.

PRODUCTION AND EVALUATION OF WHEAT FLOUR TORTILLAS

Tortilla Formulation

Ingredients	Amount
Wheat flour	100%
Salt	1.5%
Sodium Propionate	0.8%
Potassium Sorbate	0.4%
All-purpose Shortening	6.0%
Sodium Bicarbonate	0.6%
Fumaric Acid - encapsulated	0.5%
Sodium Aluminum Phosphate	0.82%

Tortilla Processing



Subjective Dough Evaluation

The dough properties were evaluated subjectively for smoothness, softness, toughness, and press rating after the first proofing. These parameters were evaluated primarily to determine the machinability of the dough.

Smoothness refers to the appearance and texture of the dough surface; suggests how cohesive the dough is.

Softness refers to the firmness of the dough when compressed.

Force to extend refers to the elasticity of the dough when pulled apart.

Extensibility refers to the length the dough extends when pulled apart.

Press rating refers to the force required to press the dough on the stainless steel round plate before dividing and rounding.

Scale	Smoothness	Softness	Force to Extend	Extensibility	Press Rating
1	very smooth	very soft	less force	breaks immed.	less force
2	smooth	soft	slight force	some extension	slight force
3	slightly smooth	slightly hard	some force	extension	some force
4	rough	hard	more force	more extension	more force
5	very rough	very hard	extreme force	extends readily	extreme force

BOLD values = desired dough properties.

Evaluation of Tortilla Properties

Tortillas were evaluated one day after processing for weight, diameter, thickness, moisture, and color. Texture tests (rollability and puncture) were performed 8 and 16 days after processing.

1. Weight

Average of 10 tortillas weighed on an analytical balance.

2. Diameter

Average diameter of 10 tortillas, which was measured by using a ruler at two points across the tortilla. This varied widely among wheat samples depending on flour quality; desired values are > 160 mm.

3. Thickness

Average height of 10 tortillas, which were measured using a digital calipers.

4. Moisture

Moisture was determined using a two-stage procedure (AACC, Method 44-15A, 2000).

5. Color Values

The color values of lightness (L*), +a* (redness and greenness) and +b* (yellowness and blueness) of tortillas were determined using a handheld colorimeter (model CR-300, Minolta Camera Co., Ltd., Chuo-Ku, Osaka, Japan). L*-values correlate with opacity and are usually greater than 80.

6. Specific Volume

Specific volume $\left[\frac{\text{cm}^3}{g}\right] = \frac{\pi * \left(\frac{\text{Diameter}}{2}\right)^2 * \text{Height}}{1000*\text{Weight}}$ This corresponds to fluffiness of the tortilla; desired value is > 1.0 cm³/g.

7. Tortilla Rollability Score

Two tortillas were evaluated on days 8 and 16 of storage by wrapping a tortilla around a dowel (1.0 cm diameter). The cracking and breakage of the tortilla was rated using a continuous scale of 1-5 (5 = no cracking, 4 = signs of cracking, but no breaking, 3 = cracking and breaking beginning on the surface, 2 = cracking and breaking imminent on both sides, 1 = unrollable, breaks easily). This measured shelf stability, and the desired value was >3 on the 16^{th} day.



8. Objective rheological test

Extensibility of two tortillas was measured on days 8 and 16 of storage using a texture analyzer (model TA XT2, Texture Technologies Corp., Scarsdale, NY/Stable Micro Systems, Godalming, Surrey, UK). The tortilla was mounted on the circular frame and a rounded nose probe (the TA-23: 0.5 inch diameter, 3 inch tall rounded end stainless steel probe) pushed into the tortilla during the test. Force and distance required to rupture were measured.



2019 WQC HARD WINTER WHEAT FLOUR PROTEIN ANALYSIS

Michael Tilley, Ph.D.

USDA, CGAHR, Manhattan, KS

Procedures

1. Determination of polymeric to monomeric protein ratio

- Protein extraction (Gupta et al, 1993): 20 mg flour + 1 ml 50 mM sodium phosphate buffer, pH 6.9, containing 0.5% SDS, sonicated for 15 sec. Collect the supernatant (contains total protein).
- Filter the supernatant in a 0.45 μ m filter and analyze by size-exclusion HPLC (SE-HPLC).
- SE-HPLC using a 300.0 x 7.8 mm BioSep S4000 column at 50°C, with a constant gradient of 50 mM sodium phosphate buffer, pH 7.0, containing 1% SDS, flow rate of 1.0 ml/min for 20 min.
- The chromatograms were manually integrated and the ratio was determined using the areas of the specific peaks.

2. Determination of the Percentage of Insoluble Polymeric Protein (%IPP)

- Protein extraction (Bean et al, 1998): 10 mg flour + 1 ml 50% 1-propanol- vortex for 5 min, centrifuge for 5 min at 12,000 x g. Discard supernatant. Repeat two times.
- Lyophylize the pellet, which contains the insoluble polymeric proteins.
- Determine pellet protein content by Nitrogen combustion (LECO analysis).
- Insoluble polymeric protein percentage (%IPP) is calculated by multiplying nitrogen values by a conversion factor of 5.7 and dividing by total flour protein.

3. Determination of High Molecular Weight Glutenin Subunit (HMW-GS) composition

Sequential protein extraction:

- 10 mg flour + 1 ml 50 mM Tris-HCl buffer, pH 7.8, containing 100 mM KCl and 5 mM EDTAvortex for 5 min, centrifuge for 5 min at 12,000 x g. Discard the supernatant.
- Repeat the procedure one more time to ensure complete removal of those proteins.
- Repeat the procedure two more times using water, to remove salt from the pellet. Discard the supernatants.
- Add 1 ml 50% 1-propanol to the pellet and vortex for 5 min, centrifuge for 5 min at 12,000 x g. Discard the supernatant.
- Repeat the extraction with 50% 1-propanol one more time. Discard the supernatant.
- Add 1 ml 50% 1-propanol containing 2% tris(2-carboxyethyl)phosphine (TCEP reducing agent) to the pellet and vortex for 30 min, centrifuge for 5 min at 12,000 x g. Collect the supernatant (contains HMW-GS and LMW-GS).
- Analyze protein in the supernatant using the Agilent 2100 Bioanalyzer (lab-on-a-chip).

References

Bean, S.R.; Lyne, R.K.; Tilley, K.A.; Chung, O.K.; Lookhart, G.L. 1998. A rapid method for quantitation of insoluble polymeric proteins in flour. *Cereal Chemistry* 75:374-379.

Gupta, R.B.; Khan, K.; MacRitchie, F. 1993. Biochemical basis of flour properties in bread wheats. I. Effects of variation in the quantity and size distribution of polymeric protein. *Journal of Cereal Science* 18:23-41.

Results of Flour Protein Analysis

	High	Molecular W	eight	Polymeric/Monomeric
	G	utenin Subun		protein
	<u>Glu-A1</u>	<u>Glu-B1</u>	<u>Glu-D1</u>	
19-2401	2*	7+8	5+10	0.88
19-2402	1,2*	17+18/7+9	5+10	0.95
19-2403	2*	7+9	5+10	0.77
19-2404	2*	7+8	5+10	0.88
19-2405	2*	7+9	5+10	0.87
19-2406	2*	7+9	5+10	1.01
19-2407	1	7+9	5+10	0.98
19-2408	2*	7+8	5+10	0.83
19-2409	1,2*	17+18/7+9	5+10	1.03
19-2410	2*	7+8	2+12	1.17
19-2411	1	7+8	5+10	0.95
19-2412	2*	7+8	5+10	1.09
19-2413	2*	7+9	5+10	1.06
19-2414	2*	7+8	5+10	0.99
19-2415	1,2*	17+18/7+9	5+10	1.03
19-2416	1	7+8	5+10	0.97
19-2417	1,2*	17+18/7+9	5+10	1.01
19-2418	1	7+8	5+10	0.86
19-2419	2*	7+9	5+10	0.98
19-2420	2*	7+9	5+10	0.97
19-2421	1,2*	17+18/7+9	5+10	0.98
19-2422	1	7+9	5+10	0.99
19-2423	1	7+8	5+10	0.99
19-2424	1,2*	17+18/7+9	5+10	1.01
19-2425	1	7+9	5+10	1.00
19-2426	2*	7+9	5+10	0.93
19-2427	2*	6+8	3+12	0.93
19-2428	2*	7+8	5+10	1.02
19-2429	1	7+8	5+10	0.96

Hard Winter Wheat WQC 2019 Crop Protein Analysis

APPENDIX A

Credits and Methods

CREDITS

Milling, Sample Analysis, Ingredients and Report Preparation

Single Kernel Analysis, Kernel Size Distribution, and Test Weight

Flour Milling (Miag Multomat)

Wheat Grading

Moisture, Ash, Protein, and Minolta Flour Color

Mixograph, Farinograph Tests, Extensigraph, and Alveograph Tests

Rapid Visco-Analyzer, and Sedimentation Tests

Marketing Scores Sedimentation Tests

Flour Protein Analysis

Falling Number Test and Starch Damage

Doh-Tone 2 as Fungi α-amylase

Tortilla Evaluation

Alkaline Noodle Evaluation

Data Compilation and Final Report

Bake Data Processing

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METHODS

<u>**Test Weight**</u> – AACC Approved Method 55-10. Test weight is the weight per Winchester bushel expressed to the nearest tenth of a pound. This method determines the weight of dockage-free grain.

<u>Weight per Hectoliter</u> - Weight per Winchester Bu x 1.292 + 1.419 (all wheats except Durum) expressed to the nearest tenth of a kilogram. Example: 60.5 lb/bu x 1.292 + 1.419 = 79.6 kg/hl.

1000 Kernel Weight - The weight in grams of 300 kernels of wheat, determined by SKCS, and converted to 1000.

Wheat Kernel Size Test - 200g of wheat are placed on the top sieve of a stack of 3 (8inch diameter) Tyler No. 7, 9 & 12 sieves (2.79, 1.98, & 1.40 mm openings; US Equiv. No. 7, 10 & 12) and sifted for 60 seconds on a Ro-Tap sifter. The percentage remaining on each sieve is reported.

<u>Wheat and Flour Moisture</u> - AACC Approved Method 44-15A. Wheat (ground in Falling Number 3303 burr-type mill to prevent drying before grinding) or flour is dried in a forced air oven at 130° C for one hour.

<u>Wheat and Flour Protein</u> - AACC Approved Method 46-30 wheat meal and flour. Combustion nitrogen method.

<u>Ash</u> - AACC Approved Method 08-01. Sample remaining after ignition is expressed as percent.

Experimental Milling Test - Brabender Quadrumat Sr. is used to mill wheat samples with 15% of tempering moisture for more than 16 hours and feed rate is 150 g/min.

<u>Miag Multomat (Small Scale) Milling</u> - Each coded variety is cleaned with a Carter dockage tester, placed in drums, and sampled for physical wheat tests and analysis. Each variety is then tempered using a double cone blender with enough added water to bring the wheat moisture to 16%. The tempered wheat is held in drums for approximately 20 hours before milling. Milling is performed on the Miag Multomat, which consists of 3 breaks, 5 reductions, and a bran duster. Feed rate is set at 850 to 900 grams per minute. The mill is warmed up and adjusted using KSU mill mix, after which 2-3 bushels of each coded experimental sample are milled.

Break rollers are adjusted to the following releases through a U.S. 20 S.S. sieve:

First Break	50%
Second Break	50%
Third Break	clean-up

Flour yields are calculated from scale weights and expressed as percentage of total products recovered from the mill.

<u>Flour Color</u> – Evaluated using Minolta Chroma Meter. The flour color results are reported in terms of 3-dimensional color values based on L^* , a^* , and b^* .

<u>Wet Gluten</u> - AACC Approved Method (38-12). 10 g. of flour and 5.2 ml. of 2% salt solution are mixed in a Glutomatic test chamber for 20 seconds and then washed for 5 minutes to separate the gluten and the soluble starch products. The gluten ball is divided and placed in a centrifuge for one minute to remove excess water. Percent Wet Gluten is calculated as weight of the centrifuged gluten x 10.

Dry Gluten - Gluten from the wet gluten test is dried between two heated, Teflon coated plates for approximately 4 minutes. Percent Dry Gluten is calculated as weight of the dry gluten x 10.

Falling Number - AACC Approved Method 56-18A. Determination is made by the method of Hagberg (Cereal Chemistry 38:202, 1961) using 7g of flour.

<u>Wheat Hardness</u> - AACC Approved Methods 39-70A (NIR hardness) and 55-31 (using Perten 4100 Single Kernel Characterization System).

Damaged Starch - AACC Approved Method 76-33 using SDmatic. Results are given in an iodine absorption index percentage (AI%) and AACC 76-31 results converted from the testing.

Flour Treatment - Fungal alpha-amylase is added to the flour by each baking cooperator.

Mixograph and Farinograph - AACC Approved Methods (54-40A and 54-21) respectively. These instruments measure and record the resistance to mixing of a flourand-water dough. The recorded curve rises to a "peak" as the gluten is developed and then falls as the gluten is broken down by continued mixing. Curves made by the two instruments are not directly comparable.

The time required for a Mixograph or Farinograph curve to reach the "peak" is an estimate of the amount of mixing required to properly develop the dough for handling and baking. The rate at which a curve falls and narrows after the peak and stability of peak height on either side of the peak are indicators of mixing tolerance. Terms used to describe the Farinograph curve or "farinogram" include:

Absorption - Reported on a 14% moisture basis. Percentage of water required to center the curve on the 500 Farinograph Unit (FU) line at maximum dough consistency (peak). This may not be optimum absorption in a bakery, because baking ingredients influence absorption and flours vary in "slacking-out" during fermentation.

Peak Time - Also called Mixing Time or Dough Development Time. Time (minutes) required for the curve to reach its full development or maximum consistency. High peak values are usually associated with strong wheats that have long mixing requirements.

Stability - Also called Tolerance. This is the time (minutes) that the top of the curve remains above the 500 FU line. Greater stability indicates that the flour can stand more mixing abuse and longer fermentation.

<u>Rapid Visco-Analyzer Test</u> – AACC Approved Methods (61-02).

<u>Sedimentation Test</u> - AACC Approved Methods (56-60).

<u>Alveograph</u> – AACC Approved Methods (54-30A). The instrument measures resistance of dough extension, extensibility, and dough strength. A sheet of dough of definite thickness prepared is expanded by air pressure into a bubble until it is ruptured. The internal pressure in bubble is recorded on automated integrator. P = Tenacity (resistance to extension), L = extensibility, W = baking strength (curve area), P/L = curve configuration ratio, G = swelling index (the square root of the volume of air needed to rupture the bubble), Ie = P200/P, elasticity index (P200: pressure 4 cm from the start of the curve, Ie will be 0 if the extensibility is shorter than 4 cm).

Extensigraph – AACC Approved Method (54-10). The Extensograph® -E stretches the dough prepared by a modified method published in AACC International's Cereal Chemistry (86(5):582-589). The instrument measures resistance of dough extension (R), extensibility (E), maximum resistance (Rmax), and energy (W).

Cumulative Ash and Protein Curves

Ideally, the miller would like to separate wheat bran from endosperm, and reduce endosperm particle size, without producing any bran powder at any stage of the milling process. Unfortunately, current milling technology does not allow this "ideal" situation to occur, and once bran powder is produced it goes into the flour and can never be removed. Ash determination has traditionally been used as an analytical tool in managing the extraction rate of wheat during the milling process. Ash determination consists of burning a known mass of the material to be analyzed and then measuring the residue. Since burning destroys everything but the mineral components, the mass of the residue provides an indication of the contribution that minerals made to the original material. The application of this method to determining bran content of flour has been justified by the fact that endosperm has a lower mineral content than bran. Ash content is lowest in the center of the kernel and increases toward the outer parts because the bran layer contains several times more minerals than pure endosperm.

Many millers have flour refinement specifications (ash content or flour color) that must be met. Therefore, the overall milling value of a wheat sample is determined not only by flour yield, but also flour refinement. A commonly used index of wheat milling value is the cumulative ash curve (Lillard and Hertsgaard 1983). Cumulative ash curves are determined by arranging millstreams in ascending order of ash content, and tabulating the ash content of the total flour produced with the addition of successive millstreams. Wheat that gives low ash content at low extraction, and a slow rate of ash content increase with increasing extraction rate, has a high milling value because of the potential to produce a high percentage of patent flour, which usually sells for a premium in many markets. It should be noted that several authors have indicated that ash curves can be influenced by hardness, variety, whole grain ash, and milling system (Seibel 1974; Posner and Deyoe 1986; Li and Posner 1987, 1989). Natural endosperm ash is typically regarded to be 0.30%; anything above that is generally considered to be due to the milling process.

Similarly, cumulative protein curves are determined by arranging millstreams in ascending order of protein content, and tabulating the protein content of the total flour produced with the addition of successive millstreams. Wheat that gives high protein content at low extraction, and a fast rate of protein content increase with increasing extraction rate, has a high milling value because high protein flour typically sells for a premium in many markets.

LI, Y. Z., and POSNER, E. S. 1987. The influence of kernel size on wheatmillability. Bull. Assoc. Operative Millers November: 5089-5098.

LI, Y. Z., and POSNER, E. S. 1989. An experimental milling techniquefor various flour extraction levels. Cereal Chem. 66:324-328.

LILLARD, D.W. and HERTSGAARD, D.M. 1983. Computer analysis and plotting of milling data: HRS wheat cumulative ash curves. Cereal Chem. 60:42-46.

C-Cell Image Analysis

Pup loaves were baked in duplicate and evaluated with the C-Cell system and its image analysis software (Campden & Chorleywood Food Research Association (CCFRA) and Calibre Control International[©]) at the USDA-ARS Hard Winter Wheat Quality Laboratory (HWWQL) in Manhattan, KS. Two slices from each loaf were scanned: with the break facing the observer, slice 4 and 5 from the right end of the loaf were selected and evaluated with the break side of the slice oriented on the left. Images of the internal grain and crumb structure of each slice represent only the fourth slice of replicate 1, and are shown in the report. Selected numerical data from the image analysis of slice 4 represent the average of slice 4 from replicates 1 and 2, and are shown in the report. General capabilities of the instrument and image analysis are shown below:

Images:



Data:

Forty-eight (48) individual measurements are presented in the data display screens and are saved to the database.

<u>Cell Size</u>: Numbers and dimensions of cells and holes are measured. Wall thickness & coarse/fine clustering.

<u>Cell Elongation and Orientation</u>: Cell alignment and elongation, circulation and curvature <u>Dimensions</u>: Sample area, height, breadth, ratios and wrapper length.

Brightness: Sample brightness and cell contrast.

Shape: Various physical features including, break, concavity and roundness.

<u>Slice Area:</u> The total area of a product slice (mm²).

<u>Slice Brightness</u>: The mean grey level (0-255) of pixels within the slice. The value is lower for products with a darker crumb and for products with larger or deeper cells that contribute to greater shadows. The measurement provides a useful indication of product reflectance.

<u>Number of Cells</u>: The number of discrete cells detected within the slice. Higher values may be due to a finer structure or a larger total slice area. The cells are shown in the Cell image. When interpreting this image, cells only touching diagonally are considered to be discrete.

<u>*Wall Thickness:*</u> The average thickness of cell walls (mm). for bright slices, saturation of some regions may be interpreted as thick walls. Walls close to the edge of the slice are given a reduced weighting in the calculation.

<u>Cell Diameter</u>: The average diameter of cells (mm), based on measurements of the average cell area. This is a good general purpose indicator of the coarseness of the texture, but does not take the depth of cells into account.

<u>Non-Uniformity</u>: A measure of the lack of uniformity between fine and coarse texture (including holes) across the slice. High values indicate less uniformity of texture. The value is useful for comparing slices of similar types of product, but comparisons between products of differing type tend to be less easily interpreted.

<u>Average Cell Elongation</u>: The average length to breadth ratio of cells, independent of their relative orientation. Lower weighting is given to cells close to the edge of the slice. Values close to 1 indicate rounded cells. Higher values indicate greater elongation.

<u>Cell Angle to Vertical (0)</u>: The angle (degrees) of the direction of Net Cell Elongation, measured clockwise from the slice vertical. Lower weighting is given to cells close to the edge of the slice. Values are given in the range of -90 to +90 degrees. Values close to 0 represent a vertical orientation. Values close to + or - 90 represent a horizontal orientation.

Collaborators' Baking Test Profiles and Other Information

2019 WQC COLLABORATORS' BAKING TEST PROFILES AND OTHER INFORMATION

Соор	No.	Test Methods	Est. Flour and Dough Wt (g)	Mixing Tolerance	Fermentation time (min)	Oven Temp (F)	Baking Time (min)
А	1	Pup-loaf straight dough	100 g	Mixograph	90 min	400	25
В	2	Pup-loaf straight dough	100 g, approx 170 g	Mixograph	90 min	400	25
С	3	Pup-loaf straight dough	100 g	Mixograph	90 min	400	25
D	4	Pup-loaf straight dough	100 g flour, approx 160 g dough	Farinograph	120 min	425	20
Е	5	Sponge and dough	700 g flour, 19 oz	Farinograph	180 min (sponge) and 70 min (fermentation)	420	20
F	6	Pup-loaf straight dough	100 g flour, approx. 175 g dough	Farinograph and Mixograph	180 fermentation and 60 min proof time	400	25
G	7	Pup-loaf straight dough	200g, 170 g dough	Mixograph	180 min	419	24
Н	8	Sponge and dough	1000 g flour, 500 g dough	Farinograph	240 min	425	20
I	9	Sponge and dough	600 g flour, 480 g dough	Other	240 min (sponge time) and 45 min (fermentation)	420	20
J	10	Pup-loaf straight dough	100 g flour, approx 170 g dough	Mixograph	120 min	420	18
K	11	Pup-loaf straight dough	100 g flour, approx 175 g dough	Mixograph	90 min	425	21
L	12	Sponge and dough	540 g dough	Mixing series	210 min	430	23
М	13	Pup-loaf straight dough	100 g		90 min	401	22
Ν	14	Straight dough	700 g flour, 525 g dough	Mixing series	120 min	400	25
0	15	Sponge and dough	700 g flour, 524 g dough	Farinograph with mixing evalu	240 min (sponge time) and 60 min (fermentation)	420	20
Р	16	Sponge and dough	600 g flour, 160 g dough	Mixing series	240 min	425	16

APPENDIX B

HWWQC Technical Board and Goals for HWW Breeders

Hard Winter Wheat Quality Council

2019 Technical Board Officers

CHAIR:	Reuben McLean, Grain Craft
VICE CHAIR:	Tess Brensing, ADM Milling
SECRETARY:	Rich Kendrick, Great Plains Analytical Lab
MEMBER:	Stephen Baenziger, University of Nebraska
MEMBER:	Chris Kirby, Oklahoma Wheat Commission

2019 Quality Evaluation & Advisory Committee

Brad Seabourn, USDA/ARS/HWWQL

Terry Selleck, Bay State Milling

Jon Rich, Syngenta/AgriPro

Craig Warner, BIMBO Bakeries USA

Richard Chen, USDA/ARS/HWWQL

Hard Winter Wheat Quality Council (HWWQC)

Charter Revised and Approved (February 20, 2003)

Mission, Policy, and Operating Procedure

The mission of the HWWQC is to provide a forum for leadership and communication in promoting continuous quality improvement among the various elements of the community of hard winter wheat interests. The HWWQC will provide an organization structure to evaluate the quality of hard winter wheat experimental lines and cultivars that may be grown in the traditional growing regions of the United States. The HWWQC also will establish other activities as requested by the membership. The HWWQC operates under the direction and supervision of the Wheat Quality Council (WQC).

Objectives

- Encourage wide participation by all members of the hard winter wheat industry.
- Determine, through professional consulting expertise, the parameters and ranges that adequately describe the performance characteristics that members seek in new and existing cultivars.
- Promote the enhancement of hard winter wheat quality in new cultivars.
- Emphasize the importance of communication across all sectors and provide resources for education on the continuous quality improvement and utilization of hard winter wheat.
- Encourage the organizations vital to hard winter 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. Hard Winter Wheat Quality Laboratory in Manhattan, KS.

Membership

• The membership of the HWWQC will consist of members of the WQC.

HWWQC Technical Board

- The Technical Board shall be the administrative unit responsible for managing the functions of the HWWQC.
- The Technical Board shall consist of five members, elected from the membership, to serve three-year terms.
- Officers of the technical board shall consist of a chair, vice-chair, and secretary.
- Each officer serves three years in his or her office.
- Terms start the day after the annual meeting of the HWWQC.
- The vice-chair generally replaces the chair at the conclusion of the chair's term and the secretary generally 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 HWWQC 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 technical board and the WQC Executive Vice President. The appointee will serve the remaining term of the vacancy (up to three years).
- Exceptions to the above may be granted if voted on by the Technical Board or by majority vote of the HWWQC 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 Wheat Quality Council (selected elements of the General Meeting).
- 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 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

• The WQC Executive Vice President for some technical board functions may authorize certain paid expenses.

Hard Winter Wheat Quality Evaluation and Advisory Committee

Committee Purpose

A technical committee entitled "Hard Winter Wheat Quality Evaluation and Advisory Committee" shall be established and consist of the five technical board members and key WQC members working on hard winter wheat. Those members should include, but are not limited to:

- The director of the USDA Hard Winter Wheat Quality Laboratory, Manhattan, KS.
- At least one hard winter wheat breeder from the Great Plains area.
- At least one cooperator from hard winter wheat milling or baking laboratories.
- The senior scientist/editor responsible for the hard winter wheat quality annual report.

Evaluation and Responsibilities

- Establish procedures and requirements for the annual grow out (if applicable), handling, evaluation and reporting of the experimental test line quality evaluation program.
- Annual approval of the samples submitted by hard winter wheat breeders.
- The collection milling and reporting of the experimental and check samples.
- Distribution of samples to cooperators (member companies willing to conduct testing and baking evaluations on the samples prepared)
- Preparation of an annual quality report.

Sample/Locations

• Each breeder entity shall have the privilege of submitting two experimental test lines and one check cultivar each year for evaluation. If slots are available by some breeders not submitting the full allotment, other breeders may submit more than two up to a maximum of 30 samples annually.

Annual Meeting

- The annual meeting of the HWWQC 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 cooperators quality testing program, elect board members and carry on other business as required by the HWWQC.
- The Technical Board may establish other meetings determined to be necessary.

Finances and Budget

- The executive board of the WQC shall designate the finances required to meet the operating expenses of the HWWQC.
- The budget shall be presented for membership approval at the annual meeting.

Amendments

- Amendments to the policy and operation procedure of the HWWQC can be made by majority vote of the HWWQC members.
- 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.

Outlined Goals for Hard Winter Wheat Breeders

Developed by the

Grain Trade, Operative Millers, and Mill Chemists Subcommittees of the

Wheat Quality Council Hard Winter Wheat Technical Committee

- 1. Adaptability. Varieties should be adaptable and retain their quality integrity over a large geographic area.
- 2. Varieties should be resistant to diseases, to insect infestation (including stored grain insects), and to sprouting.
- 3. Emphasize quality evaluation in earlier generations. Obtain milling and baking data before F7. Grain and Texture should be considered along with loaf volume, absorption, mixing, and dough properties when evaluating baking quality.
- 4. Kernel Characteristics:
 - A. Visual Appearance typical of class.
 - B. Hardness significantly greater than soft wheat, but not so hard that milling or flour properties are negatively influenced.
 - C. Uniformly large, plump, vitreous.

		Minimum
	Objective	Acceptable
Bushel Weight (lb.)	60+	58
Thousand Kernel Wt. (g)	30+	24
Over 7 Wire (%)	60+	50

5. Milling Performance. Should mill easily to produce a high extraction (yield) of quality flour. Reduction, sifting, and stock-handling consistent with class history.

Performance on KSU Pilot Mill

	Objective	Acceptable
Straight Grade Extraction		
% at .48% ash	76	74 (minimum)
StrGr. Agtron Color	50	40 (minimum)
StrGr. Flour Ash (%)	0.46	0.50 (maximum)

6. Gluten Strength-Mixing Time. About 60% strong and 40% mellow should be acceptable in the seeded acreage. A reasonably broad range of gluten strength

is needed to meet current demands of various flour users. One variety or gluten type is undesirable.

7. Improved Mixing Tolerance with 'extensible gluten', <u>not</u> bucky or tough.

APPENDIX C

Hard Red Winter Wheat Quality Targets



RECOMMENDED* QUALITY TARGETS FOR HARD RED WINTER WHEAT

HWW Quality Targets Committee Approved February, 2006



* "The purpose of Recommended Quality Targets (RQT) for Hard Red Winter Wheat (HRW) is to provide specific quality 'goals' for the breeding community, wheat producers, and marketing programs in order to assist and guide the decisions needed to maintain the consistency and end-use quality of the U.S. HRW market class. The RQT will be dynamic over time in direct response to the primary needs of the marketplace (domestic and foreign), and the needs of the U.S. industry to breed, produce and market wheats to meet market needs. The RQT should NOT be used as essential criteria for variety release decisions in breeding programs, or as marketing/grading standards for private companies or federal/state agencies. This **Statement of Purpose** <u>must</u> accompany all published forms of the RQT."

Quality Parameter (End-Use: Pan Bread)	Recommended Target Value
Wheat	
Test Weight (lb/bu)	> 60
SKCS-Hardness Index (SK-HI)	60 - 80
SK-HI Standard Deviation	< 17.0
SKCS-Weight (SK-WT, mg)	> 30.0
SK-WT Standard Deviation	< 8.0
SKCS-Diameter (SK-SZ, mm)	> 2.40
SK-SZ Standard Deviation	< 0.40
Protein Content (%, 12% mb)	> 12.0
Ash Content (%, 12% mb)	< 1.60
Falling Number (sec)	> 300
Straight Grade Flour Yield (%)	> 68
Flour	
Flour Color L-Value (Minolta Colorimeter)	> 90
Gluten Index	> 95
Sedimentation Volume (cc)	> 40
Farinograph:	
Water Absorption (%, 14% mb)	62+
Peak Time (min)	4.00 - 8.00
Stability (min)	10.00-16.00
<u>Mixograph:</u>	
Water Absorption (%, 14% mb)	62+
Peak Time (min)	3.00 - 6.00
Mixing Tolerance (HWWQL Score, 0-6)	3.0
<u>Straight Dough Pup Method:</u>	
Water Absorption (%, 14% mb)	<i>62</i> +
Mix Time (min)	3.00 - 5.00
Loaf Volume (cc)	> 850
Crumb Score (HWWQL Score, 0-6)	> 3.0

CONTACT: USDA/ARS CGAHR Hard Winter Wheat Quality Laboratory 1515 College Avenue, Manhattan, KS 66502-2796 VOICE: (785) 776-2751 FAX: (785) 537- 5534 EMAIL: brad.seabourn@usda.gov

APPENDIX D

Hard White Wheat Quality Targets Adopted from PNW for Great Plains

Hard White Wheat Quality Targets Dual Purpose -- Chinese Noodles and Western Pan Bread

Updated on March 1, 2002 at Hard White Wheat Quality Targets Meeting Wheat Marketing Center, Portland, Oregon

	Chinese Hard-Bite			
	Noodles (1)	Pan Bread		
Wheat Quality Parameter				
Test Weight (lb/bu)	60 Minimum	60 Minimum		
Kernel Hardness (SKCS 4100)	65 - 90	65 Minimum		
Kernel Diameter (mm) (SKCS 4100)	2.5 Minimum	2.5 Minimum		
Falling Number (seconds)	300 Minimum	300 Minimum		
Protein (%, 12% mb)	11-15.0	11.5-14.0		
Ash (%, 14% mb)	1.4 Maximum	1.6 Maximum		
PPO Level by L-DOPA (WWQL Method)	0	N/A		
Flour Quality Parameter				
Protein (%, 14% mb)	10-13.5	10.2-13		
Ash (14% mb)	0.38-0.45	N/A		
Patent Flour Yield at 0.4% Ash (%)	60 (by Buhler)	N/A		
Straight-Grade Flour Yield at 0.45% Ash (%)	70 (by Buhler)	N/A		
L* (Minolta Colorimeter CR 310)	91 Minimum	N/A		
Wet Gluten (%, 14% mb)	30 Minimum (2)	28		
Farinograph Absorption (%, 14% mb)	60 Minimum (2)	60		
Farinograph Stability (minutes)	12 Minimum (2)	12		
Amylograph Peak Viscosity (Bu) (3)	500-850	500 minimum		
Mixograph Peak Time (minutes)	N/A	3-7 @ 5.5 mm peak ht.		
Mixograph Absorption (%)	N/A	60		
Chinese Raw Noodle Quality Parameter (Refer to WMC Protocol) (4)				
Chinese Raw Noodle Dough Sheet L*24 h	72 Minimum	N/A		
Chinese Raw Noodle Dough Sheet L*0-L*24	10 Maximum	N/A		
Chinese Raw Noodle Dough Sheet b* 24 h	25 Maximum	N/A		
Cooked Noodle Hardness (g)	1250 Minimum (2)	N/A		
Pan Bread Quality Parameter				
Pup Loaf Volume (cc)	N/A	900 @11% flour protein		

Notes:

(1) Chinese raw, Chinese wet, Chinese instant fried, Philippine instant fried, Malaysia hokkien and Thai bamee noodles.

(2) Straight-grade flour of 12% protein wheat.

(3) Method: 65 g untreated flour + 450 ml deionized water.

(4) Noodle formula: straight-grade flour, 100%; water, 28%; and sodium chloride, 1.2%. Noodle sizes: 2.5 mm (width) x 1.2 mm (thickness).

Noodle textural measurement: cook 100 g noodles in 1000 ml deionized water for 5 min, rinse in 27⁰C water and drain. Measure noodle texture on five noodle strands by compressing to 70% of noodle thickness with a 5-mm flat probe attached to TA.XT2 Texture Analyzer.

These end-use quality targets emphasize the broadest possible utilization of hard white wheats.
Wheat Marketing Center, Portland, Oregon

	Korean Instant	Chinese Northern-Type	Hamburger/Hotdog
	Noodles	Steamed Bread	Buns
Wheat Quality Parameter			
Test Weight (lb/bu)	60 Minimum	60 Minimum	60 Minimum
Kernel Hardness (SKCS 4100)	65 Minimum	65 Minimum	65 Minimum
Kernel Diameter (mm) (SKCS 4100)	2.5 Minimum	2.5 Minimum	2.5 Minimum
Falling Number (seconds)	300 Minimum	350-400	300 Minimum
Protein (%, 12% mb)	10-11.0	10-11.5	13-15.0
Ash (%, 14% mb)	1.4 Maximum	1.4 Maximum	1.6 Maximum
PPO Level by L-DOPA (WWQL Method)	0-0.2	0-0.2	N/A
Flour Quality Parameter			
Protein (%, 14% mb)	8.5-9.5	8.5-10.0	12.2-13.0
Ash (14% mb)	0.38-0.40	0.38-0.45	N/A
Patent Flour Yield at 0.4% Ash (%)	60 (by Buhler)	60 (by Buhler)	N/A
Straight-Grade Flour Yield at 0.45% Ash (%)	70 (by Buhler)	70 (by Buhler)	N/A
L* (Minolta Colorimeter CR 310)	91 Minimum	91 Minimum	N/A
Wet Gluten (%, 14% mb)	N/A	28-30	34.5
Farinograph Absorption (%, 14% mb)	58-60	60-62	64
Farinograph Stability (minutes)	7.5-8.5	4-6.0	15-18.0
Amylograph Peak Viscosity (Bu) (1)	800 Minimum	500 Minimum	500 Minimum
Amylograph Breakdown (Bu)	200 Minimum	N/A	N/A
Mixograph Peak Time (minutes)	N/A	N/A	4-7 @ 5.8 mm peak ht.
Mixograph Absorption (%)	N/A	N/A	64
Pan Bread Quality Parameter			
Pup Loaf Volume (cc)	N/A	N/A	980 @ 13% flour protein

Notes:

(1) Method: 65 g untreated flour + 450 ml deionized water.

APPENDIX E

WQC Business Meeting Minutes Feb. 21, 2019

Hard Winter Wheat Quality Council Meeting Minutes Annual Meeting February 21, 2019

Meeting Minutes of the Hard Winter Wheat Quality Council February 21, 2019 Kansas City, Missouri

Scott Baker opened and conducted this year's meeting

<u>Review of 2018 Minutes</u> – approved as-is

Nomination and Election for 2 new members: Rich Kendrick Great Plains Analytical Lab nominated and elected Oklahoma Grain Commission nominated and elected Chris Kirby Board for 2019: Chairman Reuben McLean Grain Craft Vice Chairman Tess Brensing ADM Milling Secretary Rich Kendrick Great Plains Analytical Lab Stephen Baenziger, University of Nebraska Member Member Chris Kirby Oklahoma Wheat Commission

Overview of Wheat Tours:

Dave Green gave an overview of the two Wheat Crop Quality tours. The HRW tour in Kansas Begins on April 29. Everybody will meet in Manhattan. People are assigned to a car and they will travel on their designated route to Colby, Ks. Then there is a dinner and meeting in Colby where the days results are discussed. The next day they leave from Colby and follow designated routes to Wichita. The final day they leave from Wichita and end back in Manhattan. It is a great learning opportunity for new people in the industry. You will always have at least one experienced person in each vehicle. There is also an HRS tour in July that starts in Fargo and goes through North Dakota, parts of South Dakota and Minnesota.

Overview of Milling of Wheat Samples - Paul Blodgett - Kansas State University

- 2018 Repairs on Miag (on- going maintenance)
 - Change ducting and adjusting air-balance
- Sample Milling
 - 32 wheat samples received in late September and milling was started in early October and the flour samples sent to the collaborators to arrive by November 1
 - Miag mill functioned well with flour samples having ash levels in the low 0.50's, comparable with commercial mills.

WQC Report for 2017 Richard Chen USDA / ARS Manhattan

- 32 entries, 10 breeding Programs, 19 baking cooperators
- Jagalene was used as a common check
- 9 entries were submitted as a set from Northern States, including, NE, MT, SD and ND
- Samples were milled on Miag Mil at KSU
- Physical, chemical, flour and dough testing performed at HWWQL in Manhattan

Soft Wheat Update- Byung-Kee Baik

Byung-Kee Baik gave update for Soft Wheat. The Soft Wheat Quality Council will hold their own separate meeting in Raleigh, North Carolina April 23-25. Byung Kee invited all who were interested to attend the meeting in Raleigh.

2018 HRW Crop Overview- Mark Hodges, Plains Grains

- Another challenging crop year usual unusual year
 - Crop started good in most locations with acceptable moisture at planting however there were draught conditions through the Southern Plains through most of spring. Much of wheat crop rated poor or very poor going into Harvest. Finally got late rains right
 - \circ TX / OK the moisture was too late to help the crop
 - Kansas benefited from late moisture
 - Crop showed very good protein content and overall good quality, much stronger than previous 2 crop years.

State Crop Conditions

- Texas- Jackie Rudd, Texas A & M gave brief overview of Texas crop conditions
- Oklahoma- Chris Kirby, Oklahoma Wheat Commission gave brief overview of Oklahoma crop conditions
- Kansas Aaron Harries, Kansas Wheat gave brief overview of Kansas crop conditions
- Nebraska- Royce Schaneman, NE Wheat Board gave brief overview of Nebraska crop conditions

- Colorado- Brad Erker, CO Wheat Admin Committee gave a brief overview of Colorado crop conditions
- South Dakota-
- Montana- Cassidy Marn, MT Wheat & Barley gave brief overview of Montana conditions.

Financial Report

Dave Green gave the Financial Report. The HRW Board is good financial shape.

Scott Baker moved to adjourn meeting Seconded by Rich Kendrick

APPENDIX F

Historical WQC Hard Winter Wheat Entries from 2001 to 2019

2019						
Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Byrd	19-2401	HRW	check			Colorado
Jagalene (CC01)	19-2402	HRW	check			Colorado
CO13D0787	19-2403	HRW	yes	Guardian	2019	Colorado
CO15SFD107	19-2404	HRW	yes	Fortify SF	2019	Colorado
CO15D098R	19-2405	HRW	no			Colorado
TAM 114	19-2406					Texas
TX14A001035	19-2407					Texas
TX14M7061	19-2408					Texas
Jagalene (CC02)	19-2409					Oklahoma
Ruby Lee	19-2410					Oklahoma
OK16D101089	19-2411	HRW	pending		2020	Oklahoma
OK168512	19-2412	HRW	pending		2020	Oklahoma
OCW04S717T-6W	19-2413	HW	pending		2020	Oklahoma
OK12912C-138407-2	19-2414	HRW	pending		2020	Oklahoma
Jagalene (CC03)	19-2415					Limagrain
ERYTHR02420-2010	19-2416					Limagrain
Jagalene (CC04)	19-2417					Kansas-Hays
KS15H116-6-1	19-2418	HRW	yes	KS DALLAS	2019	Kansas-Hays
KS15H161-1-4	19-2419	HRW	yes	KS WESTERN STAR	2019	Kansas-Hays
Danby	19-2420					Kansas-Hays
Jagalene (CC05)	19-2421					Monsanto
MODI4-5179	19-2422	HRW	yes	WB4505	2019	Monsanto
NEDI4-5304	19-2423	HRW	yes	WB4309	2019	Monsanto
Jagalene (CC06)	19-2424					Northern States
NW13493	19-2425	HWW	Too soon			Nebraska
NE14691	19-2426	HRW	Too soon			Nebraska
SD14113-3	19-2427	HRW	yes	Draper	2019	South Dakota
MTCS1601R	19-2428	HRW	yes	to be decided	2019	Montana
MT1683	19-2429					Montana
204.0						
2018						
Jagalene (CC01)	18-2401					Texas
TAM 111	18-2402					Texas
TX12V7415	18-2403	HRW	under con	sideration		Texas
LINK	18-2404					Limagrain
Jagalene (CC02)	18-2405					Limagrain
DH11HRW53-34	18-2406					Limagrain
LCI13DH-22-22	18-2407					Limagrain
MOD14-4919	18-2408				TBD	Monsanto
Jagalene (CC03)	18-2409					Monsanto
H4N13-0253	18-2410	HRW	yes	N/A	2017	Monsanto
Danby	18-2411					Kansas-Hays
Jagalene (CC04)	18-2412					Kansas-Hays
KS14H180-4-63	18-2413		no			Kansas-Hays
Jagalene (CC05)	18-2414					Syngenta
10BC107#115	18-2415					Syngenta
SY Monument	18-2416					Syngenta

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
08BC379-40-1	18-2417					Syngenta
Jagalene (CC06)	18-2418					Oklahoma
Ruby Lee	18-2419					Oklahoma
OK12716-159319-13	18-2420	HRW	yes	Showdown	2018	Oklahoma
OK13621	18-2421	HRW	yes	Baker's Ann	2018	Oklahoma
OK12206-127206-2	18-2422	HRW	yes	OK Corral	2019	Oklahoma
OK1059018-129332-5	18-2423	HRW	no			Oklahoma
Jagalene (CC07)	18-2424					Northern States
NE10478-1	18-2425	HRW		LCS Valiant	2019	Nebraska
NHH144913-3	18-2426	SRW	no			Nebraska
MT1564	18-2427	HWW	yes	Flathead	2019	Montana
MTS1588	18-2428	HRW	yes	Bobcat	2019	Montana
NORD58	18-2429	HWW	no			North Dakota
NORD62	18-2430	HWW	no			North Dakota
SD09227	18-2431	HRW	yes	Thompson	2017	Sourth Dakota
SD14115-5	18-2432	HRW	yes	Winner	2019	Sourth Dakota
2017						
SY Monument	17-2401	HRW				Syngenta
SY Achieve CL2	17-2402	XWHT	yes	SY Achieve CL2	2017	Syngenta
SY 517 CL2	17-2403	HRW	yes	S 517 CL2	2017	Syngenta
Jagalene (CC01)	17-2404	HRW				Syngenta
Jagalene (CC02)	17-2405	HRW				Texas
TAM 111	17-2406	HRW				Texas
TX11A001295	17-2407	HRW	no			Texas
TX12M4068	17-2408	HRW	no			Texas
Byrd	17-2409	HRW				Colorado
CO12D1770	17-2410	HRW				Colorado
Jagalene (CC03)	17-2411	HRW				Colorado
CO13D1783	17-2412	HRW				Colorado
CO12D2011	17-2413	HDWH	yes	Breck	2017	Colorado
Jagalene (CC04)	17-2414	HRW				Kansas-Hays
KS13HW92-3	17-2415	HDWH	yes	Venada	2018	Kansas-Hays
Danby	17-2416	HDWH				Kansas-Hays
KS14HW106-6-6	17-2417	HDWH	YES	KS SILVERADO	2019	Kansas-Hays
Yellowstone	17-2418	HRW				Montana
MT1465	17-2419	HRW	yes	FourOsix	2018	Montana
Jagalene (CC05)	17-2420	HRW				Montana
MTW1491	17-2421	HDWH				Montana
NI13706	17-2422	HRW	no			Nebraska
NE12561	17-2423	HRW	yes	Siege	2020	Nebraska
Jagalene (CC06)	17-2424	HRW				Nebraska
Jagalene (CC07)	17-2425	HRW				Monsanto
WB4623CLP	17-2426	HRW	yes	WB4623CLP	2014	Monsanto
WB4721	17-2427	HRW	yes	WB4721	2015	Monsanto
Ruby Lee	17-2428	HRW				Oklahoma
OK13621	17-2429	HRW	yes	Baker's Ann	2018	Oklahoma
OK12D22004-016	17-2430	HRW	no			Oklahoma
OCW04S7171T-6W	17-2431	HDWH	pending		2020	Oklahoma
Jagalene (CC08)	17-2432	HRW				Oklahoma

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
2016						
LCH13-048	16-2401	HRW				Limagrain
LCH13NEDH-12-27	16-2402	HRW				Limagrain
Jagalene (CC01)	16-2403	HRW				Limagrain
PSB13NEDH-11-26	16-2404	HRW				Limagrain
LCI13-069	16-2405	HWW				Limagrain
PSB13NEDH-14-83	16-2406	HWW				Limagrain
KS1256-6-4	16-2407	HRW	yes	Tatanka	2016	Kansas-Hays
Danby	16-2408	HWW				Kansas-Hays
Jagalene (CC02)	16-2409	HRW				Kansas-Hays
LCH13NEDH-14-53	16-2410	HWW	no			Nebraska
Jagalene (CC03)	16-2411	HRW				Nebraska
LCHNEDH-4-16	16-2412	HWW	no			Nebraska
Postrock	16-2413	HRW				Syngenta
Jagalene (CC04)	16-2414	HRW				Syngenta
AP11T2409	16-2415	HRW				Syngenta
Jagalene (CC05)	16-2416	HRW				Monsanto
HV9W10-0458	16-2417	HRW	yes	WB4515	2015	Monsanto
Jagalene (CC06)	16-2418	HRW	·			Oklahoma
Ruby Lee	16-2419	HRW				Oklahoma
OK10126	16-2420	HRW	yes	Spirit Rider	2017	Oklahoma
OK12D22004-016	16-2421	HRW	no	·		Oklahoma
OK12912C	16-2422	HRW	under Cons	ideration		Oklahoma
OK13209	16-2423	HRW	yes	Green Hammer	2018	Oklahoma
Everest	16-2424	HRW	,			Kansas-Manhattan
Jagalene (CC07)	16-2425	HRW				Kansas-Manhattan
Larry	16-2426	HRW				Kansas-Manhattan
Zenda	16-2427	HRW				Kansas-Manhattan
2015						
Jagalene (CC01)	15-2401	HRW				Kansas-Hays
Danby (IC)	15-2402	HRW				Kansas-Hays
KS11HW39-5	15-2403	HRW	yes	Joe	2015	Kansas-Hays
Jagalene (CC04)	15-2404	HRW				Nebraska
NE1059	15-2405	HRW	yes	Ruth	2016	Nebraska
Jagalene (CC06)	15-2406	HRW				Monsanto
BZ9W09-2075	15-2407	HWW	yes	WB4575	2015	Monsanto
HV9W10-1002	15-2408	HWW	yes	WB4303	2015	Monsanto
Jagalene (CC09)	15-2409	HRW				Colorado
Byrd (IC)	15-2410	HRW				Colorado
CO11D1397	15-2411	HRW				Colorado
CO11D1539	15-2412	HRW				Colorado
CO11D1767	15-2413	HRW				Colorado
Jagalene (CC14)	15-2414	HRW				Oklahoma
Gallagher (IC)	15-2415	HRW				Oklahoma
OK11D25056	15-2416	HRW	yes	Smith's Gold	2017	Oklahoma
OK13625	15-2417	HRW	yes	Skydance	2017	Oklahoma
OK10728W	15-2418	HWW	yes	Stardust	2017	Oklahoma

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Jagalene (CC19)	15-2419	HRW				Montana
Yellowstone (IC)	15-2420	HRW				Montana
MTS1224	15-2421	HRW	yes	Loma	2016	Montana
MT1265	15-2422	HRW				Montana
Ideal (IC)	15-2423	HRW				South Dakota
SD10257-2	15-2424	HRW	yes	Oahe	2016	South Dakota
LCH13DH-20-87	15-2425	HRW	yes	LCS Chrome	2015	Limagrain
2014						
Jagalene (CC01)	14-2401	HRW				Kansas_Hays
Danby (IC)	14-2402	HWW				Kansas_Hays
KS11HW15-4	14-2403	HWW				Kansas_Hays
KS11W39-5	14-2404	HWW				Kansas_Hays
Jagalene (CC05)	14-2405	HRW				Texas_Amarillo
TAM 111 (IC)	14-2406	HRW				Texas_Amarillo
TX08A001249	14-2407	HRW				Texas_Amarillo
TX09A001194	14-2408	HRW				Texas_Amarillo
TX09D1172	14-2409	HRW				Texas_Amarillo
Jagalene (CC10)	14-2410	HRW				Colorado
Byrd (IC)	14-2411	HRW				Colorado
CO11D174	14-2412	HRW	yes	Avery	2014	Colorado
CO11D446	14-2413	HRW	,			Colorado
Jagalene (CC)	14-2414	HRW				Nebraska
Camelot (IC)	14-2415	HRW				Nebraska
NE07531	14-2416	HRW				Nebraska
NE09521	14-2417	HRW				Nebraska
Jagalene (CC18)	14-2418	HRW				Montana
Yellowstone (IC)	14-2419	HRW				Montana
MT1078	14-2420	HRW				Montana
MT1138	14-2421	HRW				Montana
Jagalene (CC22)	14-2422	HRW				Oklahoma
Ruby Lee (IC)	14-2423	HRW				Oklahoma
OK09125	14-2424	HRW	ves	Bentley	2015	Oklahoma
OK10126	14-2425	HRW	ves	Spirit Rider	2017	Oklahoma
Jagalene (CC26)	14-2426	HRW	,		;	Kansas Manhattan
KanMark	14-2427	HRW				Kansas Manhattan
06BC722#25	14-2428	HRW	ves	SY Flint	2015	Agrinro
06BC796#68	14-2429	HRW	yes	SY Sunrise	2015	Agripro
2013						
Check Blend (check)	13-2401	HRW				Limagrain
LCH08-80	13-2402	HRW				Limagrain
ICS Mint	13-2403	HRW				Limagrain
Danby (check)	13-2404	HWW				Kansas-Hays
Oakley CL	13-2405	HRW	yes	Oakley CL	2013	Kansas-Hays
KS10HW78-1	13-2406	HWW				Kansas-Hays
Lyman (check)	13-2407	HRW				South Dakota
SD08200	13-2408	HRW				South Dakota
SD09192	13-2409	HRW				South Dakota

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Postorock (check)	13-2410	HRW				Agripro
04BC574-2	13-2411	HRW	yes	SY Monument	2014	Agripro
Millennium (check)	13-2412	HRW				Nebraska
NE09521	13-2413	HRW				Nebraska
NE08499	13-2414	HRW				Nebraska
Yellowstone (check)	13-2415	HRW				Montana
MT1090	13-2416	HRW				Montana
MTW08168	13-2417	HWW	yes	WB3768	2013	Montana
Ruby Lee (check)	13-2418	HRW				Oklahoma
Doublestop CL+	13-2419	HRW	yes	Doublestop CL+	2013	Oklahoma
OK09125	13-2420	HRW	yes	Bentley	2015	Oklahoma
2012						
WB-Stout (check)	12-2401	HRW				Westbred
HV9W07-1028	12-2402	HRW				Westbred
Millennium (check)	12-2403	HRW				Nebraska
NW07505	12-2404	HWW				Nebraska
NE06545	12-2405	HRW	yes	Freeman	2012	Nebraska
NE06607	12-2406	HRW				Nebraska
Byrd (check)	12-2407	HRW				Colorado
Snowmass (check)	12-2408	HWW				Colorado
CO07W245	12-2409	HWW	yes	Antero	2012	Colorado
CO07W722-F5	12-2410	HWW				Colorado
Billings (check)	12-2411	HRW				Oklahoma
Ruby Lee	12-2412	HRW				Oklahoma
, Gallagher (OK07214)	12-2413	HRW	ves		2012	Oklahoma
lba (OK07209)	12-2414	HRW	ves		2012	Oklahoma
OK09634	12-2415	HRW	no			Oklahoma
Lyman (check)	12-2416	HRW				South Dakota
SD08080	12-2417	HRW				South Dakota
SD06158	12-2419	HRW	Ves	Redfield	2013	South Dakota
Vellowstone (check)	12-2410	HRW	yes	neuneu	2015	Montana
MT08172	12-2415		VOC	Coltor	2012	Montana
MT00172	12-2420		yes	Northorn	2012	Montana
TAM 111 (chock)	12-2421		yes	Northern	2015	Toyac
	12-2422					Toyac
TYN2AN562 07	12-2423 12-2424					Toyac
170340303-07	12-2424	ПКVV				TEXAS
2011						
Danhy (check)	11 2404					Kancas Have
	11 2401		Noc			Kansas-Have
	11-2402		yes	Clara Cl	2011	Kansas-Hays
	11-2403		yes	Clara CL	2011	Nansas-mays
POSTROCK (Check)	11-2404					Agripro
SY Wolf	11-2405	HKW	yes		2042	AgriPro
Syngenta Exp 138-45	11-2406	HRW	yes	SY Southwind	2012	AgriPro
Fuller (check)	11-2407	HKW		4055	2245	Kansas-Manhattan
KS020319-7-3	11-2408	HRW	yes	1863	2012	Kansas-Manhattan
KS020633M-13	11-2409	HRW	no			Kansas-Manhattan
McGill (check)	11-2410	HRW				Nebraska

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
NE05496	11-2411	HRW	no			Nebraska
NE05548	11-2412	HRW	no			Nebraska
NI08708	11-2413	HRW	no			Nebraska
Jagalene (check)	11-2414	HRW				Westbred
HV9W06-509	11-2415	HWW	yes	WB-Grainfield	2012	Westbred
Yellowstone (check)	11-2416	HRW				Montana
MTS0808	11-2417	HRW	yes	Warhorse	2013	Montana
MT0871	11-2418	HRW	no			Montana
Lyman (check)	11-2419	HRW				South Dakota
SD06158	11-2420	HRW	yes	Redfield		South Dakota
SD07184	11-2421	HRW	no			South Dakota

2010						
Lyman (check)	10-2401	HRW				SDSU
SD05118-1	10-2402	HRW	yes	Ideal	2011	SDSU
SD06158	10-2403	HRW	yes	Redfield		SDSU
Hatcher (check)	10-2404	HRW				CSU
CO050303-2	10-2405	HRW	yes	Denali	2011	CSU
CO06052	10-2406	HRW	yes	Brawl CL Plus	2011	CSU
CO06424	10-2407	HRW	yes	Byrd	2011	CSU
Millennium (check)	10-2408	HRW				NU
NE03490	10-2409	HRW	no			NU
NE04490	10-2410	HRW	no			NU
Billings (check)	10-2411	HRW				OSU
OK05526	10-2412	HRW	yes	Ruby Lee	2011	OSU
OK05212	10-2413	HRW	yes	Garrison	2011	OSU
OK07231	10-2414	HRW	no			OSU
Smoky Hill (check)	10-2415	HRW				Westbred
HV9W06-262R	10-2416	HRW	no			Westbred
HV9W06-218W	10-2417	HWW	no			Westbred
Yellowstone (check)	10-2418	HRW				MSU
MTS0721	10-2419	HRW	yes	Bearpaw	2011	MSU
TAM 111 (check)	10-2420	HRW				TAMU
TX05A001822	10-2421	HRW	no			TAMU
TX06A001263	10-2422	HRW	no			TAMU

2009						
Smoky Hill (check)	09-2401	HRW				Westbred
Stout (HV9W03-539R)	09-2402	HRW	yes	WB-Stout	2009	Westbred
RonL (check)	09-2403	HWW				KSU-Hays
Tiger	09-2404	HWW	yes			KSU-Hays
Hatcher (check)	09-2405	HRW				CSU
CO04393	09-2406	HRW	no			CSU
CO04499	09-2407	HRW	no			CSU
OK Bullet (check)	09-2408	HRW				OSU
Billings	09-2409	HRW	yes			OSU
OK05526	09-2410	HRW	yes	Ruby Lee	2011	OSU
PostRock (check)	09-2411	HRW				AgriPro
CJ	09-2412	HRW	yes			AgriPro

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
SY Gold (AP00x0100-51)	09-2413	HRW	yes	SY Gold	2010	AgriPro
Yellowstone (check)	09-2414	HRW				MSU
MT06103	09-2415	HRW	no			MSU
MTS0713	09-2416	HRW	yes	Judee	2011	MSU
TAM 111 (check)	09-2417	HRW				TAMU
TX02A0252	09-2418	HRW	yes	TAM 113	2010	TAMU
Millennium (check)	09-2419	HRW				NU
NE01481	09-2420	HRW	yes	McGill	2010	NU
NI04421	09-2421	HRW	yes	Robidoux	2010	NU

2008						
Jagalene (check)	08-2401	HRW				AgriPro
Art	08-2402	HRW	yes			AgriPro
Hawken	08-2403	HRW	yes			AgriPro
NuDakota	08-2404	HRW	yes			AgriPro
Hatcher (check)	08-2405	HRW				CSU
Thunder CL	08-2406	HWW	yes			CSU
CO03W054	08-2407	HWW	yes	Snowmass		CSU
CO03064	08-2408	HRW	no			CSU
Danby (check)	08-2409	HWW				KSU-Hays
Tiger	08-2410	HWW	yes			KSU-Hays
Karl 92 (check)	08-2411	HRW				KSU-Manhattan
KS970093-8-9-#1	08-2412	HRW	yes	Everest	2009	KSU-Manhattan
OK Bullet (check)	08-2413	HRW				OSU
OK03305	08-2414	HRW	yes	Pete	2009	OSU
OK03522	08-2415	HRW	yes	Billings	2009	OSU
OK03825-5403-6	08-2416	HRW				OSU
Tandem (check)	08-2417	HRW	yes	STARS0601W	2006	SDSU
SD05W030	08-2418	HWW	no			SDSU

2007						
Hatcher (check)	07-2401	HRW				CSU
CO03W239	07-2402	HWW	yes	Thunder CL	2008	CSU
CO03W054	07-2403	HWW	yes	Snowmass		CSU
CO02W237	07-2404	HWW	no			CSU
Millennium (check)	07-2405	HRW				NU
NH03614	07-2406	HRW	yes	Settler CL	2008	NU
OK Bullet (check)	07-2407	HRW				OSU
OK00514-05806	07-2408	HRW	no			OSU
OK05737W	07-2409	HWW	no			OSU
OK03522	07-2410	HRW	yes	Billings	2009	OSU
OK02405	07-2411	HRW	no			OSU
Tandem (check)	07-2412	HRW				SDSU
SD98W175-1	07-2413	HRW	no			SDSU
SD01058	07-2414	HRW	no			SDSU
SD0111-9	07-2415	HRW	yes	Lyman	2008	SDSU
SD01273	07-2416	HRW	no			SDSU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Genou (check)	07-2417	HRW				MSU
MT0495	07-2418	HRW	no			MSU
MTS04114	07-2419	HRW	no			MSU
2000						
2006						
Overley (check)	06-2401	HRW				KSU-Manhattan
Fuller	06-2402	HRW	yes			KSU-Manhattan
KS990498-3-&~2	06-2403	HRW	no			KSU-Manhattan
KS970274-14*9	06-2404	HRW	no			KSU-Manhattan
Overley (check)	06-2405	HRW				Westbred
Smoky Hill	06-2406	HRW	yes			Westbred
Aspen	06-2407	HRW	yes			Westbred
Millennium (check)	06-2408	HRW				NU
NW98S097	06-2409	HRW	yes	Anton	2008	NU
N02Y5117	06-2410	HRW	yes	Mace	2007	NU
NE01643	06-2411	HRW	yes	Overland	2007	NU
NE02584	06-2412	HRW	no			NU
OK Bullet (check)	06-2413	HRW				OSU
Duster	06-2414	HRW	yes			OSU
OK01420	06-2415	HRW	no			OSU
OK02405	06-2416	HRW	no			OSU
OK02522W	06-2417	HWW	yes	OK Rising	2008	OSU
Tandem (check)	06-2418	HRW				SDSU
SD96240-3-1	06-2419	HRW	no			SDSU
SD01122	06-2420	HRW	no			SDSU
SD01W065	06-2421	HWW	no			SDSU
TAM 111 (check)	06-2422	HRW				TAMU
TAM 112	06-2423	HRW	yes			TAMU
TX01A5936	06-2424	HRW	no			TAMU
TX01D3232	06-2425	HRW	yes	TAM 304	2006	TAMU
TX01V5314	06-2426	HRW	yes	TAM 203	2007	TAMU
2005						
Akron (check)	05-2401	HRW				CSU
CO00016	05-2402	HRW	yes	Ripper	2006	CSU
Jagger (check)	05-2403	HRW				KSU-Hays
2137	05-2404	HRW	yes			KSU-Hays
KS03HW6-6	05-2405	HWW	no			KSU-Hays
KS03HW158-1	05-2406	HWW	yes	RonL		KSU-Hays
Jagger (check)	05-2407	HRW				AgriPro
Neosho	05-2408	HRW	yes			AgriPro
W03-20	05-2409	HRW	yes	Postrock	2005	AgriPro
Goodstreak (check)	05-2410	HRW				NU
Infinity CL	05-2411	HRW	yes			NU
OK Bullet (check)	05-2412	HRW	-			OSU
OK93p656H3299-2c04	05-2413	HRW	yes	Duster	2006	OSU
OK01307	05-2414	HRW	, no			OSU
OK03918C	05-2415	HRW	yes	Centerfield	2006	OSU
OK00611W	05-2416	HWW	no			OSU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Tandem (check)	05-2417	HRW				SDSU
Crimson	05-2418	HRW	yes			SDSU
SD97059-2	05-2419	HRW	no			SDSU
SD01W064	05-2420	HWW	no			SDSU
	_					
2004						
Jagger (check)	04-2401	HRW				KSU-Hays
2137	04-2402	HRW	yes			KSU-Hays
KS02HW34	04-2403	HWW	yes	Danby	2005	KSU-Hays
KS02HW35-5	04-2404	HWW	no			KSU-Hays
KS03HW158	04-2405	HWW	yes	RonL	2006	KSU-Hays
Antelope (check)	04-2406	HRW				NE-USDA-ARS
Arrowsmith	04-2407	HRW	yes			NE-USDA-ARS
NW99L7068	04-2408	HRW	no			NE-USDA-ARS
Millennium (check)	04-2409	HRW				NU
NE99495	04-2410	HRW	yes	NE99495	2005	NU
OK102 (check)	04-2411	HRW	•			OSU
OK00618W	04-2412	HWW	yes	Guymon	2005	OSU
OK99212	04-2413	HRW	, no			OSU
OK00514	04-2414	HRW	ves	OK Bullet	2005	OSU
OK02909C	04-2415	HRW	ves	Okfield	2005	OSU
Tandem (check)	04-2416	HRW	,			SDSU
SD97W609	04-2417	HWW	ves	Alice	2006	SDSU
SD97538	04-2418	HRW	no			SDSU
SD98102	04-2419	HRW	ves	Darrell	2006	SDSU
			,			
2003						
Akron (check)	03-2401	HRW				CSU
CO980607	03-2402	HRW	yes	Hatcher	2004	CSU
CO00D007	03-2403	HRW	yes	Bond CL	2004	CSU
Jagger (check)	03-2404	HRW				KSU-Hays
2137	03-2405	HRW	yes			KSU-Hays
KS01HW152-6	03-2406	HWW	no			KSU-Hays
KS01HW163-4	03-2407	HWW	no			KSU-Hays
KS02HW34	03-2408	HWW	yes	Danby	2005	KSU-Hays
Jagger (check)	03-2409	HRW				KSU-Manhattan
2137	03-2410	HRW	yes			KSU-Manhattan
Overley	03-2411	HRW	yes			KSU-Manhattan
, KS940786-6-9	03-2412	HRW	, no			KSU-Manhattan
OK 102 (check)	03-2413	HRW				OSU
OK94P549-11	03-2414	HRW	ves	Endurance	2004	OSU
OK98690	03-2415	HRW	ves	Deliver	2004	OSU
Crimson (check)	03-2416	HRW	, 20			SDSU
SD97W604	03-2417	HWW	ves	Wendv	2004	SDSU
SD92107-5	03-2418	HRW	no		2001	SDSU
2002						
2002	00.0101					A 15
Jagger (check)	02-2401	HRW				AgriPro
Cutter	02-2402	HRW	yes			AgriPro

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Dumas	02-2403	HRW	yes			AgriPro
Jagalene	02-2404	HRW	yes			AgriPro
G1878 (check)	02-2405	HRW				Cargill
G980723	02-2406	HRW	no			Cargill
G970252W	02-2407	HWW	no			Cargill
Prowers (check)	02-2408	HRW				CSU
CO980376	02-2409	HRW	no			CSU
CO980607	02-2410	HRW	yes	Hatcher	2004	CSU
CO980630	02-2411	HRW	no			CSU
Jagger (check)	02-2412	HRW				KSU-Manhattan
KS940748-2-2	02-2413	HRW	no			KSU-Manhattan
KS940786-6-7	02-2414	HRW	yes	Overley	2003	KSU-Manhattan
KS940786-6-9	02-2415	HRW	no			KSU-Manhattan
Millennium (check)	02-2416	HRW				NU
NE97V121	02-2417	HRW	no			NU
NE98466	02-2418	HRW	no			NU
NE98471	02-2419	HRW	yes	Hallam	2004	NU
NI98439	02-2420	HRW	no			NU
2174 (check)	02-2421	HRW				OSU
OK102	02-2422	HRW	yes			OSU
OK95548-54	02-2423	HRW	no			OSU
OK95616-56	02-2424	HRW	no			OSU
OK96705-38	02-2425	HRW	no			OSU
ОК98699	02-2426	HRW	no			OSU
2001						
Jagger (check)	01-2401	HRW				Cargill
G970380A	01-2402	HRW	no			Cargill
G970209W	01-2403	HWW	no			Cargill
Prowers 99 (check)	01-2404	HRW				CSU
CO970547	01-2405	HRW	no			CSU
Millennium (check)	01-2406	HRW				NU
NE97426	01-2407	HRW	no			NU
NE97465	01-2408	HRW	yes	Goodstreak	2002	NU
NE97638	01-2409	HRW	yes	Empire	2002	NU
NE97669	01-2410	HRW	no			NU
NE97689	01-2411	HRW	yes	Harry	2002	NU
2174 (check)	01-2412	HRW				OSU
OK96717-99-6756	01-2413	HRW	no			OSU
OK97508	01-2414	HRW	yes	Ok102	2002	OSU













Thank you for reviewing this report of 2019 WQC Hard Winter Wheat milling and baking. Please let me know if you have any comments on this report. I can be reached at (785)776-2750 or by email, <u>Richard.chen@usda.gov</u>