Milling and Baking Test Results
for Hard Winter Wheat
Harvested in 2020

71st 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), Bayer, Limagrain, BASF, and laboratories from milling, baking, grain trade, 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 and other wheat end-use quality 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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2020

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 2020 Testing Program

Founded in 1949, this is the **71st** 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 wheat growing region. This technical report includes GIPSA wheat market classification, physical grain testing, milling, analytical, rheological, and bread baking results.

A total of 40 entries this year were grown in different locations and submitted for small-scale testing by 11 wheat breeding programs. 8 of the entries were submitted as a set representing the new growout in the Northern States including NE, SD, ND, and Syngenta (since 2018). 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 16 cooperators (14 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.

2020 WQC HWW Entries & Breeding Programs

Breeding Programs	Entry Number	Sample Identification
COLORADO	20-2401	Byrd
	20-2402	Jagalene (CC01)
	20-2403	CO14A055-258
	20-2404	CO15D098R
	20-2405	CO16SF070
BASF	20-2406	Jagalene (CC02)
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	20-2410	DH11HRW55-4
	20-2411	LCH13DH-47-1675
	20-2412	LCH15ACC-13-4
KANSAS-HAYS	20-2413	Jagalene (CC04)
	20-2414	Danby
	20-2415	KS15H137-2-2
BAYER	20-2416	Jagalene (CC05)
	20-2417	MODI4-6036
	20-2418	NEDI4-5064
OKLAHOMA	20-2419	Jagalene (CC06)
	20-2420	Baker’s Ann
	20-2421	OK14124-2
	20-2422	OK15MASBx7 ARS8-20
	20-2423	OK15818
	20-2424	OK12716W Comp I

MONTANA	20-2425	Jagalene (CC07)
	20-2426	Yellowstone
	20-2427	MTCL1737
	20-2428	MT1745
KANSAS-MANHATTAN	20-2429	Everest
	20-2430	Jagalene (CC08)
	20-2431	KS12DH0156-88
	20-2432	KS090616K-1
NORTHERN STATES	20-2433	Jagalene (CC09)
	20-2434	17NORD-94
	20-2435	17NORD-96
	20-2436	NE14434
	20-2437	NE14696
	20-2438	PSB13NEDH-14-83W
	20-2439	09BC308-14-16
	20-2440	SD12DHA03282

CC = Common Check

2020 Wheat Classification Results from GIPSA

GIPSA Wheat Market Classification

ID	CL	DKG	TW	M	ODOR	HT	DKT	FM	SHBN	DEF	CCL	WOCL	GRADE	REMARKS
20-2401	HRW	0.0	58.0	9.7	OK	0.0	0.0	0.0	2.7	2.7	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2402	HRW	0.0	59.0	9.4	OK	0.0	0.0	0.0	1.0	1.0	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2403	HRW	0.2	58.9	10.0	OK	0.0	0.0	0.0	1.9	1.9	0.0	0.0	U.S. NO. 2 HRW, DKG 0.2%	
20-2404	HRW	0.0	59.2	9.6	OK	0.0	0.0	0.0	2.4	2.4	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2405	HRW	0.0	57.7	9.8	OK	0.0	0.0	0.0	2.5	2.5	0.0	6.5	U.S. NO. 3 HRW, DKG 0.0%	
20-2406	HRW	0.4	60.0	13.9	OK	0.0	0.3	0.0	0.0	0.3	0.0	0.0	U.S. NO. 1 HRW, DKG 0.4%	Ergot 0.01%
20-2407	HRW	0.0	62.0	13.3	OK	0.0	0.1	0.0	0.0	0.1	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2408	HRW	0.1	61.8	13.6	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%	
20-2409	HRW	0.0	61.3	12.6	OK	0.0	0.0	0.0	0.1	0.1	0.2	0.2	U.S. NO. 1 HRW, DKG 0.0%	
20-2410	HRW	0.0	60.0	12.5	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HRW,, DKG 0.0%	
20-2411	HRW	0.0	62.6	12.8	OK	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2412	HRW	0.0	61.4	11.2	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2413	HRW	0.0	63.3	11.6	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.2	U.S. NO. 1 HRW, DKG 0.0%	
20-2414	HDWH	0.1	64.1	11.7	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HDWH, DKG 0.1%	
20-2415	HRW	0.0	62.1	11.7	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2416	HRW	0.0	65.4	9.1	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2417	HRW	0.0	63.5	9.1	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2418	HRW	0.0	64.5	9.4	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2419	HRW	0.0	64.3	11.8	OK	0.0	0.0	0.0	0.3	0.3	0.0	1.8	U.S. NO. 1 HRW, DKG 0.1%	
20-2420	HRW	0.0	63.8	11.9	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.6	U.S. NO. 1 HRW, DKG 0.0%	
20-2421	HRW	0.1	64.2	13.0	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.2	U.S. NO. 1 HRW, DKG 0.1%	
20-2422	HRW	0.0	60.9	12.1	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2423	HRW	0.2	64.2	12.0	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.7	U.S. NO. 1 HRW, DKG 0.2%	
20-2424	HDWH	0.2	62.4	11.1	OK	0.0	2.9	0.0	0.3	3.2	0.0	2.3	U.S. NO. 2 HDWH, DKG 0.2%	
20-2425	HRW	0.0	65.4	9.9	OK	0.0	0.0	0.0	0.4	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2426	HRW	0.0	64.5	10.4	OK	0.0	0.1	0.0	0.2	0.3	0.0	0.3	U.S. NO. 1 HRW, DKG 0.0%	
20-2427	HRW	0.0	64.5	9.7	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.1	U.S. NO. 1 HRW, DKG 0.0%	
20-2428	HRW	0.0	65.1	9.7	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2429	HRW	0.0	59.5	11.7	OK	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2430	HRW	0.0	60.8	11.7	OK	0.0	0.1	0.0	0.3	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2431	HRW	0.0	59.3	11.5	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2432	HDWH	0.0	59.5	11.9	OK	0.0	2.9	0.0	0.1	3.0	0.0	7.0	U.S. NO. 3 HDWH, DKG 0.0%	
20-2433	HRW	0.0	60.0	11.8	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2434	HRW	0.0	58.9	11.7	OK	0.0	0.8	0.0	0.2	1.0	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2435	HRW	0.0	60.4	12.3	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2436	HRW	0.0	58.9	11.8	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.5	U.S. NO. 2 HRW, DKG 0.0%	
20-2437	HRW	0.0	60.0	11.8	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	
20-2438	HRW	0.0	59.7	11.9	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2439	HRW	0.0	59.9	11.7	OK	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U.S. NO. 2 HRW, DKG 0.0%	
20-2440	HRW	0.0	60.1	12.1	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%	

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

20-2401	Byrd
20-2402	Jagalene (CC01)
20-2403	CO14A055-258
20-2404	CO15D098R
20-2405	CO16SF070

Description of Test Plots and Breeder Entries

COLORADO – Esten Mason and Scott Haley

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 9/12/19 and the harvest date was July 7. The growing conditions in Colorado were extremely dry in most eastern counties with minimal snowfall to fill the soil profile. In Akron there was moderate drought with significant wheat stem sawfly pressure. Dry conditions paired with early hot temperatures in June and high winds reduced yield potential and test weight.

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 2020, Byrd was the third most widely grown wheat cultivar in Colorado (12.8% of total acreage).

CO15D098R (Released as 'Steamboat')
CO15D098R is a doubled-haploid HRW line from the cross TAM 114/Antero//Byrd made in 2012. CO15D098R was tested in the 2019 WQC sample set under the same experimental number. CO15D098R was released in 2020 and is marketed by the Wyoming Crop Research Foundation as 'Steamboat'. CO15D098R is a tall wheat with medium-late maturity, has a medium-long coleoptile, and lower than average straw strength. CO15D098R 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. CO15D098R 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 moderately susceptible to susceptible.

Across 72 site-years in the CSU Elite Trial (2017-20) and CSU Uniform Variety Performance Trial (2018-20), grain yield of CO15D098R was lower than the two highest yielding wheats in the trials (~2 bu/A lower than both Langin and Whistler) with higher test weight (~2 lb/bu higher than Whistler, ~1 lb/bu higher than Langin). In the 2019

Southern Regional Performance Nursery (SRPN), CO15D098R was the 10^{th} highest yielding entry in the trial. In the 2020 SRPN, CO15D098R was the 4^{th} 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.

CO14A055-258 (Released as 'Kivari AX')

CO14A055-258 [(AF28/Byrd)/(AF10/2*Byrd)] is a HRW line tolerant to Aggressor™ herbicide for the CoAXium system. CO14A055-258 was developed using a modified pedigree breeding method from a cross between an F1 plant carrying the A genome ACC1 mutation (AF28/Byrd) and a backcross-F1 (BC1F1) plant carrying the D genome ACC1 mutation (AF10/2*Byrd). CO14A055-258 was released in 2020 and is marketed by the Colorado Wheat Research Foundation (CWRF) under the *PlainsGold*™ brand as 'Kivari AX'. CO14A055-258 is a medium height wheat with medium maturity, has a medium-long coleoptile, and lower than average straw strength. CO14A055-258 is susceptible to stripe and leaf rust and moderately susceptible to stem rust. CO14A055-258 has good resistance to wheat streak mosaic virus due to resistance to the wheat curl mite vector (carries the Cmc_{TAM112} gene from Byrd). CO14A055-258 has medium test weight and above average grain protein deviation. CO14A055-258 is susceptible to Hessian fly and its response to Russian wheat aphid and soilborne mosaic virus are not known. The reaction of CO14A055-258 to Fusarium head blight is not known.

Across 32 site-years in the CSU Elite Trial (2018-20) and CSU Uniform Variety Performance Trial (2020), grain yield of CO14A055-258 was slightly lower than the highest yielding wheats in the trials (~ 2 bu/A lower than Langin, ~1 bu/A lower than Whistler) with a similar test weight (~1 lb/bu higher than Whistler, ~ equal to Langin). In the 2020 SRPN, CO14A055-258 was the 9^{th} highest yielding entry in the trial. CO14A055-258 has shown average milling and good baking properties in tests conducted in the CSU Wheat Quality Lab. Compared to Byrd, CO14A055-258 has similar SKCS kernel weight and similar SKCS kernel hardness, similar or just slightly lower Brabender quadrumat senior total and break flour yield, similar mixing time and lower tolerance, similar SRC water absorption, and similar loaf volume and crumb grain scores.

CO16SF070

CO16SF070 (Antero/Judee//Antero) is a semi-solid stemmed HRW line tolerant to wheat stem sawfly. CO16SF070 is a short wheat with early maturity, medium-short coleoptile length, and good straw strength. CO16SF070 has a stem solidness rating of 14.5 (out of 24) across 24 evaluations. CO16SF070 is moderately susceptible to stripe rust, susceptible to leaf rust and has good resistance to stem rust. The reaction of CO16SF070 to wheat streak mosaic virus is not known though it does not carry the Cmc_{TAM112} gene. CO16SF070 has medium-high test weight. CO16SF070 is susceptible to Hessian fly and its reaction to Russian wheat aphid, wheat soilborne mosaic virus, and *Fusarium* head blight are not known.

Across 33 site-years in the CSU Wheat Stem Sawfly Trial (2017-2019), CSU Elite Trial (2018-20) and CSU Uniform Variety Performance Trial (2020) without sawfly pressure, grain yield of CO16SF070 was lower than the highest yielding wheats in the trials (~ 4 bu/A lower than both Langin and Whistler) with a similar or higher test weight (~1 lb/bu higher than Whistler, ~ equal to Langin). Grain yield of CO16SF070 was significantly higher than other semi-solid stemmed lines (~4 bu/A higher than Fortify SF). Across 15 site-years with sawfly pressure, grain yield of CO16SF070 was higher than all hollow stemmed wheats (~5 bu/A higher than Whistler, ~2 bu/A higher than Langin). In the 2020 SRPN, CO16SF070 was the 8th highest yielding entry in the trial. CO16SF070 has shown average milling and baking properties in tests conducted in the CSU Wheat Quality Lab. Compared to Byrd, CO16SF070 has similar SKCS kernel weight and lower SKCS kernel hardness, similar or slightly lower Brabender quadrumat senior total and break flour yield, lower mixing time and tolerance, similar SRC water absorption, and lower loaf volume and crumb grain scores.

Colorado: 2020 (Small-Scale) Samples

Test entry number	20-2401	20-2402	20-2403
Sample identification	**Byrd**	**Jagalene (CC01)**	**CO14A055-258**
Wheat Data			
GIPSA classification	2 HRW	2 HRW	2 HRW
Test weight (lb/bu) **Hectoliter weight (kg/hl)**	58.0 76.4	59.0 77.6	58.9 77.5
1000 kernel weight (gm)	22.5	23.9	23.4
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 11.1 82.0 6.9	 9.6 85.0 5.4	 14.8 80.6 4.6
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	 72.6/18.4 22.5/9.5 2.20/0.34 9.5/0.7 02-07-14-77-01 Hard	 75.7/18.5 23.9/9.0 2.33/0.31 9.3/0.7 03-04-12-81-01 Hard	 68.4/18.2 23.4/9.3 2.25/0.35 9.9/0.7 02-10-20-68-01 Hard
Wheat protein (12% mb) **Wheat ash (12% mb)**	13.4 1.79	14.4 1.78	12.7 1.70
Milling and Flour Quality Data			
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 69.7 68.6	 71.8 66.7	 73.8 70.1
Flour moisture (%) **Flour protein (14% mb)** **Flour ash (14% mb)**	13.4 12.2 0.51	12.6 13.4 0.57	13.6 11.7 0.53
Rapid Visco-Analyser Peak time (min) Peak viscosity (RVU) Breakdown (RVU) Final viscosity at 13 min (RVU)	 6.3 225.5 67.3 284.1	 6.3 178.6 48.0 232.7	 6.2 221.3 70.4 278.1
Minolta color meter L* a* b* **PPO**	 91.35 -1.49 9.68 0.477	 91.07 -1.30 9.85 0.402	 91.50 -1.42 9.65 0.395
Falling number (sec)	384	390	373
Damaged Starch (AI%) (AACC76-31)	 96.5 6.7	 97.9 7.8	 97.3 7.4

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Colorado: 2020 (Small-Scale) Samples (Continued)

Test entry number	20-2404	20-2405
Sample identification	**CO15D098R**	**CO16SF070**
Wheat Data		
GIPSA classification	2 HRW	3 HRW
Test weight (lb/bu) **Hectoliter weight (kg/hl)**	59.2 77.9	57.7 76.0
1000 kernel weight (gm)	23.2	22.0
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 15.6 78.7 5.7	 11.6 82.7 5.7
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	 75.1/18.4 23.2/9.1 2.24/0.35 9.6/0.9 02-05-13-80-01 Hard	 69.9/19.1 22.0/8.8 2.20/0.37 9.6/0.7 03-07-20-70-01 Hard
Wheat protein (12% mb) **Wheat ash (12% mb)**	13.7 1.72	13.2 1.76
Milling and Flour Quality Data		
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 73.8 67.7	 73.7 67.9
Flour moisture (%) **Flour protein (14% mb)** **Flour ash (14% mb)**	12.6 12.6 0.56	12.7 12.1 0.52
Rapid Visco-Analyser Peak time (min) Peak viscosity (RVU) Breakdown (RVU) Final viscosity at 13 min (RVU)	 6.3 225.3 89.3 250.8	 6.5 212.8 53.6 262.3
Minolta color meter L* a* b* **PPO**	 91.20 -1.56 10.29 0.466	 91.37 -1.40 9.65 0.520
Falling number (sec)	386	386
Damaged Starch (AI%) (AACC76-31)	 97.5 7.5	 96.7 6.8

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Colorado: Physical Dough Tests and Gluten Analysis
2020 (Small-Scale) Samples

Test Entry Number	20-2401	20-2402	20-2403
Sample Identification	**Byrd**	**Jagalene (CC01)**	**CO14A055-258**
MIXOGRAPH			
Flour Abs (% as-is)	67.0	70.8	65.9
Flour Abs (14% mb)	66.2	69.2	65.5
Mix Time (min)	7.5	4.8	7.0
Mix tolerance (0-6)	5	4	5
FARINOGRAPH			
Flour Abs (% as-is)	60.7	65.7	60.9
Flour Abs (14% mb)	60.0	64.1	60.4
Peak time (min)	10.7	8.9	10.1
Mix stability (min)	24.4	20.8	24.7
Mix Tolerance Index (FU)	4	18	4
Breakdown time (min)	26.0	19.6	26.0
ALVEOGRAPH			
P(mm): Tenacity	109	139	124
L(mm): Extensibility	67	80	84
G(mm): Swelling index	18.2	19.9	17.8
W(10^{-4} J): strength (curve area)	307	431	320
P/L: curve configuration ratio	1.63	1.74	1.94
Ie(P_{200}/P): elasticity index	67.1	64.9	62.2
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	731/1184/1157	518/735/711	632/887/1068
Extensibility (mm at 45/90/135 min)	125/105/107	140/131/128	127/129/111
Energy (cm^2 at 45/90/135 min)	151/180/171	128/165/150	135/190/179
Resist $_{max}$ (BU at 45/90/135min)	963/1517/1353	722/1081/973	844/1196/1346
Ratio (at 45/90/135 min)	5.8/11.3/10.8	3.7/5.6/5.6	5.0/6.9/9.6
PROTEIN ANALYSIS			
HMW-GS Composition	2*, 7+8, 5+10	1,2*, 17+18/, 5+10	2*, 7+8, 5+10
TPP/TMP	0.90	0.81	0.78
SEDIMENTATION TEST			
Volume (ml)	69.0	67.9	68.2

Colorado: Physical Dough Tests and Gluten Analysis 2020 (Small-Scale) Samples (continued)

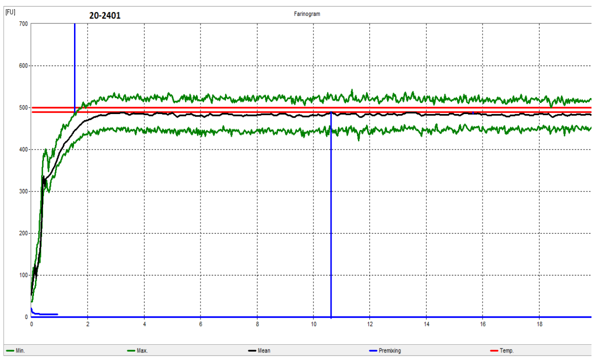
Test Entry Number	**20-2404**	**20-2405**
Sample Identification	**CO15D098R**	**CO16SF070**
MIXOGRAPH		
Flour Abs (% as-is)	68.6	67.0
Flour Abs (14% mb)	67.0	65.5
Mix Time (min)	5.9	4.0
Mix tolerance (0-6)	5	4
FARINOGRAPH		
Flour Abs (% as-is)	63.0	62.9
Flour Abs (14% mb)	61.4	61.4
Peak time (min)	11.2	8.5
Mix stability (min)	22.5	16.5
Mix Tolerance Index (FU)	10	22
Breakdown time (min)	26.0	16.7
ALVEOGRAPH		
P(mm): Tenacity	118	111
L(mm): Extensibility	79	79
G(mm): Swelling index	19.7	19.7
W(10^{-4} J): strength (curve area)	360	321
P/L: curve configuration ratio	1.49	1.41
Ie(P_{200}/P): elasticity index	63.7	58.7
EXTENSIGRAPH		
Resist (BU at 45/90/135 min)	520/816/942	425/602/787
Extensibility (mm at 45/90/135 min)	132/127/113	131/120/111
Energy (cm^2 at 45/90/135 min)	116/165/154	94/120/133
Resist $_{max}$ (BU at 45/90/135min)	694/1071/1201	556/819/977
Ratio (at 45/90/135 min)	3.9/6.4/8.4	3.3/5.0/7.1
PROTEIN ANALYSIS		
HMW-GS Composition	2*, 7+9, 5+10	2*, 7+9. 5+10
TPP/TMP	0.80	0.79
SEDIMENTATION TEST		
Volume (ml)	67.4	62.6

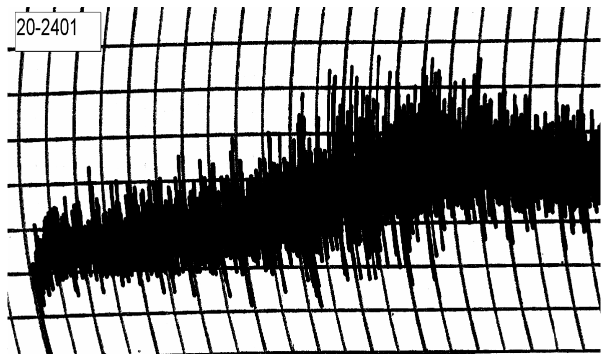
Physical Dough Tests

2020 (Small Scale) Samples - Colorado

Farinograms

Mixograms

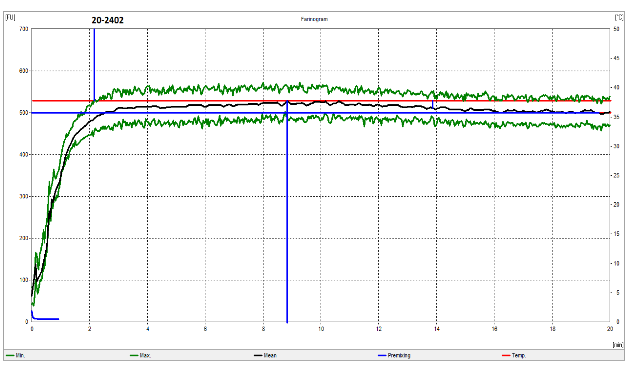


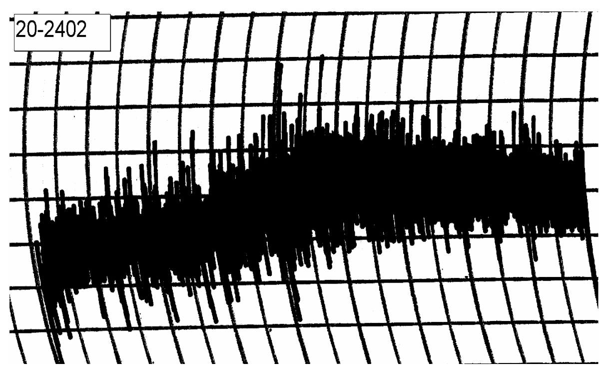


Water abs = 60.0%, Peak time = 10.7 min,
Mix stab = 24.4 min, MTI = 4 FU

Water abs = 66.2%
Mix time = 7.5 min

20-2401, Byrd





Water abs = 64.1%, Peak time = 8.9 min,
Mix stab = 20.8 min, MTI = 18 FU

Water abs = 69.2%
Mix time = 4.8 min

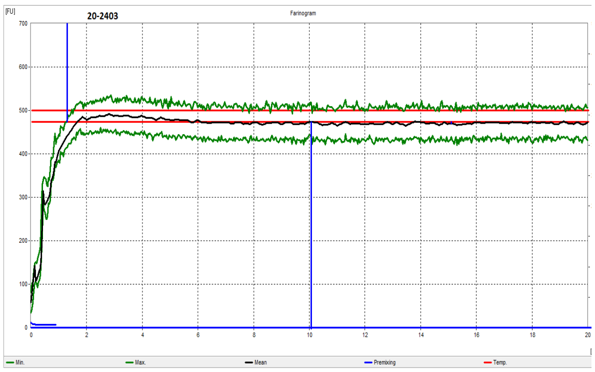
20-2402, Jagalene (CC01)

Physical Dough Tests

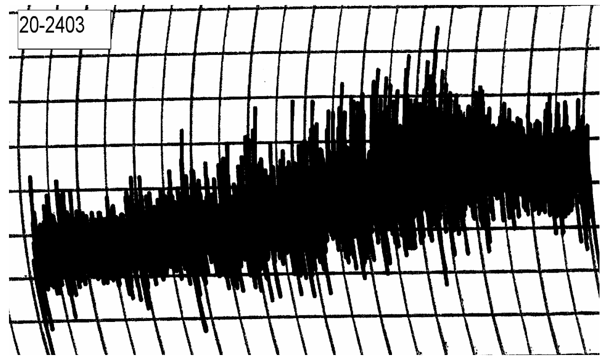
2020 (Small Scale) Samples - Colorado

Farinograms

Mixograms

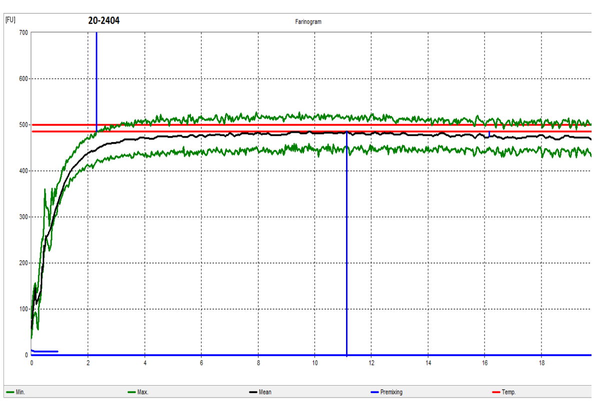


Water abs = 60.4%, Peak time = 10.1 min,
Mix stab = 24.7 min, MTI = 4 FU

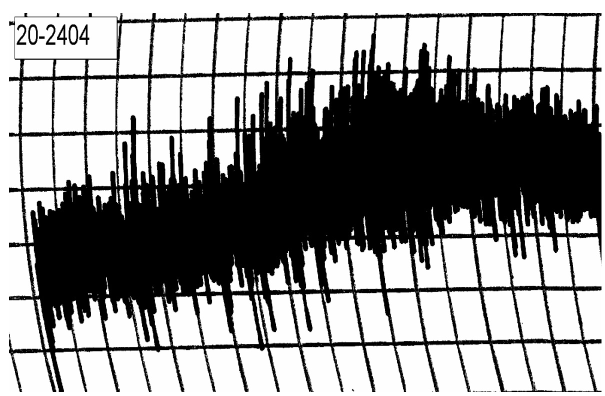


Water abs = 65.5%
Mix time = 7.0 min

20-2403, CO14055-258



Water abs = 61.4%, Peak time = 11.2 min,
Mix stab = 22.5 min, MTI = 10 FU



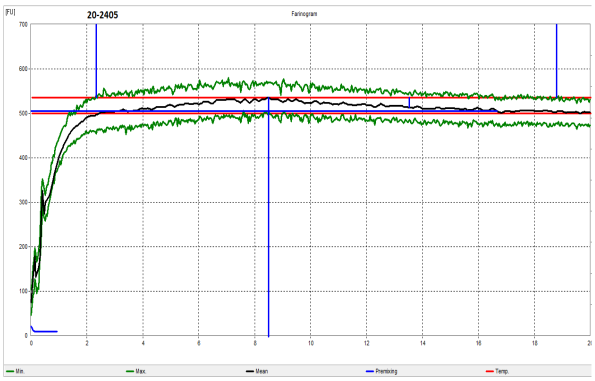
Water abs = 67.0%
Mix time = 5.9 min

20-2404, CO15D098R

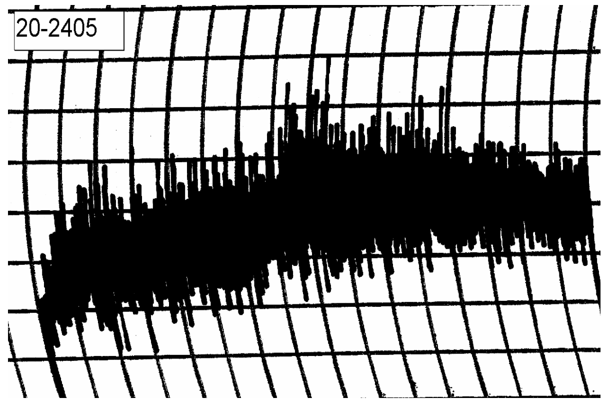
Physical Dough Tests
2020 (Small Scale) Samples - Colorado

Farinograms

Mixograms



Water abs = 61.4%, Peak time = 8.5 min,
Mix stab = 16.5 min, MTI = 22 FU

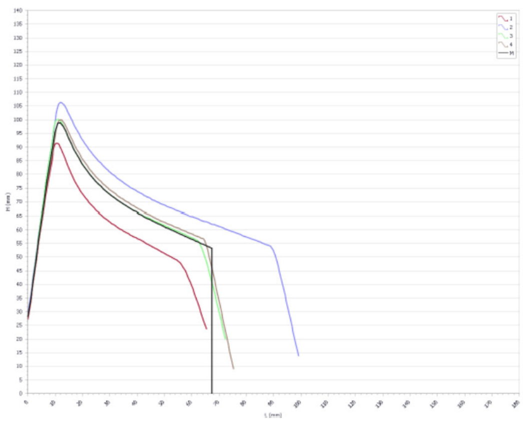


Water abs = 65.5%
Mix time = 4.0 min

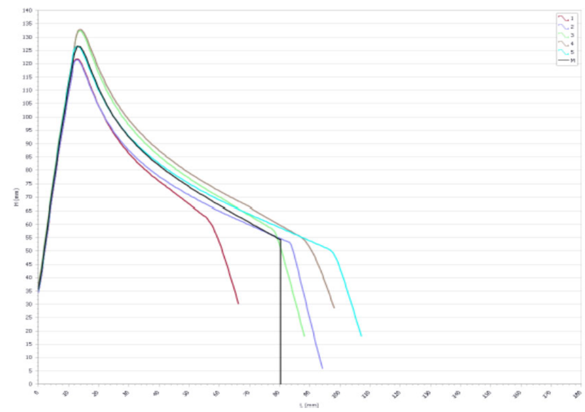
20-2405, CO16SF070

Physical Dough Tests - Alveograph

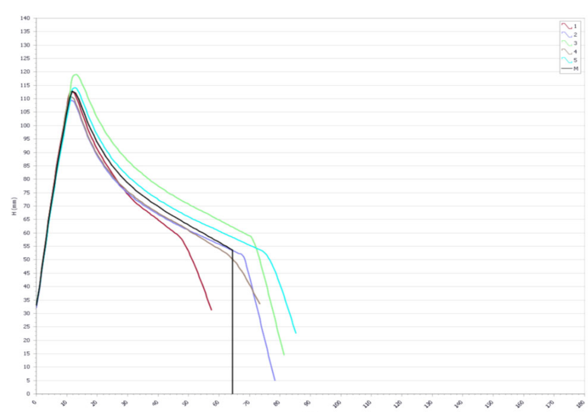
2020 (Small Scale) Samples – Colorado



20-2401, Byrd
P(mm $H_2$0) =109, L(mm) = 67, W(10E^{-4} J) = 307



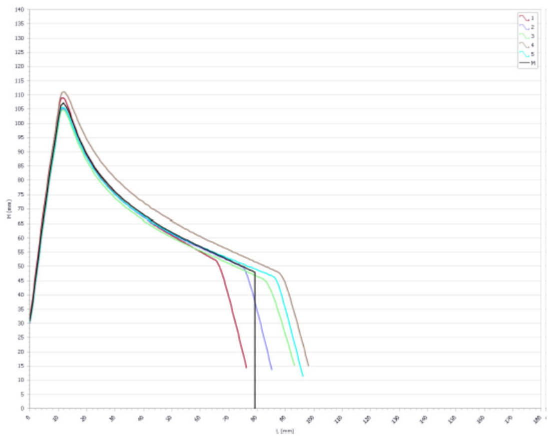
20-2402, Jagalene (CC01)
P(mm $H_2$0) = 139, L(mm) = 80, W(10E^{-4} J) = 431



20-2403, CO14A055-258
P(mm $H_2$0) =12, L(mm) = 64, W(10E^{-4} J) = 320

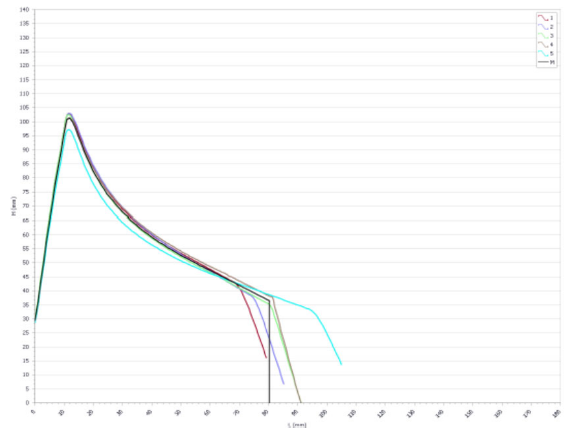
Physical Dough Tests - Alveograph

2020 (Small Scale) Samples – Colorado



20-2404, CO15D098R

P(mm H_20) = 118, L(mm) = 79, W($10E^{-4}$ J) = 360

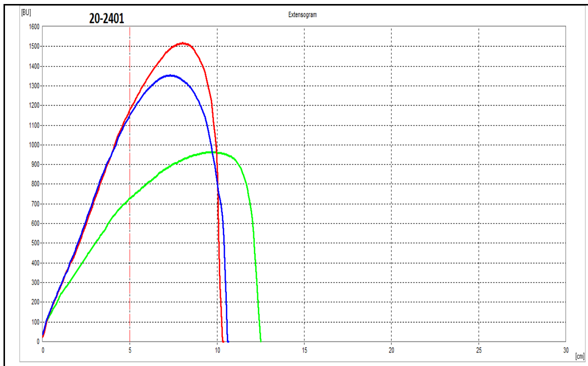


20-2405, CO16SF070

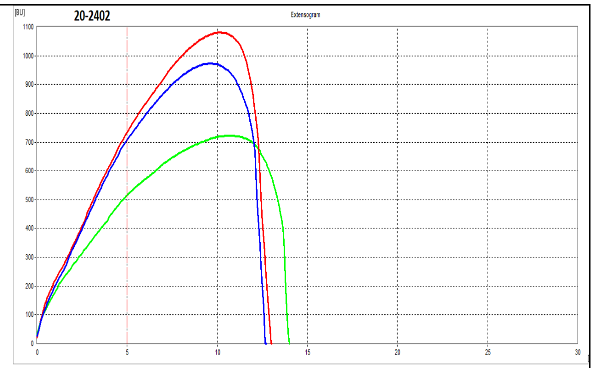
P(mm H_20) = 111, L(mm) = 79, W($10E^{-4}$ J) = 321

Physical Dough Tests - Extensigraph

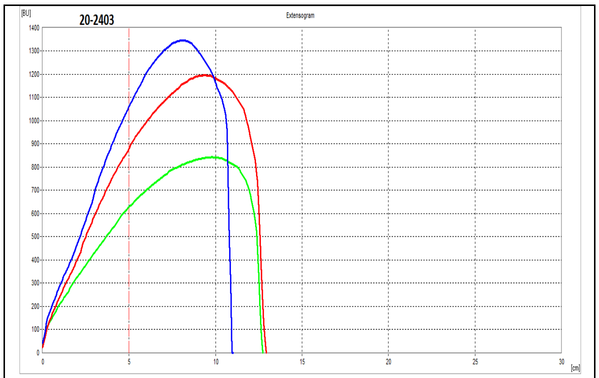
2020 (Small Scale) Samples – Colorado



20-2401, Byrd
R (BU) =1184, E (mm) = 105, W (cm^2) = 180
Rmax (BU) = 1517, Ratio = 11.3 at 90 min



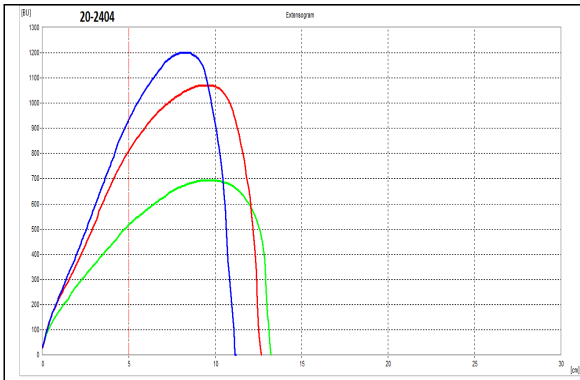
20-2402, Jagalene (CC01)
R (BU) = 735, E (mm) = 131, W (cm^2) = 165
Rmax (BU) = 1081, Ratio = 5.6 at 90 min



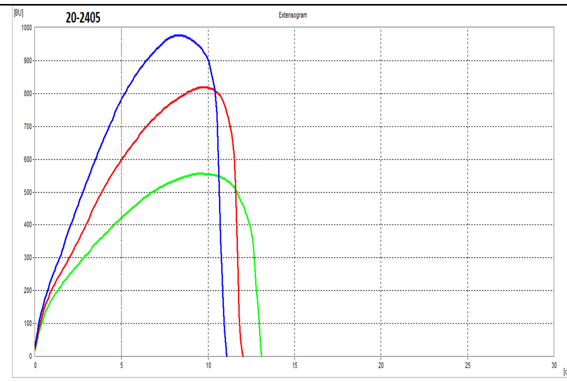
20-2403, CO14A055-258
R (BU) = 887, E (mm) = 129, W (cm^2) = 190
Rmax (BU) = 1196, Ratio = 6.9 at 90 min

Physical Dough Tests - Extensigraph

2020 (Small Scale) Samples – Colorado



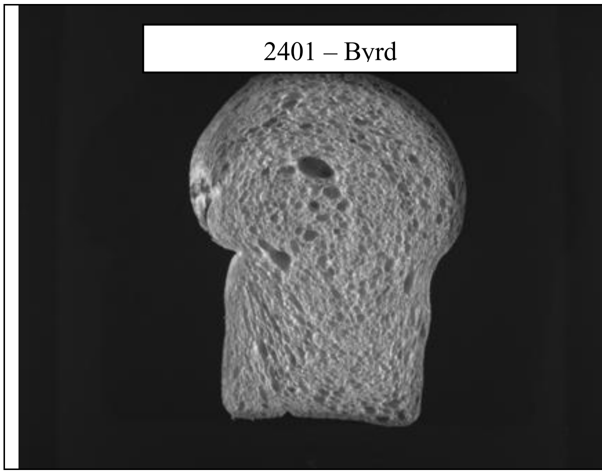
20-2404, CO15D098R
R (BU) = 816, E (mm) = 127, W (cm^2) = 165
Rmax (BU) = 1071, Ratio = 6.4 at 90 min

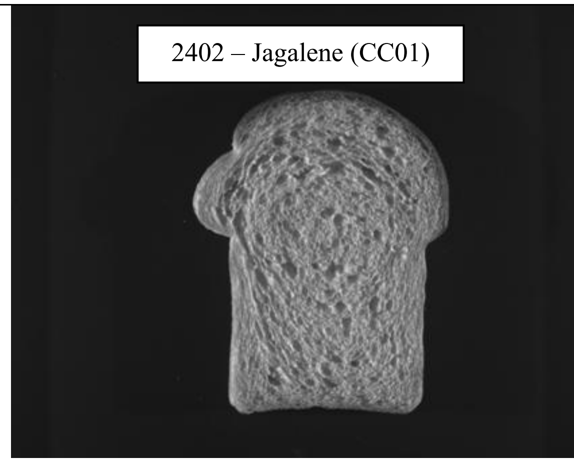


20-2405, CO16SF070
R (BU) = 602, E (mm) = 120, W (cm^2) = 120
Rmax (BU) = 819, Ratio = 5.0 at 90 min

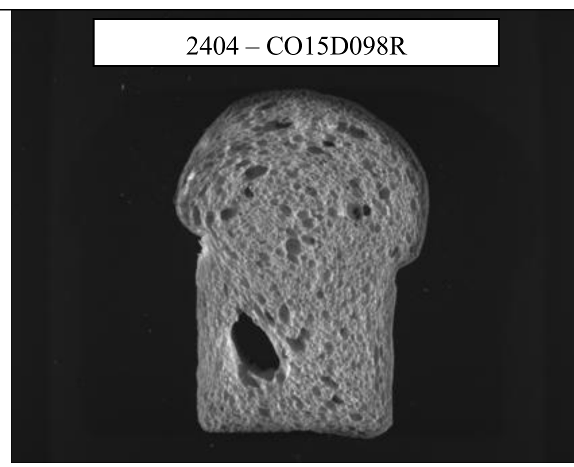
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Colorado: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples





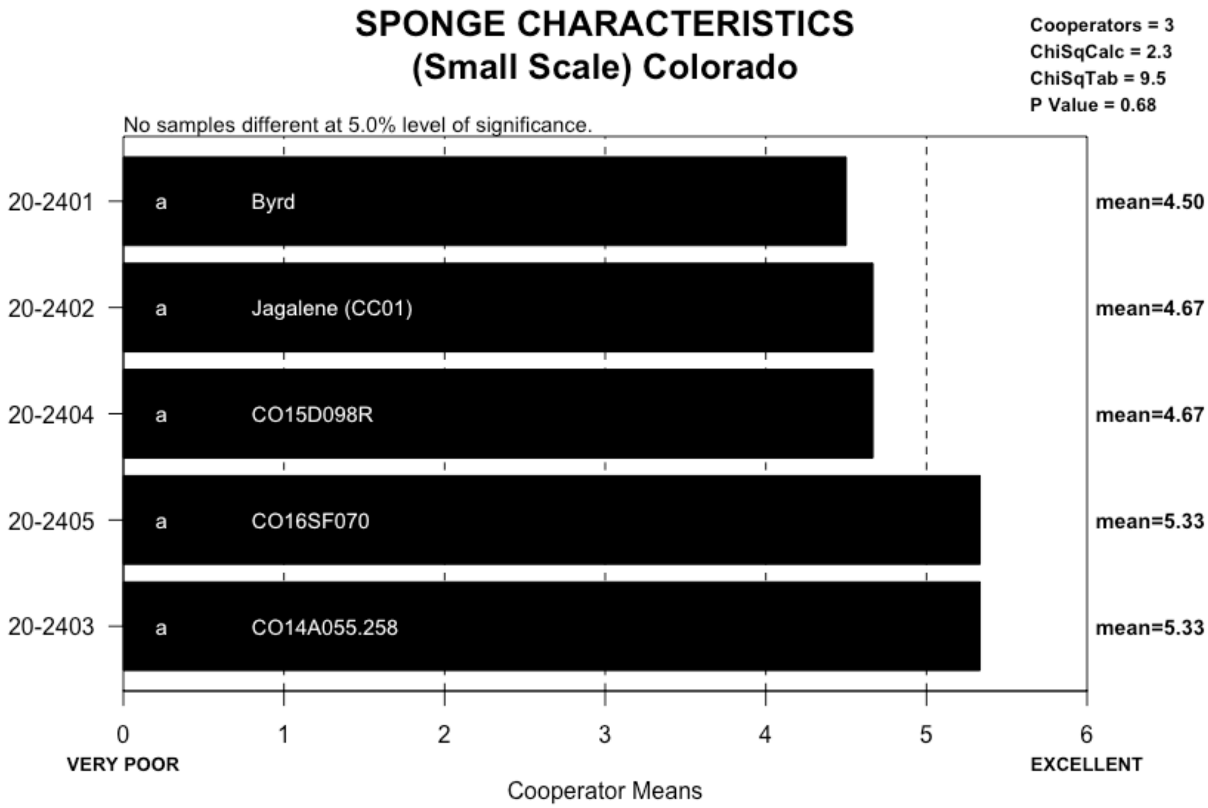
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical $(^0)$
2401	7536	120	4017	0.439	2.367	5.638	1.809	-8.10
2402	6912	117	3442	0.448	2.434	2.700	1.835	-9.67



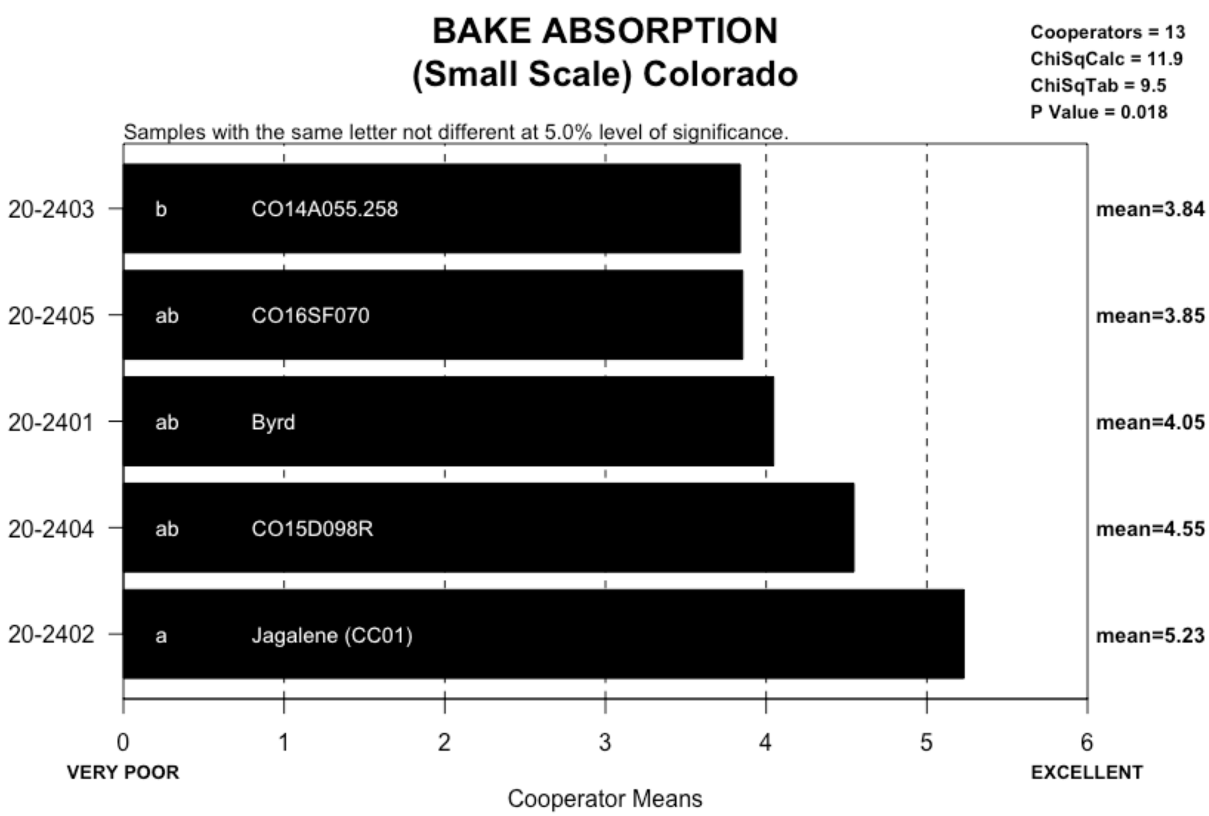
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical $(^0)$
2403	6595	116	3596	0.431	2.176	6.046	1.844	-1.82
2404	6719	113	3403	0.439	2.282	2.237	1.853	-6.68

Colorado: C-Cell Bread Images and Analysis
2020 (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})
2405	6620	117	3460	0.440	2.236	5.124	1.812	-9.52



SPONGE CHARACTERISTICS
(Small Scale) Colorado
Cooperators = 3
ChiSqCalc = 2.3
ChiSqTab = 9.5
P Value = 0.68
No samples different at 5.0% level of significance.
20-2401 a Byrd mean=4.50
20-2402 a Jagalene (CC01) mean=4.67
20-2404 a CO15D098R mean=4.67
20-2405 a CO16SF070 mean=5.33
20-2403 a CO14A055.258 mean=5.33
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



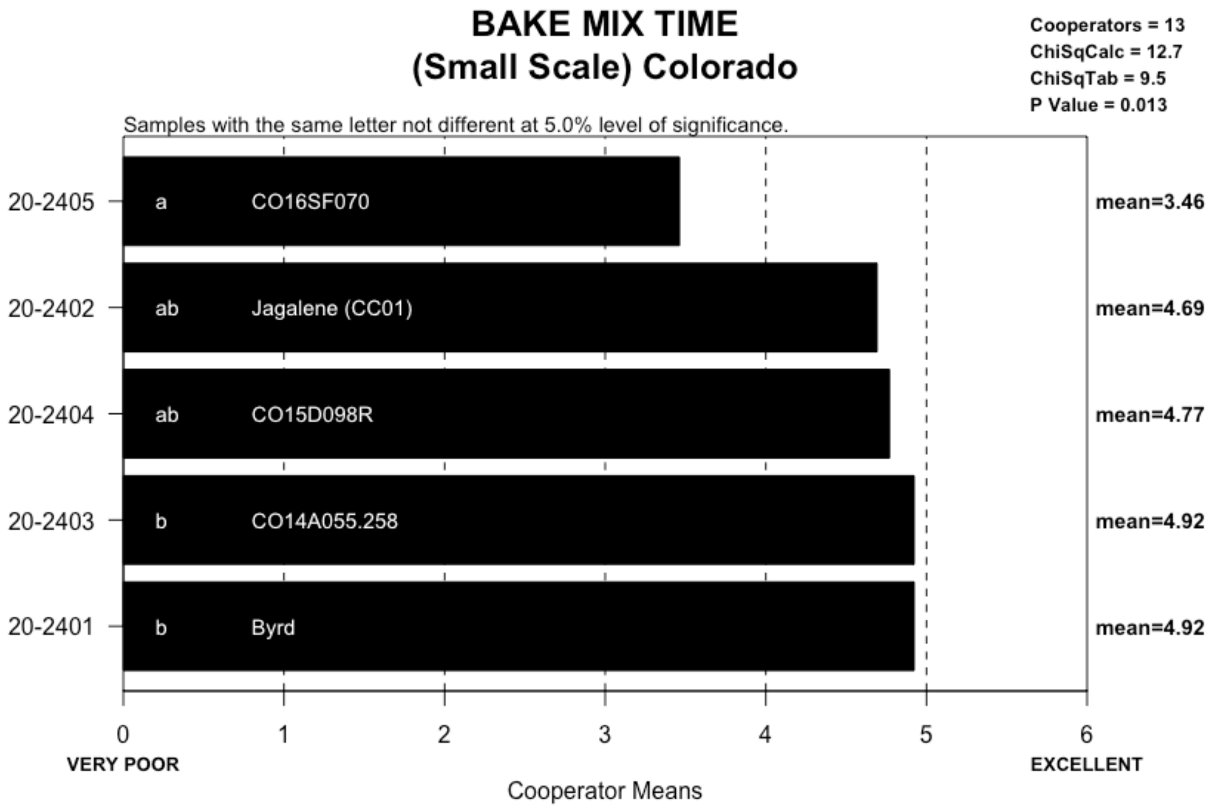
BAKE ABSORPTION
(Small Scale) Colorado
Cooperators = 13
ChiSqCalc = 11.9
ChiSqTab = 9.5
P Value = 0.018
Samples with the same letter not different at 5.0% level of significance.
20-2403 b CO14A055.258 mean=3.84
20-2405 ab CO16SF070 mean=3.85
20-2401 ab Byrd mean=4.05
20-2404 ab CO15D098R mean=4.55
20-2402 a Jagalene (CC01) mean=5.23
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

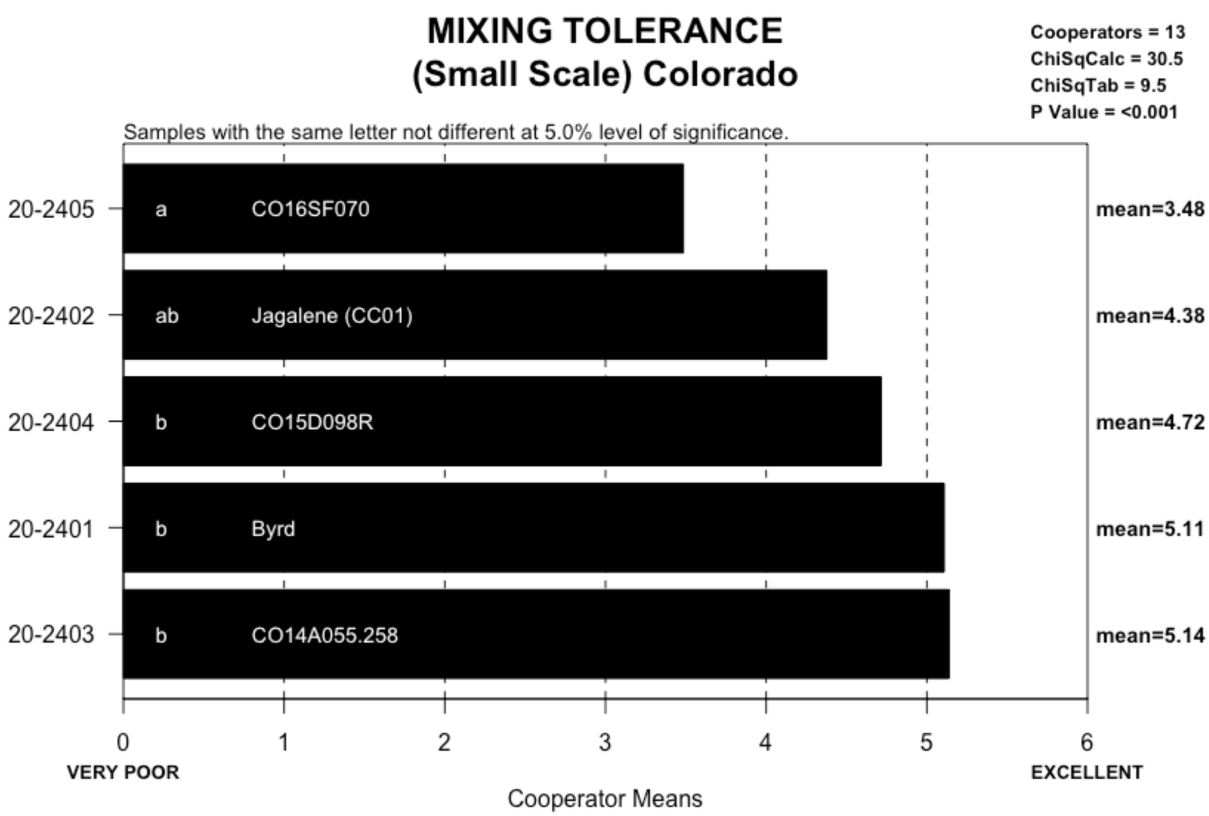
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Colorado
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2401	Byrd	58	66.2	66.0	71.0	65.0	63.6	64.8	65.9	60.5	60.0	57.2	66.2	62.0
20-2402	Jagalene (CC01)	59	71.8	69.1	70.1	66.9	65.4	67.4	72.1	64.4	64.1	62.4	69.2	66.1
20-2403	CO14A055-258	58	66.2	65.3	68.7	64.2	62.9	63.9	68.3	60.4	60.4	59.6	65.5	62.4
20-2404	CO15D098R	59	67.1	67.1	69.6	65.7	64.6	65.7	70.1	61.8	61.4	59.4	67.0	63.4
20-2405	CO16SF070	58	63.8	63.9	66.7	65.1	63.6	64.2	65.2	61.4	61.4	58.5	65.5	63.4

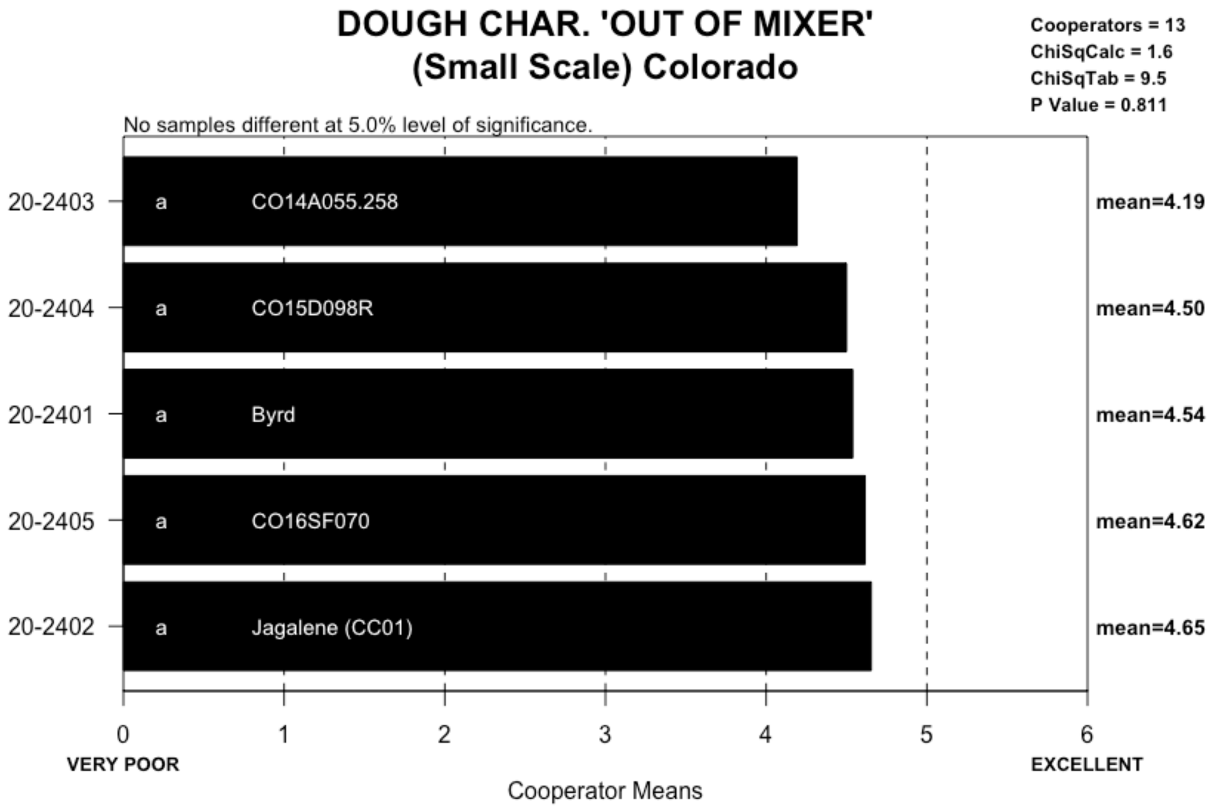
BAKE MIX TIME, ACTUAL
(Small Scale) Colorado
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2401	Byrd	15	4	7.4	8.2	7.0	11.2	6.5	9.5	7.0	8	14	7.5	20
20-2402	Jagalene (CC01)	10	5	4.9	5.1	4.5	6.5	4.3	6.5	5.0	8	9	4.8	20
20-2403	CO14A055-258	15	3	7.0	7.2	6.2	13.1	6.3	9.0	7.5	8	12	7.0	20
20-2404	CO15D098R	10	6	6.0	4.5	5.3	9.1	5.0	8.0	5.5	8	9	5.9	20
20-2405	CO16SF070	6	4	4.3	4.5	4.0	6.1	4.0	5.0	4.3	8	5	4.0	12


BAKE MIX TIME
(Small Scale) Colorado
Cooperators = 13
ChiSqCalc = 12.7
ChiSqTab = 9.5
P Value = 0.013
Samples with the same letter not different at 5.0% level of significance.
20-2405 a CO16SF070 mean=3.46
20-2402 ab Jagalene (CC01) mean=4.69
20-2404 ab CO15D098R mean=4.77
20-2403 b CO14A055.258 mean=4.92
20-2401 b Byrd mean=4.92
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

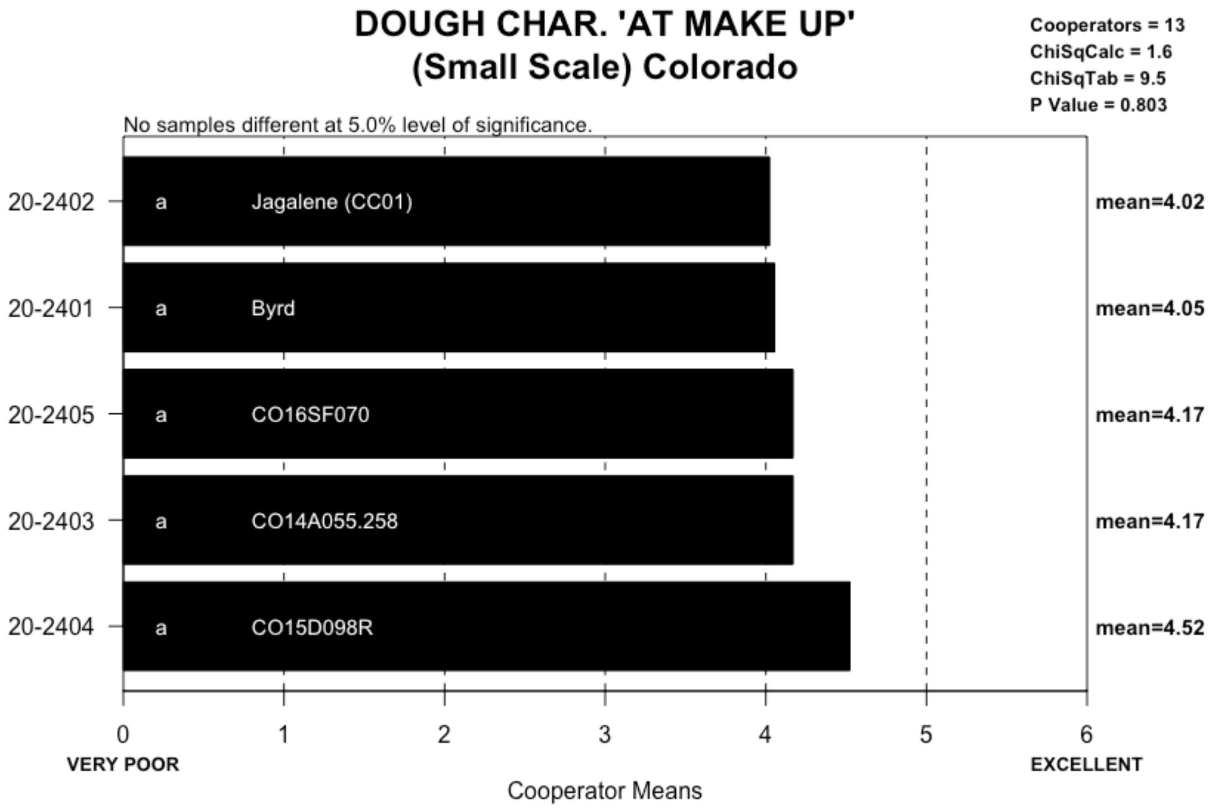

MIXING TOLERANCE
(Small Scale) Colorado
Cooperators = 13
ChiSqCalc = 30.5
ChiSqTab = 9.5
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2405 a CO16SF070 mean=3.48
20-2402 ab Jagalene (CC01) mean=4.38
20-2404 b CO15D098R mean=4.72
20-2401 b Byrd mean=5.11
20-2403 b CO14A055.258 mean=5.14
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

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



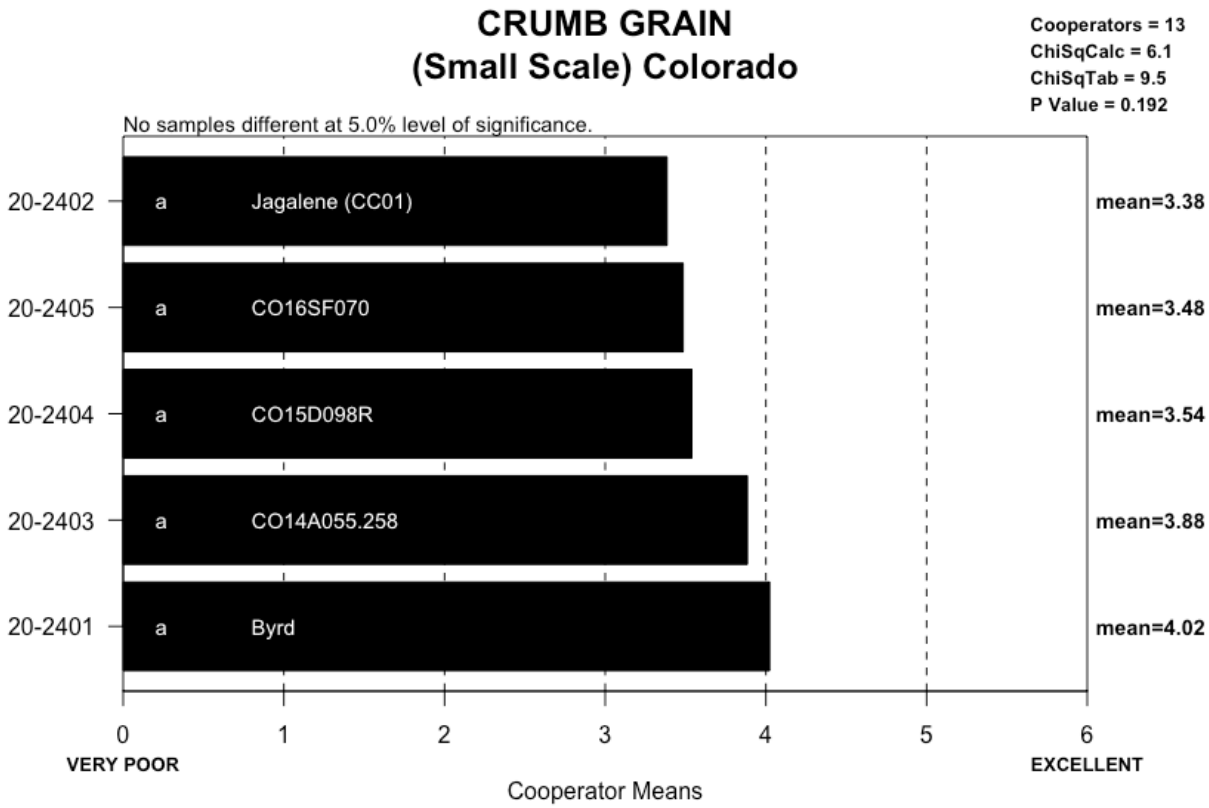
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Colorado

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2401	Byrd	1	1	3	5	3
20-2402	Jagalene (CC01)	0	1	2	6	4
20-2403	CO14A055-258	1	0	5	7	0
20-2404	CO15D098R	0	0	3	8	2
20-2405	CO16SF070	0	2	0	8	3



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2401	Byrd	2	0	5	4	2
20-2402	Jagalene (CC01)	0	0	5	6	2
20-2403	CO14A055-258	1	0	4	5	3
20-2404	CO15D098R	0	0	3	5	5
20-2405	CO16SF070	1	1	1	8	2

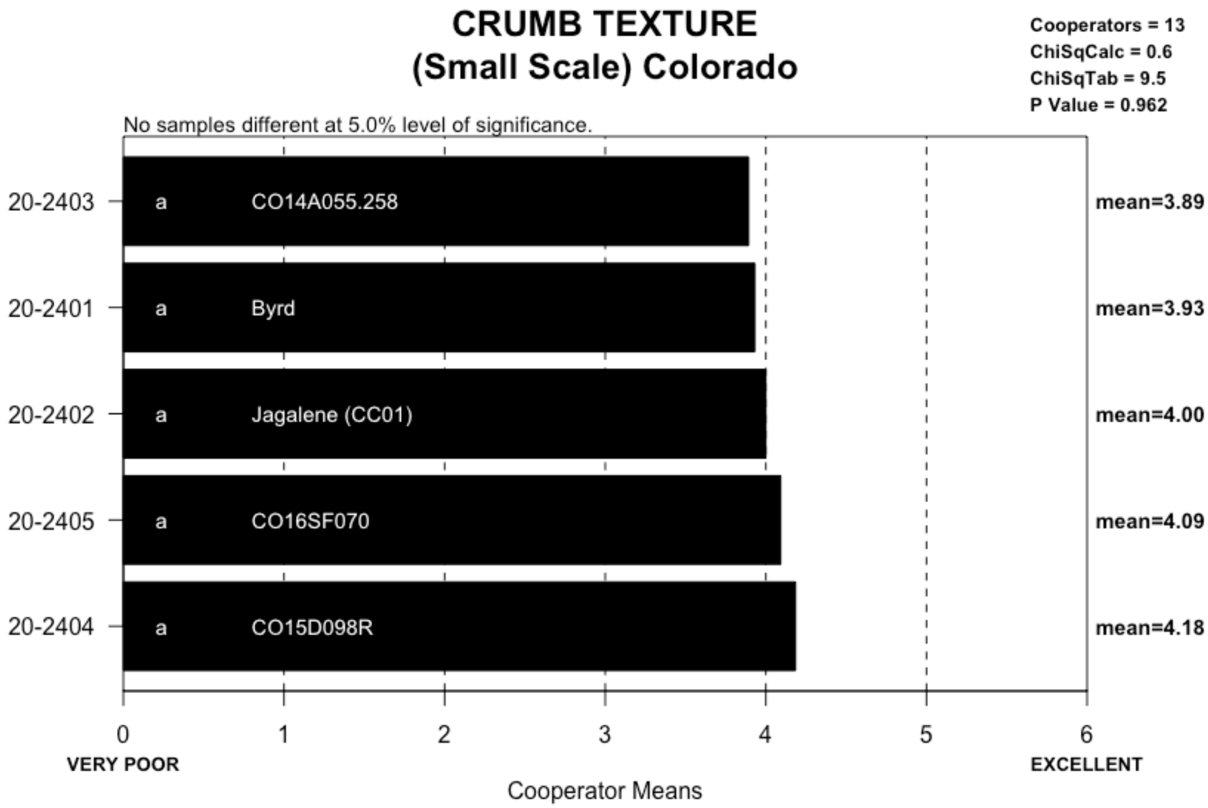


CRUMB GRAIN, DESCRIBED
(Small Scale) Colorado

IDCODE	ID	Open	Fine	Dense
20-2401	Byrd	8	3	2
20-2402	Jagalene (CC01)	8	5	0
20-2403	CO14A055-258	5	7	1
20-2404	CO15D098R	6	7	0
20-2405	CO16SF070	7	6	0

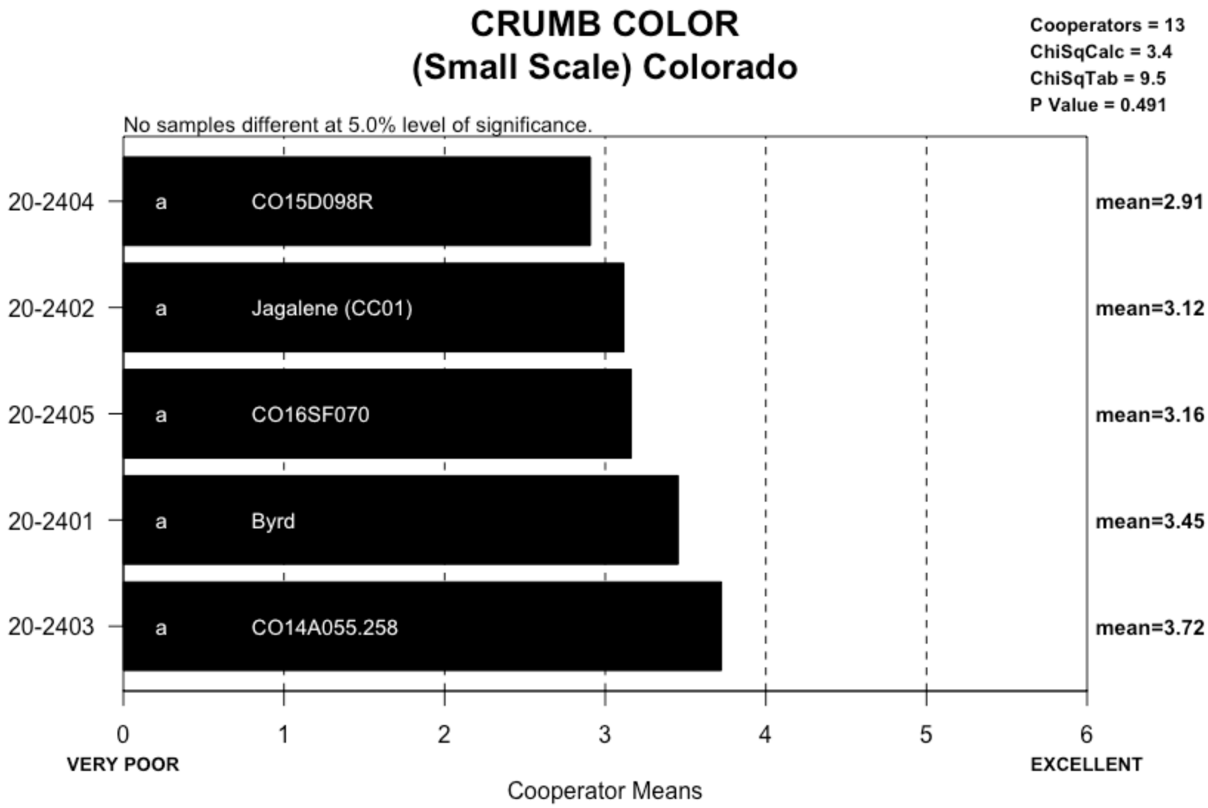
CELL SHAPE, DESCRIBED
(Small Scale) Colorado

IDCODE	ID	Round	Irregular	Elongated
20-2401	Byrd	4	6	3
20-2402	Jagalene (CC01)	2	6	5
20-2403	CO14A055-258	2	6	5
20-2404	CO15D098R	2	7	4
20-2405	CO16SF070	2	5	6



CRUMB TEXTURE, DESCRIBED
(Small Scale) Colorado

IDCODE	ID	Harsh	Smooth	Silky
20-2401	Byrd	3	6	4
20-2402	Jagalene (CC01)	3	6	4
20-2403	CO14A055-258	3	8	2
20-2404	CO15D098R	3	6	4
20-2405	CO16SF070	1	10	2



CRUMB COLOR, DESCRIBED
(Small Scale) Colorado

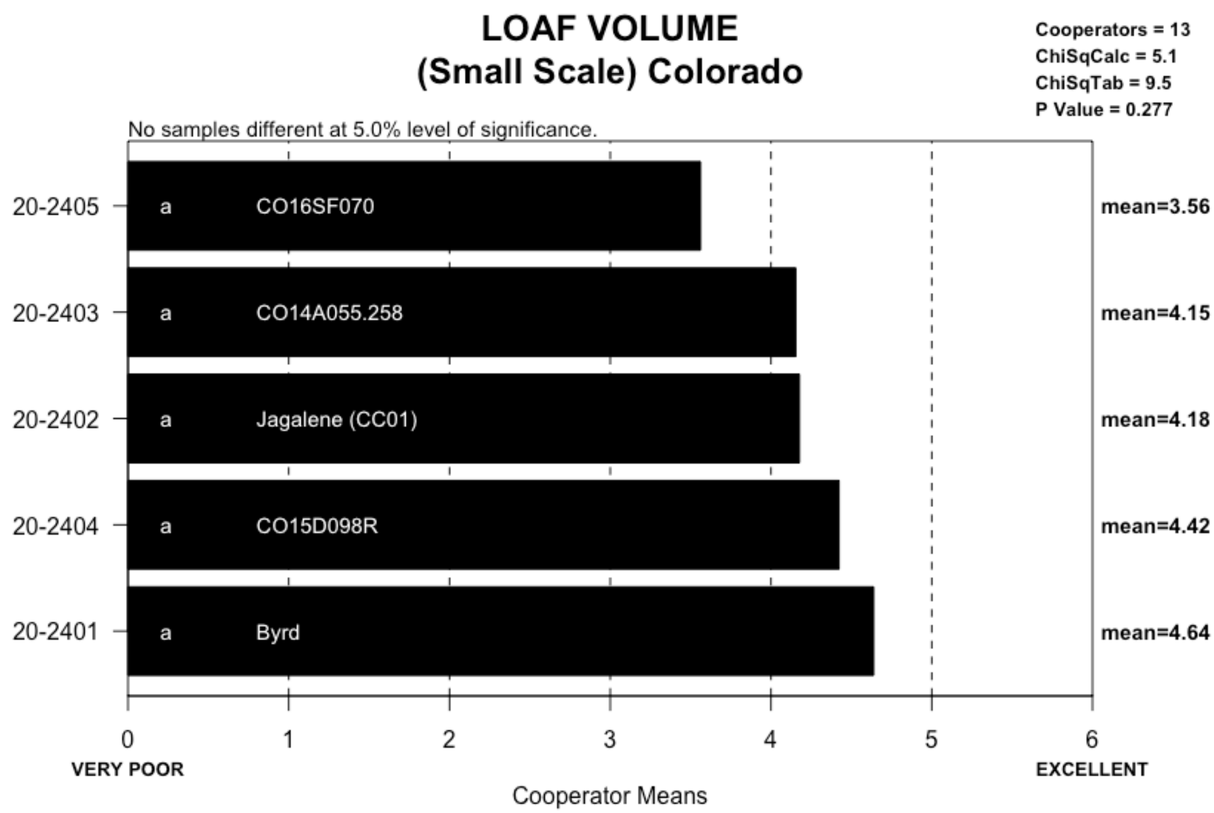
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2401	Byrd	0	0	4	3	4	2	0
20-2402	Jagalene (CC01)	0	0	4	4	5	0	0
20-2403	CO14A055-258	0	0	3	3	4	3	0
20-2404	CO15D098R	0	1	5	2	5	0	0
20-2405	CO16SF070	0	0	4	5	4	0	0

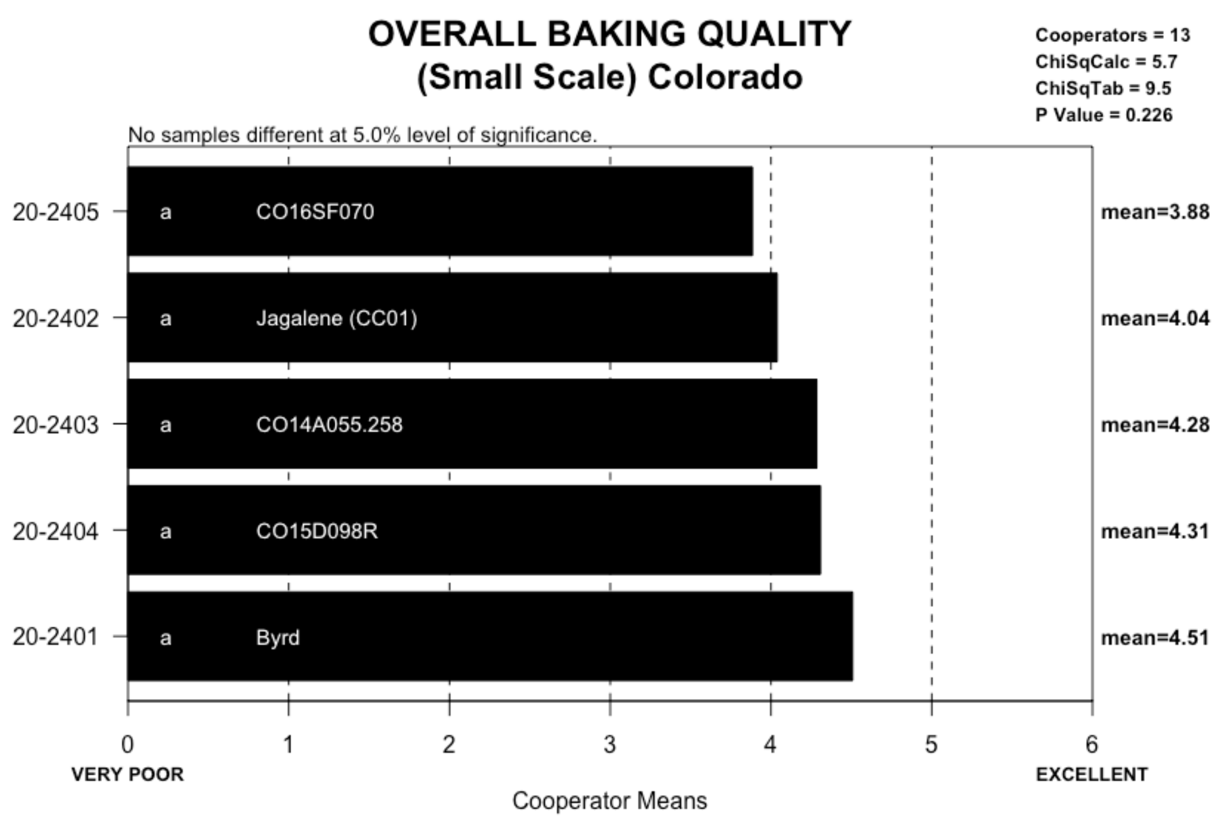
LOAF WEIGHT, ACTUAL
(Small Scale) Colorado
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2401	Byrd	417	131.2	134.8	152.1	141.7	135.7	139.7	148.8	140	454.6	478.7	142.4	418.5
20-2402	Jagalene (CC01)	414	133.2	137.4	153.4	144.7	138.3	144.1	155.6	144	453.3	477.2	145.8	416.1
20-2403	CO14A055-258	412	136.0	138.0	154.2	141.7	139.1	140.1	150.6	139	462.0	481.9	144.5	424.1
20-2404	CO15D098R	414	134.4	138.3	150.8	142.5	138.0	142.5	151.7	140	457.2	478.7	144.9	416.5
20-2405	CO16SF070	411	132.0	137.8	154.1	143.9	139.1	142.0	151.3	141	453.0	482.8	141.0	413.1

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2401	Byrd	2850	755	1126	1010	945	1038	1135	1020	694	2874	2650	765	2700
20-2402	Jagalene (CC01)	2800	985	926	960	830	978	1035	960	668	2918	2638	785	2700
20-2403	CO14A055-258	2900	710	909	995	885	968	990	960	730	2450	2700	875	2550
20-2404	CO15D098R	2825	820	919	970	880	1015	1050	975	702	2624	2663	865	2800
20-2405	CO16SF070	2850	810	864	943	775	993	900	895	717	2691	2588	815	2600


LOAF VOLUME
(Small Scale) Colorado
Cooperators = 13
ChiSqCalc = 5.1
ChiSqTab = 9.5
P Value = 0.277
No samples different at 5.0% level of significance.
20-2405 a CO16SF070 mean=3.56
20-2403 a CO14A055.258 mean=4.15
20-2402 a Jagalene (CC01) mean=4.18
20-2404 a CO15D098R mean=4.42
20-2401 a Byrd mean=4.64
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Small Scale) Colorado
Cooperators = 13
ChiSqCalc = 5.7
ChiSqTab = 9.5
P Value = 0.226
No samples different at 5.0% level of significance.
20-2405 a CO16SF070 mean=3.88
20-2402 a Jagalene (CC01) mean=4.04
20-2403 a CO14A055.258 mean=4.28
20-2404 a CO15D098R mean=4.31
20-2401 a Byrd mean=4.51
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Colorado

COOP. **20-2401 Byrd**

A. No comment.
B. Small and dense loaf.
C. No comment.
D. Mix time somewhat long but good volume, good volume for protein level, good absorption.
E. Long mix time, loaf volume matched predicted loaf volume.
F. High Protein & Water Abs, Very Long MT, Slight Sticky & Strong Dough, Very High Volume, Creamy Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Long time to pick up, excellent loaf externals.
H. Long mix time, high absorption, avg grain, excellent volume.
I. Poor crumb color.
J. No comment.
K. Long mix time, very tolerant to mixing, low absorption, good grain, good volume.
L. No comment.
M. Good protein and volume. Recommend for bread application.

COOP. **20-2402 Jagalene (CC01)**

A. No comment.
B. No comment.
C. No comment.
D. Good dough properties and overall bread performance.
E. Good mix time, loaf volume less than predicted.
F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, High Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. Excellent loaf externals.
H. Very high absorption (72%), open grain, good volume.
I. Dough felt rubbery and lifeless.
J. No comment.
K. Long mix time, very tolerant to mixing, good absorption, avg grain, good volume.
L. No comment.
M. Good performance, higher protein and absorption. Recommend.

COOP. 20-2403 CO14A055-258

A. No comment.
B. Uneven crust color.
C. No comment.
D. Mix time somewhat long but good overall dough properties, good volume performance for protein level.
E. Two large holes in loaf.
F. Normal Protein & Water Abs, Very Long MT, Slight Sticky & Weak Dough, High Volume, Yellow Crumb, Open Irregular Cells, Soft Resilient & Slightly Harsh Texture.
G. Cap, rough break.
H. Long mix time, high absorption, avg grain, good volume.
I. Dough felt rubbery and lifeless.
J. No comment.
K. Long mix time, very tolerant to mixing, avg absorption, good grain, tough dough at makeup, excellent volume.
L. No comment.
M. Fair protein and strong notes in dough performance, high tolerance in mix, nice crumb and grain.

COOP. 20-2404 CO15D098R

A. No comment.
B. No comment.
C. No comment.
D. Good overall dough performance, good volume and crumb grain performance.
E. Two large holes in loaf.
F. High Protein, High Water Abs, Very Long MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Excellent loaf externals.
H. Long mix time, very high absorption (70%), open grain, dark yellow crumb, excellent volume.
I. Dough felt rubbery and lifeless.
J. No comment.
K. Long mix time, very tolerant to mixing, low absorption and grain, good volume.
L. No comment.
M. Long mix and good notes. Recommend for bread application.

COOP. 20-2405 CO16SF070

A. No comment.
B. No comment.
C. No comment.
D. Dough mix tolerance somewhat low but mix time and crumb grain at acceptable levels.
E. Good mix time, loaf volume less than predicted, lower mixograph ETI.
F. High Protein, High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume with Keyhole, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Left and right break, weak dough?
H. Good absorption, avg grain, excellent dough characteristics, avg volume.
I. Dough did not seal well at moulding, some large cells in the crumb.
J. No comment.
K. Low absorption, avg grain and volume, excellent dough out of mixer.
L. No comment.
M. Average mix time. Fair product.

Notes: **A, K, and M** conducted sponge and dough bake tests

BASF

20-2406	Jagalene (CC02)
20-2407	BASF1
20-2408	BASF2

Description of Test Plots and Breeder Entries

BASF – William Berzonsky

The 2020 Hard Winter Wheat samples from BASF were grown in a strip increase in Beaver Crossing, NE. The WQC strips were planted into good soil moisture on September 28, 2019. Unfortunately, due to difficulties acquiring source seed for Jagalene we experienced poor germination and emergence in those strips. Consequently, the Jagalene strips were considerably thinner stands which resulted in dramatic yield differences between the check and hybrids. The hybrids emerged well and had decent fall growth before winter. The soil was sampled and recommendations matching our expected yield goal were established. The strips were top-dressed with 90lbs of N (actual) in March upon spring greenup. A broadleaf herbicide application was also made in March. A foliar fungicide application was applied on the emerged flag leaf, and a fungicide was applied at flowering to prevent FHB infection. Strips were harvested without any pre-harvest rains upon ripening in early July.

BASF-1 is an experimental hard red winter wheat hybrid developed by BASF. The F_1 is the result of combining female and male parents that are well-adapted to a specific winter wheat area that spans the predominant production regions of Nebraska, Kansas, and north-central Oklahoma. This hybrid has been tested in internal yield trials for 4 years, and it was also tested in the 2020 Southern Regional Performance Nursery (SRPN). It exhibits a bronze chaff color and is a medium-maturity hybrid that is medium-tall for height. Its straw strength is average-poor, and it should be managed to mitigate the risk of lodging late in the growing season. It has expressed resistance to BYDV and moderate resistance to FHB. It is moderately susceptible to WSMV and the prevalent races of leaf and stripe rust. As a hybrid, its grain yield is expected to be an average of 5 to 10% above most pure line varieties. Internal evaluations have typically characterized its mix and bake qualities as acceptable-excellent for the hard winter wheat class.

BASF-2 is an experimental hard red winter wheat hybrid developed by BASF. The F_1 is the result of combining female and male parents that are well-adapted to a specific winter wheat area that spans the predominant production regions of Nebraska, Kansas, and north-central Oklahoma. This hybrid has been tested in internal yield trials for 3 years, and it was also tested in the 2020 Southern Regional Performance Nursery (SRPN). It exhibits a white chaff color and is a medium-maturity hybrid that is medium-tall for height. Its straw strength is average-good, and despite being slightly taller than BASF-1, it is more resistant to late-season lodging. It has expressed resistance to BYDV but is moderately susceptible to FHB, WSMV, and the prevalent races of leaf rust. It is moderately resistant to the prevalent races of stripe rust. The yield of BASF-2 has been as good and often slightly better than BASF-1, and as it is a hybrid, its grain yield is expected to be an average of 5 to 10% above most pure line varieties. Internal evaluations have typically characterized its mix and bake qualities as acceptable for the hard winter wheat class.

Jagalene-check

BASF: 2020 (Small-Scale) Samples

Test entry number	20-2406	20-2407	20-2408
Sample identification	**Jagalene (CC02)**	**BASF1**	**BASF2**
Wheat Data			
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu) **Hectoliter weight (kg/hl)**	60.0 78.9	62.0 81.5	61.8 81.3
1000 kernel weight (gm)	30.4	30.6	33.2
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 66.6 33.4 0.0	 67.5 32.4 0.1	 80.7 19.2 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	 92.4/15.7 30.4/8.7 2.71/0.33 14.4/0.4 00-01-02-97-01 Hard	 66.0/15.5 30.6/8.7 2.69/0.33 13.4/0.3 03-07-24-66-01 Hard	 73.6/14.5 33.2/8.7 2.80/0.35 13.7/0.3 01-04-11-84-01 Hard
Wheat protein (12% mb) **Wheat ash (12% mb)**	15.3 1.72	13.8 1.60	14.2 1.62
Milling and Flour Quality Data			
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 74.5 68.5	 76.5 70.2	 75.7 70.1
Flour moisture (%) **Flour protein (14% mb)** **Flour ash (14% mb)**	13.2 14.0 0.64	12.6 12.4 0.54	12.6 12.9 0.54
Rapid Visco-Analyser Peak Time (min) Peak Viscosity (RVU) Breakdown (RVU) Final Viscosity at 13 min (RVU)	 6.07 195.8 79.3 221.4	 6.07 216.5 88.9 232.0	 6.2 216.7 86.5 226.4
Minolta color meter L* a* b* **PPO**	 90.21 -1.06 8.85 0.506	 90.42 -1.11 9.07 0.597	 90.65 -0.99 7.85 0.607
Falling number (sec)	380	387	377
Damaged Starch (AI%) (AACC76-31)	 98.0 8.0	 96.7 6.8	 96.9 7.0

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

BASF: Physical Dough Tests and Gluten Analysis For 2020 (Small-Scale) Samples

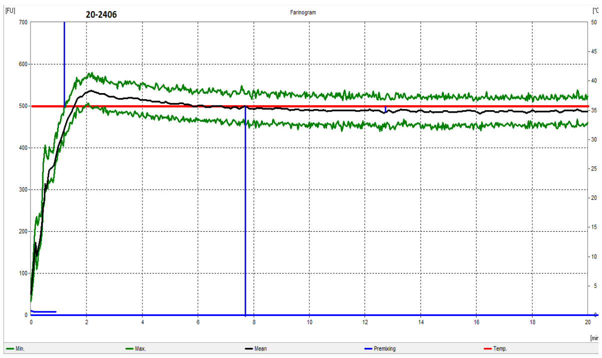
Test Entry Number	20-2406	20-2407	20-2408
Sample Identification	Jagalene (CC02)	BASF1	BASF2
MIXOGRAPH			
Flour Abs (% as-is)	70.3	68.7	69.5
Flour Abs (14% mb)	69.3	67.1	67.9
Mix Time (min)	7.6	7.0	5.0
Mix tolerance (0-6)	6	6	5
FARINOGRAPH			
Flour Abs (% as-is)	65.4	61.4	65.5
Flour Abs (14% mb)	64.5	59.8	63.9
Peak time (min)	7.7	5.6	7.8
Mix stability (min)	24.8	15.8	18.0
Mix Tolerance Index (FU)	14	19	17
Breakdown time (min)	26.0	14.5	18.9
ALVEOGRAPH			
P(mm): Tenacity	159	107	135
L(mm): Extensibility	49	82	73
G(mm): Swelling index	15.5	20.1	19.0
W(10^{-4} J): strength (curve area)	347	324	368
P/L: curve configuration ratio	3.24	1.30	1.85
Ie(P_{200}/P): elasticity index	66.5	60.7	58.3
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	739/1171/1180	571/851/921	407/516/523
Extensibility (mm at 45/90/135 min)	130/113/105	139/124/106	141/139/138
Energy (cm^2 at 45/90/135 min)	164/200/166	137/173/150	97/126/132
Resist $_{max}$ (BU at 45/90/135 min)	1044/1504/1379	780/1155/1267	523/715/763
Ratio (at 45/90/135 min)	5.7/10.4/11.3	4.3/6.9/8.7	2.9/3.7/3.8
PROTEIN ANALYSIS			
HMW-GS Composition	1,2*, 17+18, 5+10	2*, 7+9, 5+10	1,2*, 7+9, 17+18, 5+10
TPP/TMP	0.90	0.94	0.79
SEDIMENTATION TEST			
Volume (ml)	66.8	60.0	60.5

Physical Dough Tests

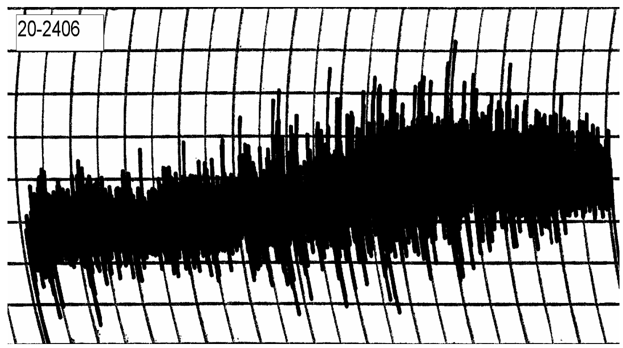
2020 (Small Scale) Samples – BASF

Farinograms

Mixograms

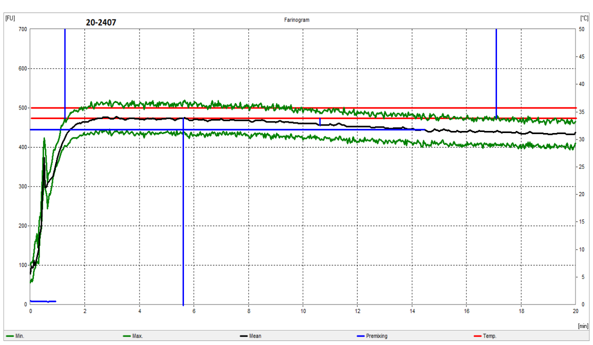


Water abs = 64.5%, Peak time = 7.7 min,
Mix stab = 24.8 min, MTI = 14 FU

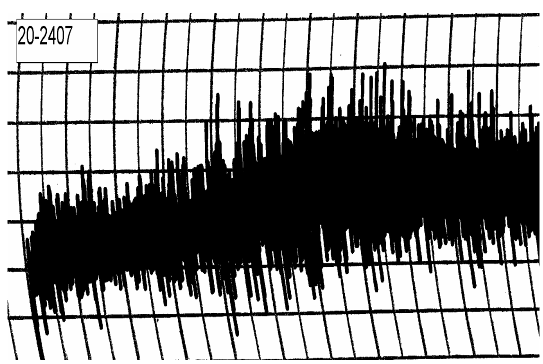


Water abs = 69.3%
Mix time = 7.6 min

20-2406, Jagalene (CC02)



Water abs = 59.8%, Peak time = 5.6 min,
Mix stab = 15.8 min, MTI = 19 FU

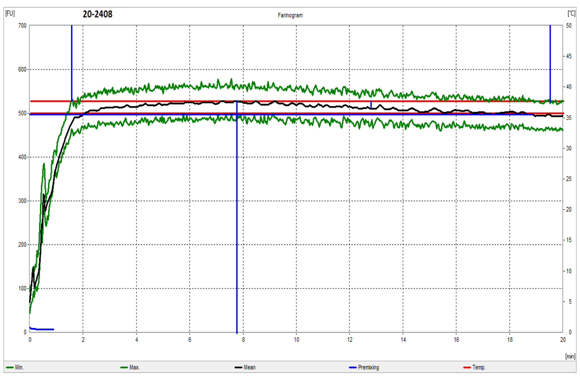


Water abs = 67.1%
Mix time = 7.0 min

20-2407, BASF1

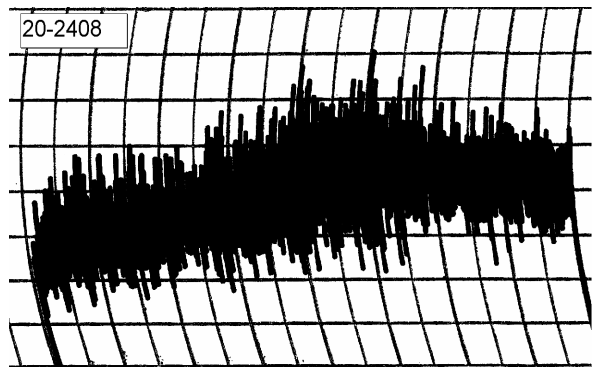
Physical Dough Tests
2020 (Small Scale) Samples – BASF

Farinograms



Water abs = 63.9%, Peak time = 7.8 min,
Mix stab = 18 min, MTI = 17 FU

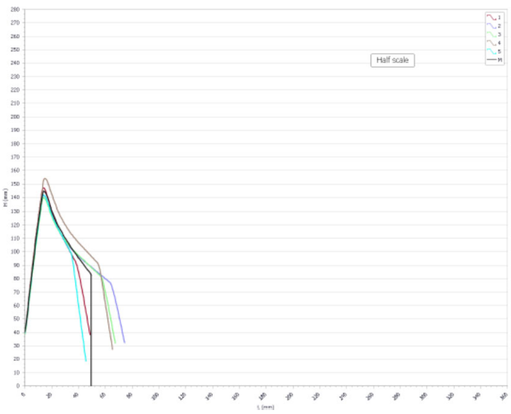
Mixograms



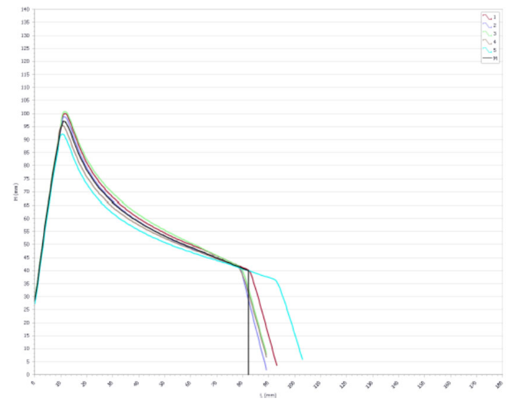
Water abs = 67.9%
Mix time = 5.0 min

20-2408, BASF2

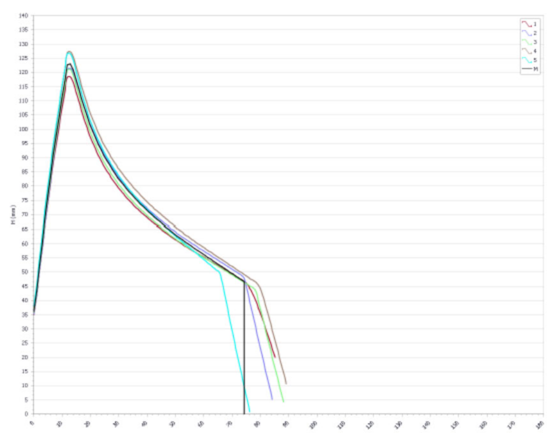
Physical Dough Tests - Alveograph
2020 (Small Scale) Samples – BASF



20-2406, Jagalene (CC02)
P (mm $H_2 0$) = 159, L (mm) = 49, W ($10E^{-4}J$) = 347



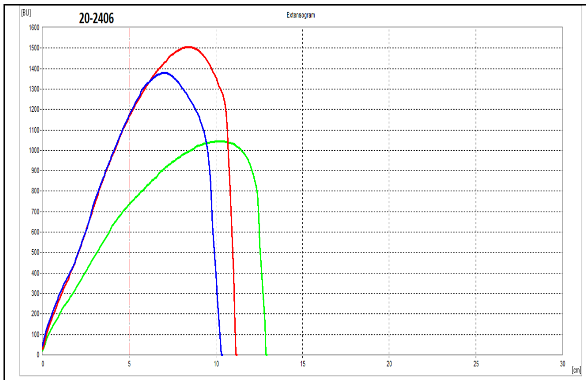
20-2407, BASF1
P (mm $H_2 0$) = 107, L (mm) = 82, W ($10E^{-4}J$) = 324



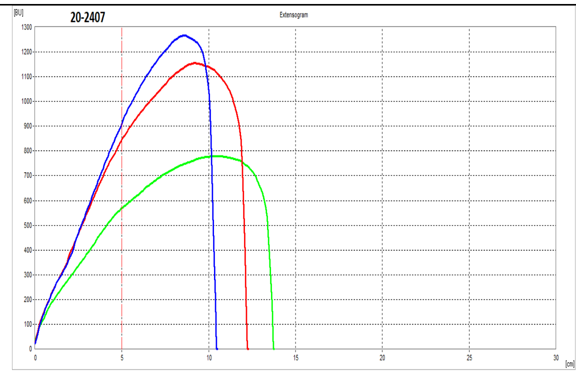
20-2408, BASF2
P (mm $H_2 0$) = 135, L (mm) = 73, W ($10E^{-4}J$) = 368

Physical Dough Tests - Extensigraph

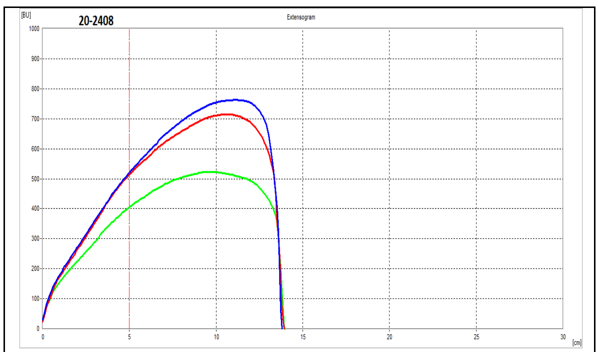
2020 (Small Scale) Samples – BASF



20-2406, Jagalene (CC02)
R (BU) = 1171, E (mm) = 113, W (cm^2) = 200
Rmax (BU) = 1504, Ratio = 10.4 at 90 min



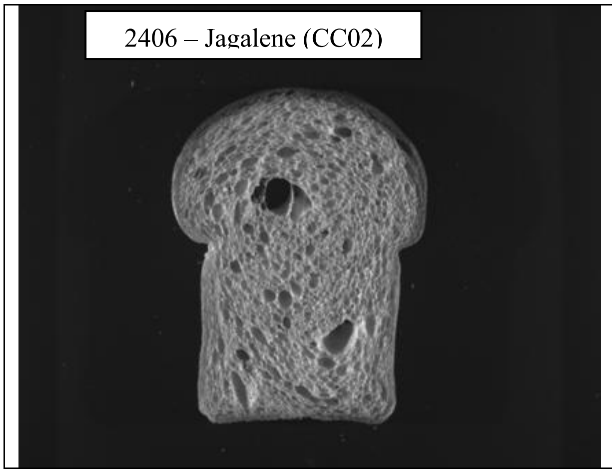
20-2407, BASF1
R (BU) = 851, E (mm) = 124, W (cm^2) = 173
Rmax (BU) = 1155, Ratio = 6.9 at 90 min

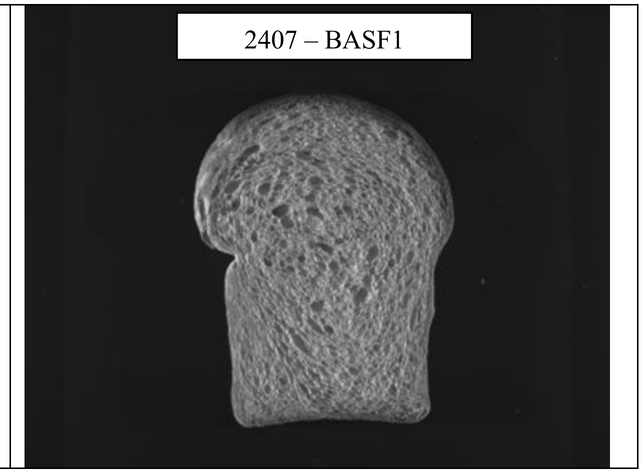


20-2408, BASF2
R (BU) = 516, E (mm) = 139, W (cm^2) = 126
Rmax (BU) = 715, Ratio = 3.7 at 90 min

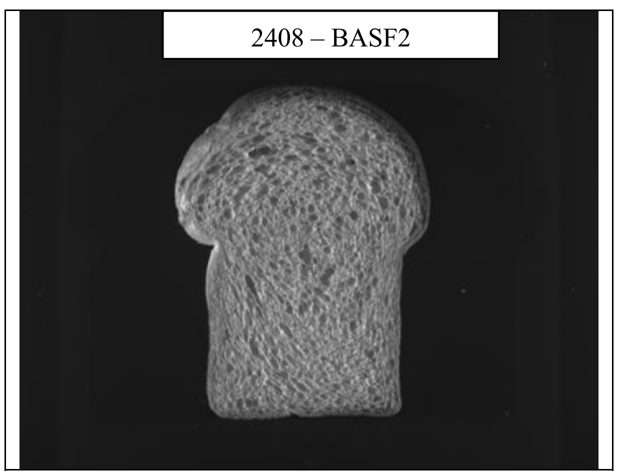
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

BASF: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples

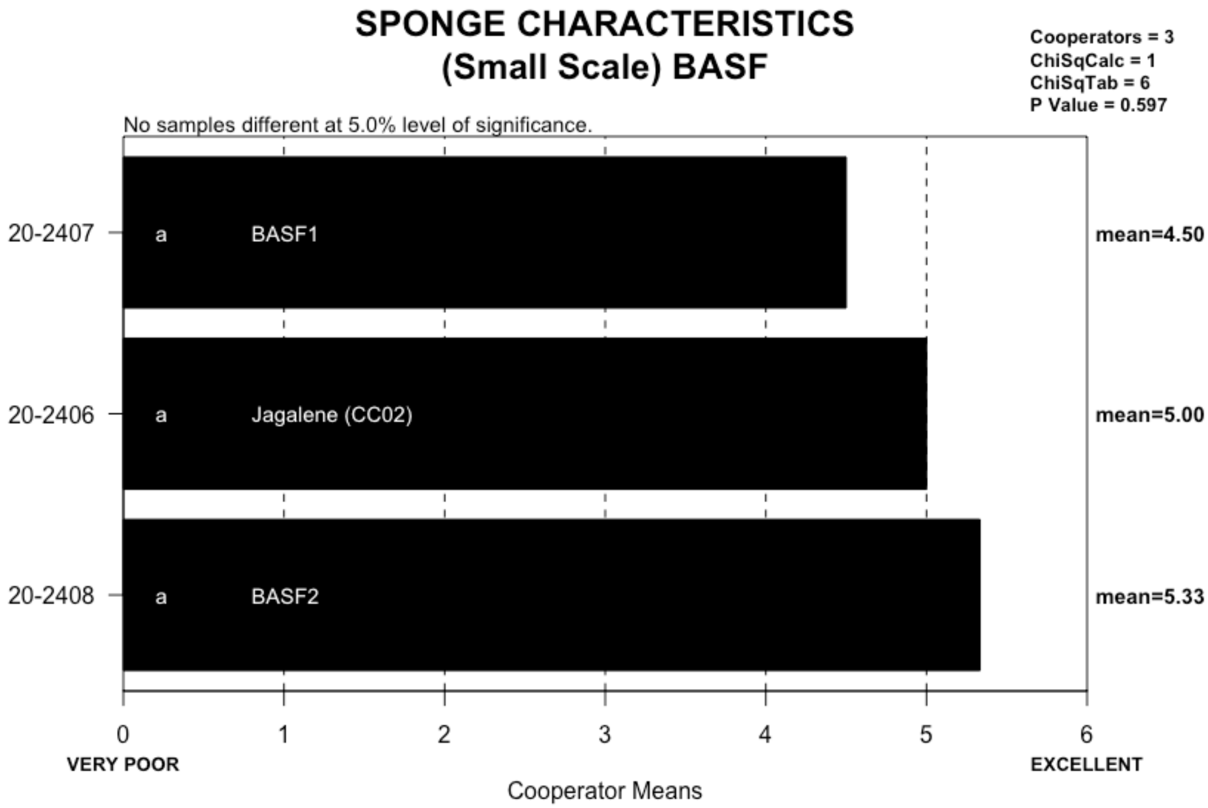


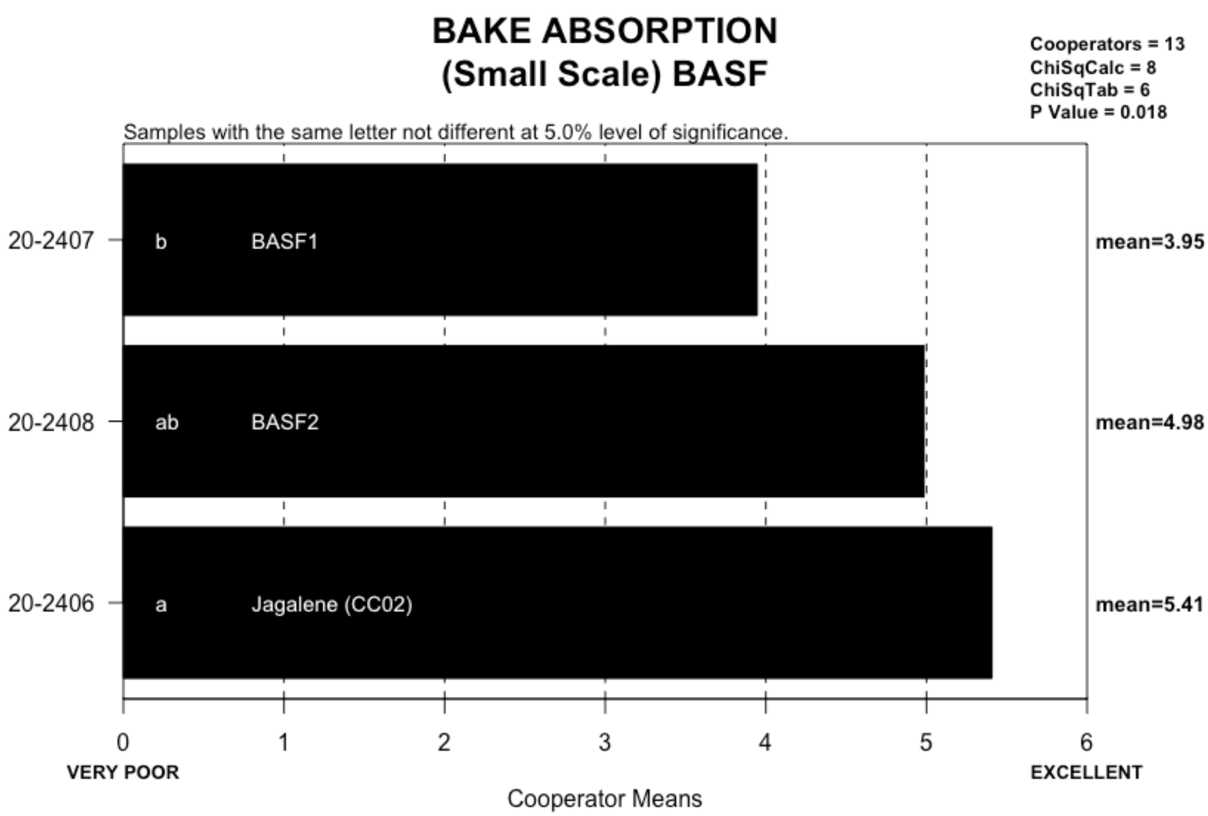


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2406	6709	112	3534	0.438	2.286	3.460	1.815	-3.73
2407	6759	112	3891	0.425	2.056	2.687	1.812	-4.67



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})
2408	6750	115	3674	0.432	2.247	3.548	1.821	-3.71


SPONGE CHARACTERISTICS
(Small Scale) BASF
Cooperators = 3
ChiSqCalc = 1
ChiSqTab = 6
P Value = 0.597
No samples different at 5.0% level of significance.
20-2407
a
BASF1
mean=4.50
20-2406
a
Jagalene (CC02)
mean=5.00
20-2408
a
BASF2
mean=5.33
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

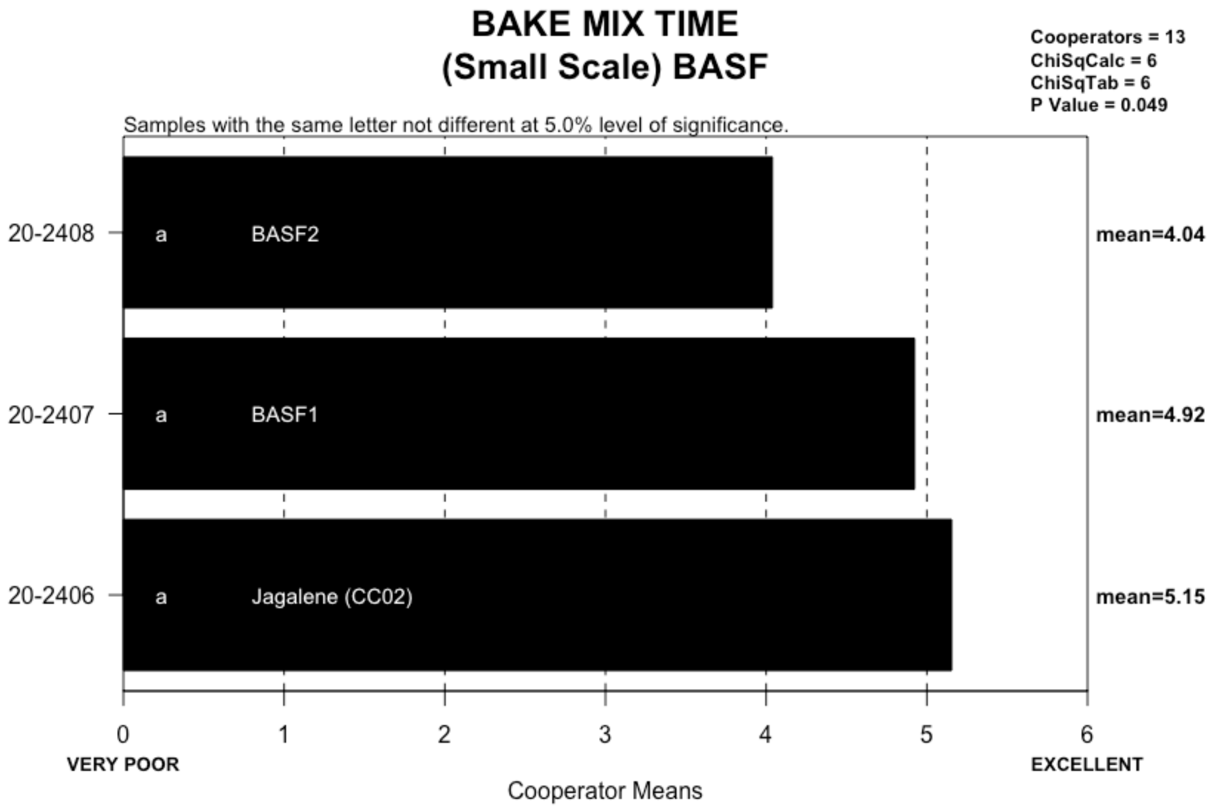

BAKE ABSORPTION
(Small Scale) BASF
Cooperators = 13
ChiSqCalc = 8
ChiSqTab = 6
P Value = 0.018
Samples with the same letter not different at 5.0% level of significance.
20-2407
b
BASF1
mean=3.95
20-2408
ab
BASF2
mean=4.98
20-2406
a
Jagalene (CC02)
mean=5.41
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

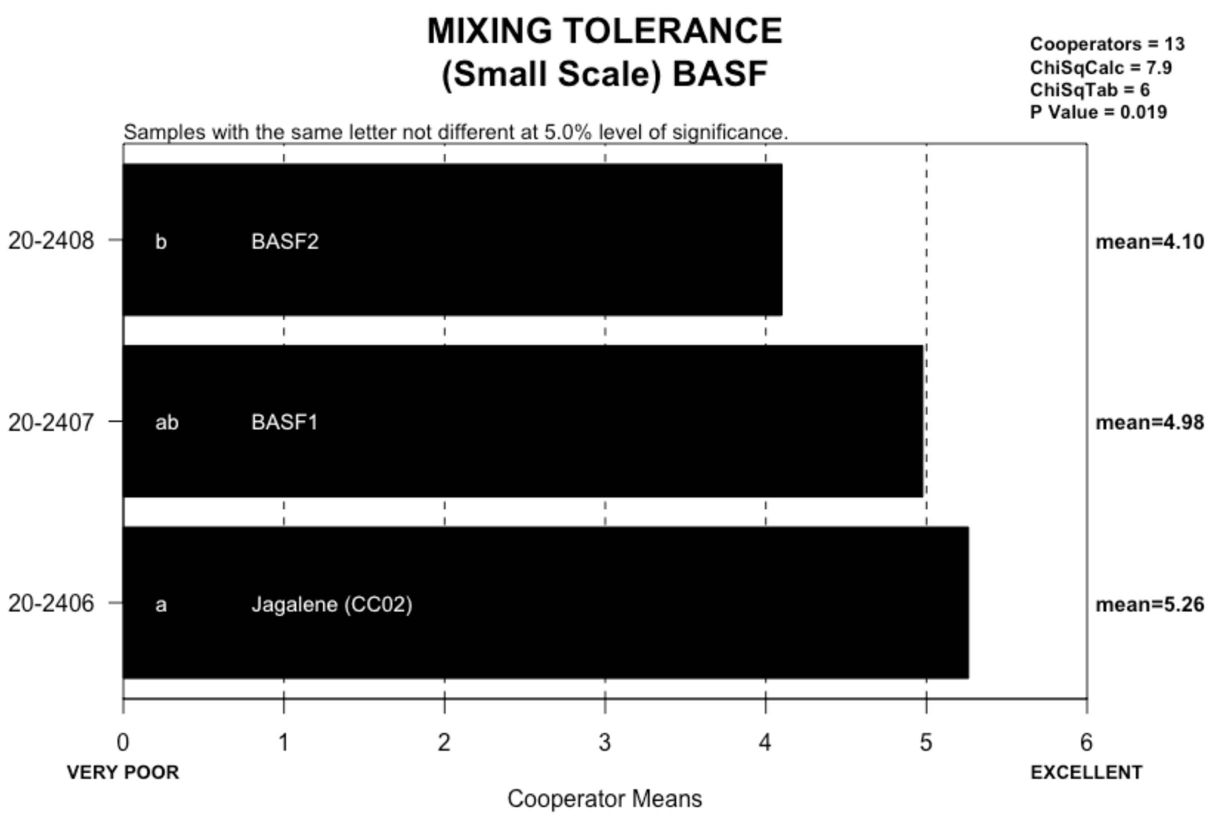
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) BASF
Cooperators A – M

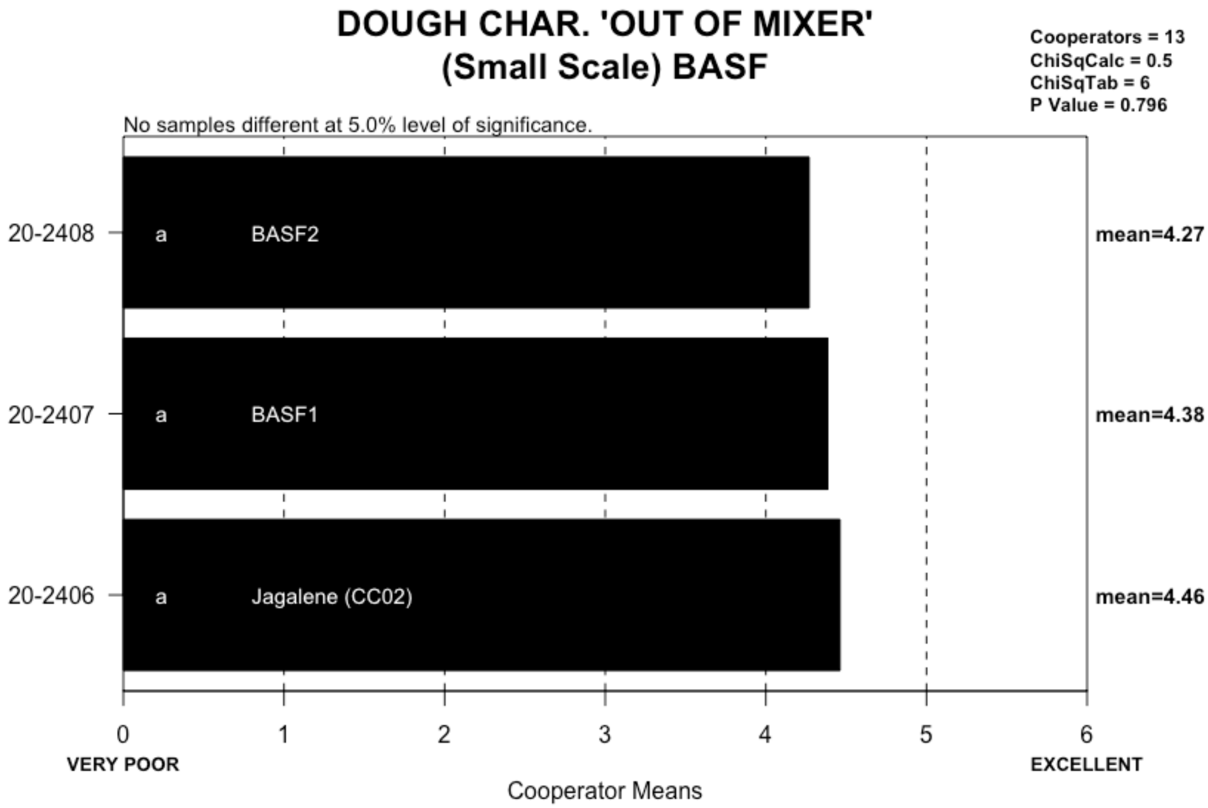
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2406	Jagalene (CC02)	60	71.1	70.2	71.3	68.0	64.8	68.6	72.7	65.0	64.5	63.0	69.3	66.5
20-2407	BASF1	58	62.4	68.6	68.1	65.2	64.3	64.4	67.1	60.4	59.8	57.4	67.1	61.8
20-2408	BASF2	59	71.6	69.6	68.6	66.4	64.8	66.9	68.1	64.9	63.9	60.4	67.9	65.9

BAKE MIX TIME, ACTUAL
(Small Scale) BASF
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2406	Jagalene (CC02)	15	7.0	8.3	8.4	7.2	8.6	7.0	10.0	7.3	8	9	7.6	20
20-2407	BASF1	15	5.5	7.2	6.9	6.0	9.1	6.5	8.0	6.3	8	6	7.0	20
20-2408	BASF2	8	4.5	5.0	4.6	4.5	7.1	4.5	5.6	4.5	8	4	5.0	17

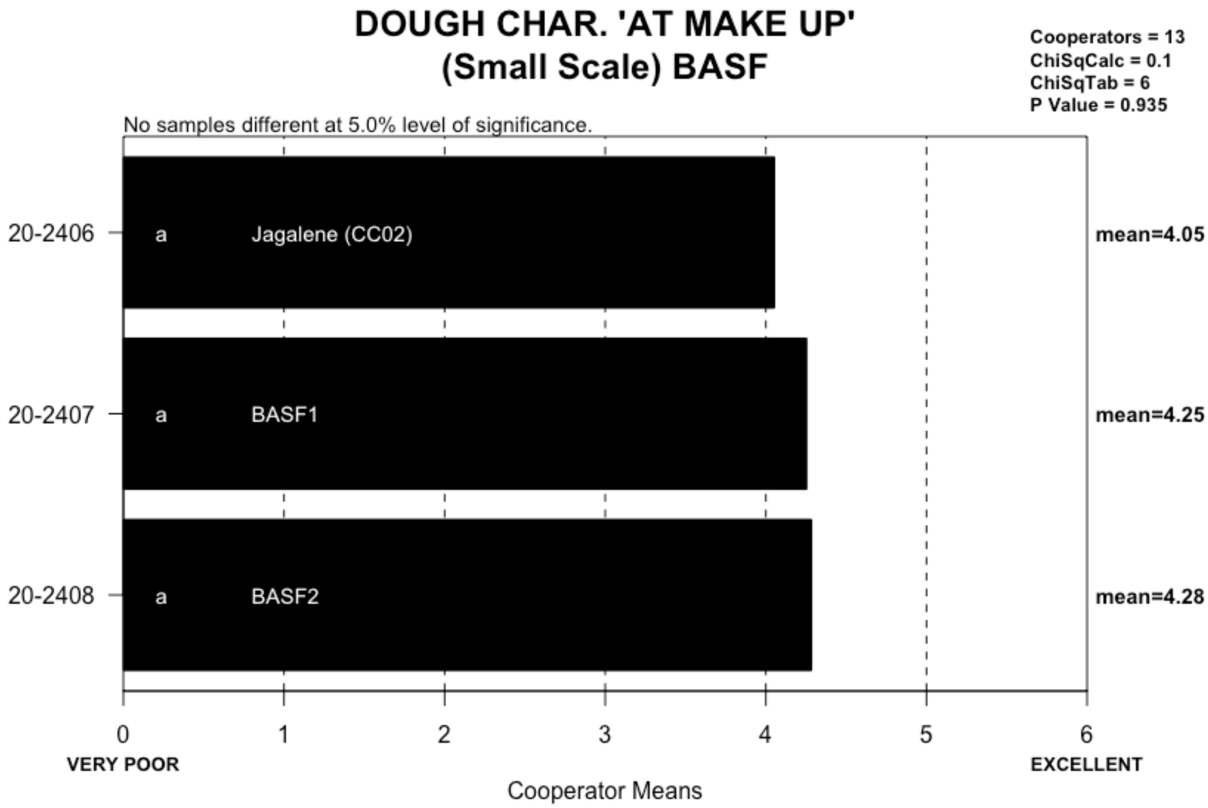

BAKE MIX TIME
(Small Scale) BASF
Cooperators = 13
ChiSqCalc = 6
ChiSqTab = 6
P Value = 0.049
Samples with the same letter not different at 5.0% level of significance.
20-2408
a
BASF2
mean=4.04
20-2407
a
BASF1
mean=4.92
20-2406
a
Jagalene (CC02)
mean=5.15
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) BASF
Cooperators = 13
ChiSqCalc = 7.9
ChiSqTab = 6
P Value = 0.019
Samples with the same letter not different at 5.0% level of significance.
20-2408
b
BASF2
mean=4.10
20-2407
ab
BASF1
mean=4.98
20-2406
a
Jagalene (CC02)
mean=5.26
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



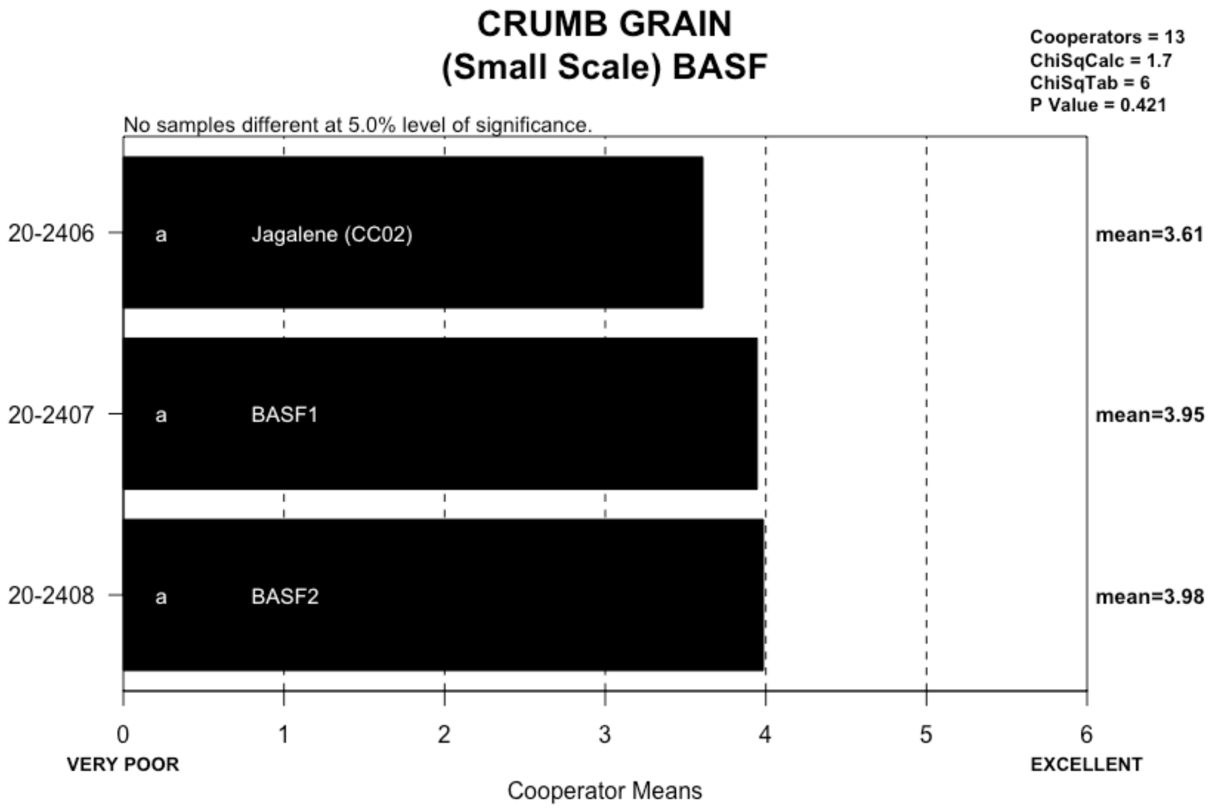
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) BASF

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2406	Jagalene (CC02)	0	0	5	4	4
20-2407	BASF1	0	0	3	9	1
20-2408	BASF2	0	0	3	9	1



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2406	Jagalene (CC02)	0	0	6	5	2
20-2407	BASF1	0	0	6	4	3
20-2408	BASF2	1	0	4	7	1

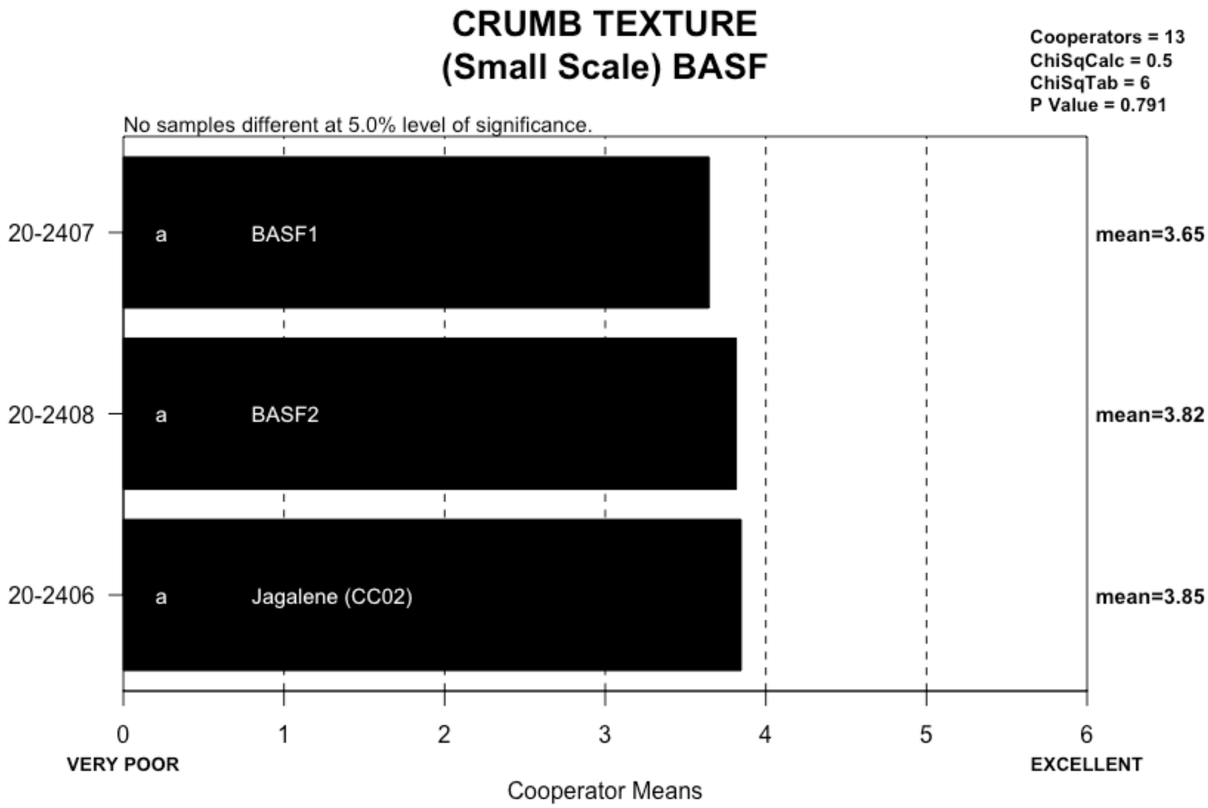


CRUMB GRAIN, DESCRIBED
(Small Scale) BASF

IDCODE	ID	Open	Fine	Dense
20-2406	Jagalene (CC02)	6	5	2
20-2407	BASF1	3	9	1
20-2408	BASF2	7	5	1

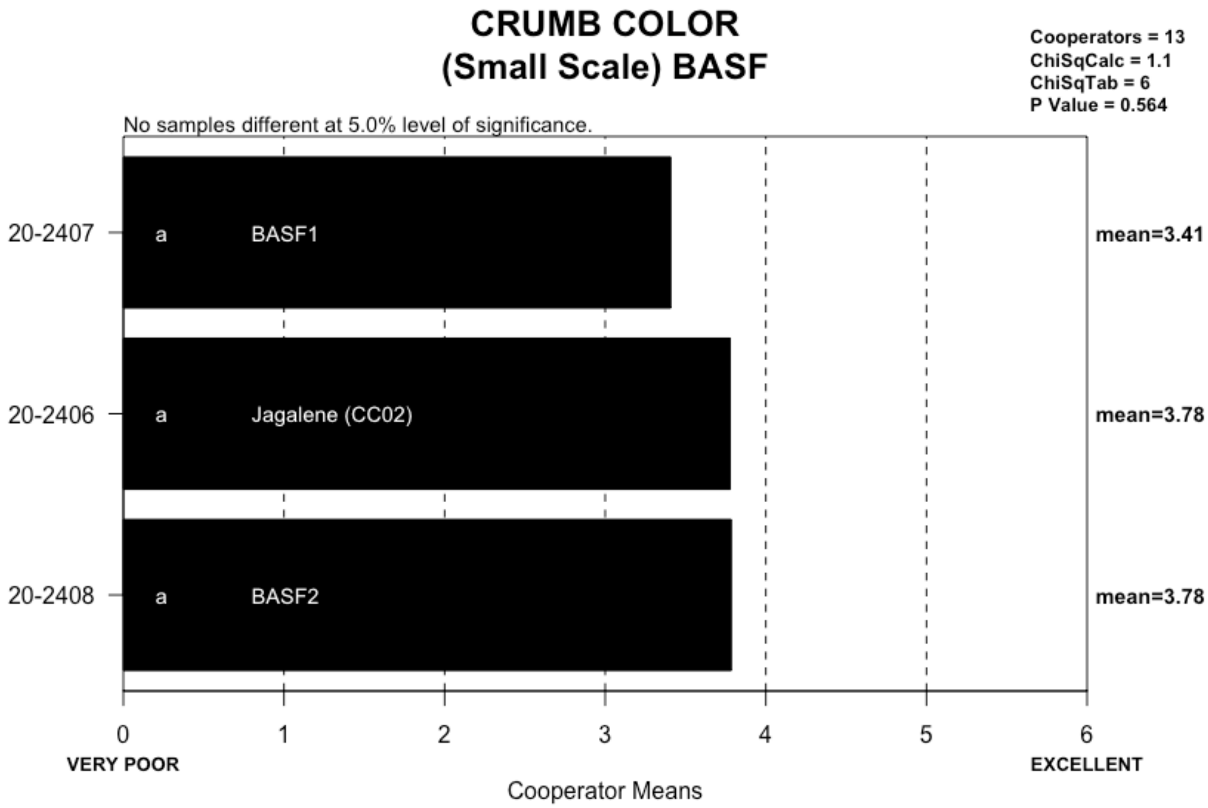
CELL SHAPE, DESCRIBED
(Small Scale) BASF

IDCODE	ID	Round	Irregular	Elongated
20-2406	Jagalene (CC02)	5	4	4
20-2407	BASF1	5	4	4
20-2408	BASF2	5	5	3



CRUMB TEXTURE, DESCRIBED
(Small Scale) BASF

IDCODE	ID	Harsh	Smooth	Silky
20-2406	Jagalene (CC02)	4	6	3
20-2407	BASF1	2	9	2
20-2408	BASF2	4	8	1



CRUMB COLOR, DESCRIBED
(Small Scale) BASF

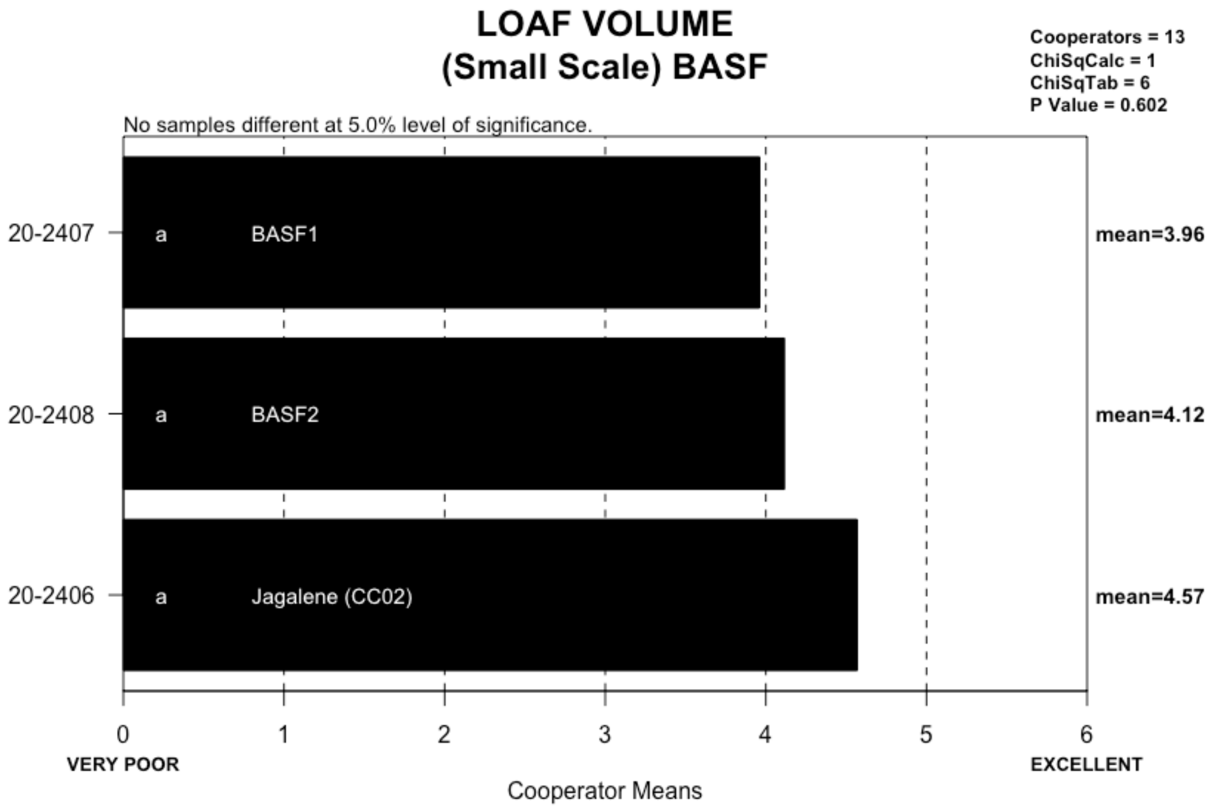
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2406	Jagalene (CC02)	0	1	0	4	5	3	0
20-2407	BASF1	0	1	0	6	6	0	0
20-2408	BASF2	1	0	0	5	6	1	0

LOAF WEIGHT, ACTUAL
(Small Scale) BASF
Cooperators A – M

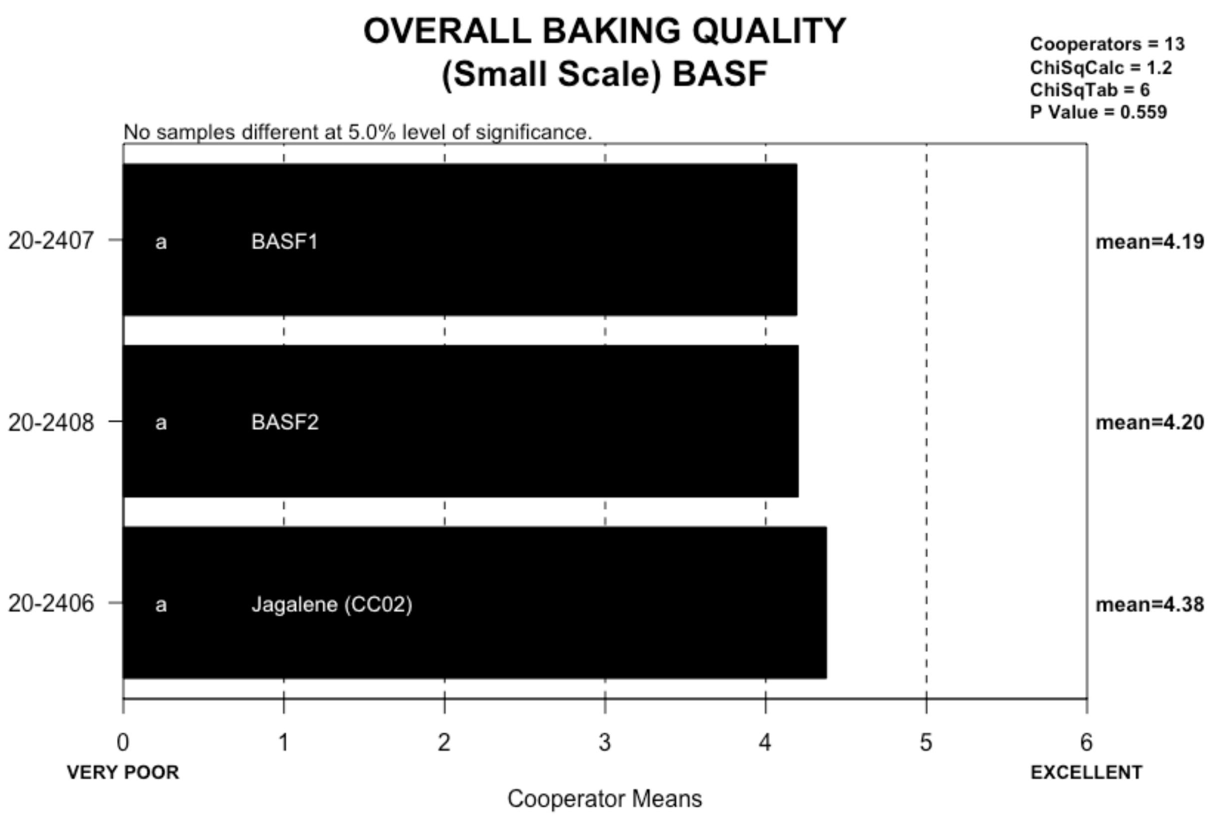
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2406	Jagalene (CC02)	417	135.4	135.8	160.0	144.9	140.4	143.5	153.5	141	457.9	478.1	144.8	422.0
20-2407	BASF1	414	132.0	137.9	152.5	142.7	139.2	143.2	150.2	138	457.8	480.4	142.8	424.6
20-2408	BASF2	413	134.4	137.8	154.4	142.9	139.2	144.3	151.0	140	456.4	479.9	142.5	418.0

LOAF VOLUME, ACTUAL
(Small Scale) BASF
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2406	Jagalene (CC02)	3000	975	982	960	930	841	1130	955	714	2539	2638	910	2800
20-2407	BASF1	2900	820	900	915	890	978	1060	915	726	2746	2375	805	2650
20-2408	BASF2	2875	800	872	993	885	1050	1000	935	834	2569	2613	785	2550



LOAF VOLUME
(Small Scale) BASF
Cooperators = 13
ChiSqCalc = 1
ChiSqTab = 6
P Value = 0.602
No samples different at 5.0% level of significance.
20-2407
a
BASF1
mean=3.96
20-2408
a
BASF2
mean=4.12
20-2406
a
Jagalene (CC02)
mean=4.57
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



OVERALL BAKING QUALITY
(Small Scale) BASF
Cooperators = 13
ChiSqCalc = 1.2
ChiSqTab = 6
P Value = 0.559
No samples different at 5.0% level of significance.
20-2407
a
BASF1
mean=4.19
20-2408
a
BASF2
mean=4.20
20-2406
a
Jagalene (CC02)
mean=4.38
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) BASF

COOP. 20-2406 Jagalene (CC02)

A. No comment.
B. Nice loaf.
C. No comment.
D. Dough mix time somewhat long but generally good overall properties, high absorption, loaf volume somewhat low for protein level.
E. One large hole in loaf.
F. Very High Protein & Water Abs, Long MT, Slight Sticky & Weak Dough, Low Volume, Dark Yellow Crumb, Tight Round Cells, Resilient & Harsh Texture.
G. Yellowish dough, excellent loaf externals.
H. Long mix time, very high absorption (73%), open grain, good volume.
I. High protein, tough dough, hard spots throughout the crumb.
J. No comment.
K. Long mix time, very tolerant to mixing, high absorption, avg grain, creamy color, good volume.
L. No comment.
M. High protein, absorption, and mix time. Recommend for blending.

COOP. 20-2407 BASF1

A. No comment.
B. Even crumb.
C. No comment.
D. Long mix time but dough generally weaker looking, volume and crumb grain at acceptable levels.
E. Longer mix time, overall good.
F. High Protein & Water Abs, Very Long MT, Slight Sticky & Strong Dough, Very High Volume, Dark Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Yellowish dough, good loaf externals.
H. Long mix time, high absorption, good grain, good volume.
I. Nice crumb grain.
J. No comment.
K. Low absorption, dense grain, very low volume.
L. No comment.
M. Protein is higher, volume is good.

COOP. **20-2408 BASF2**

A. No comment.
B. No comment.
C. No comment.
D. Good dough properties, good loaf volume and crumb grain performance.
E. Nice grain and color.
F. Very High Protein & Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Dull Crumb, Open Irregular Cells, Soft Resilient & Slightly Harsh Texture.
G. Yellowish dough, cap.
H. High absorption, good grain, good volume.
I. No comment.
J. No comment.
K. Avg absorption, good grain, creamy crumb, good volume.
L. No comment.
M. Protein and absorption were higher, volume has room for improvement.

Notes: **A, K, and M** conducted sponge and dough bake tests

LIMAGRAIN

20-2409	Jagalene (CC03)
20-2410	DH11HRW55-4
20-2411	LCH13DH-47-1675
20-2412	LCH15ACC-13-4

Description of Test Plots and Breeder Entries

LIMAGRAIN – Marla Barnett

Description of Breeder Entries – Limagrain Cereal Seeds

<u>Growing Location & Conditions</u>

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 26, 2019 into good soil moisture with good fall stands and decent growth. The field received 80 lbs actual N and 14 lbs sulfur top-dressed in early December, a broadleaf herbicide and foliar fungicide in late March, and one additional foliar fungicide (Meravis Ace) application in late-May. Field moisture from September 2019 through June 2020 totaled 6.2 inches of rain. Two separate freeze events occurred in April. Adjacent yield plots averaged 57 bushels/acre. The following measurements were taken on the whole grain samples before submission.

	TW (lbs/bu)	Grain Protein (%)
Jagalene	61.3	10.7
DH11HRW55-4	59.4	11.6
LCH13DH-47-1675	62.5	11.5
LCH15ACC-13-4	61.0	11.9

<u>DH11HRW55-4</u>

DH11HRW55-4 is a late maturing hard-red winter wheat with excellent disease resistance. The pedigree of DH11HRW55-4 is KS020840-8 / VA07HRW-130. The line was developed in collaboration between LCS and Virginia Tech. DH11HRW55-4 has excellent straw strength, medium-tall height, and large seed size. Excellent winter-hardiness and resistance to both stem rust and Fusarium head blight make this late maturing line very attractive in growing regions within northern Kansas and central Nebraska. DH11HRW55-4 has resistance to stem rust, stripe rust, leaf rust, and soil-borne mosaic virus. The line was tested in the 2019 Southern Regional Performance Nursery.

Milling and baking quality data from LCS show desirable milling quality and dough properties with most desirable baking quality. DH11HRW55-4 was ultimately released as LCS Diesel.

LCH13DH-47-1675

LCH13DH-47-1675 is a medium maturing hard-red winter wheat with very good drought tolerance. The pedigree of LCH13DH-47-1675 is T153 / LCSMint. Tolerance to acidic soils with resistance to stripe rust and soil-borne mosaic virus make this medium maturing line very attractive to growers in central Oklahoma and southcentral Kansas. LCH13DH-47-1675 is moderately resistant to leaf rust and stem rust with excellent resistance to stripe rust. This line was tested in the 2019 Southern Regional Performance Nursery.

Milling and baking quality data from LCS show acceptable milling quality and desirable dough properties and baking quality. LCH13DH-47-1675 was released as LCS Julep to replace LCS Mint acres with improved stripe rust resistance.

LCH15ACC-13-4

LCH15ACC-13-4 is a medium-early maturing hard-red winter wheat with two genes of tolerance to Quizalofop-P-ethyl group 1 ACCase inhibiting herbicides. The pedigree of LCH15ACC-13-4 is T158 / ACC10-50. Very high tillering combined with an intermediate timing in appearance of the first hollow stem with excellent stripe rust and Fusarium head blight resistance makes LCH15ACC-13-4 a very attractive line throughout Kansas and Oklahoma where growers want to graze wheat while also controlling winter annual grassy weeds like rye, downy brome, and cheat. LCH15ACC-13-4 is susceptible to stem rust and intermediate to leaf rust.

Milling and baking quality data from LCS show acceptable milling quality, most desirable dough properties,and desirable baking quality. The line was ultimately released as LCS Photon AX under the CoAXium wheat production system.

Jagalene – common check

Limagrain: 2020 (Small-Scale) Samples

Test entry number	20-2409	20-2410	20-2411	20-2412
Sample identification	**Jagalene (CC03)**	**DH11HRW55-4**	**LCH13DH-47-1675**	**LCH15ACC-13-4**
Wheat Data				
GIPSA classification	1 HRW	1 HRW	1 HRW	1 HRW
Test weight (lb/bu) **Hectoliter weight (kg/hl)**	61.3 80.6	60.0 78.9	62.6 82.3	61.4 80.7
1000 kernel weight (gm)	30.7	29.4	31.6	28.5
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 73.1 26.8 0.1	 61.5 37.9 0.6	 77.0 22.9 0.1	 60.6 39.4 0.0
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	 70.7/17.6 30.7/8.8 2.74/0.30 12.7/0.3 02-07-16-75-01 Hard	 67.6/19.0 29.4/9.8 2.57/0.38 12.8/0.4 03-09-19-69-01 Hard	 73.0/14.9 31.6/7.3 2.69/0.32 13.1/0.3 01-02-14-83-01 Hard	 67.8/16.1 28.5/8.7 2.58/0.31 11.3/0.4 02-06-25-67-01 Hard
Wheat protein (12% mb) **Wheat ash (12% mb)**	11.0 1.46	11.2 1.57	11.4 1.53	11.5 1.53
Milling and Flour Quality Data				
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 78.5 69.9	 73.2 66.4	 76.0 67.6	 78.9 70.3
Flour moisture (%) **Flour protein (14% mb)** **Flour ash (14% mb)**	12.7 10.0 0.60	12.7 10.3 0.58	12.7 10.3 0.61	13.0 10.6 0.65
Rapid Visco-Analyser Peak Time (min) Peak Viscosity (RVU) Breakdown (RVU) Final Viscosity at 13 min (RVU)	 6.4 197.0 54.1 246.8	 6.5 246.3 78.3 261.5	 6.3 172.8 42.9 228.0	 6.5 231.5 57.1 291.6
Minolta color meter L* a* b* **PPO**	 91.28 -1.09 8.45 0.476	 92.09 -1.35 8.11 0.411	 91.37 -1.02 7.89 0.571	 90.77 -1.29 9.59 0.708
Falling number (sec)	402	412	400	502
Damaged Starch (AI%) (AACC76-31)	 98.1 8.0	 96.7 6.8	 98.7 8.6	 97.1 7.1

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Limagrain: Physical Dough Tests and Gluten Analysis
2020 (Small-Scale) Samples

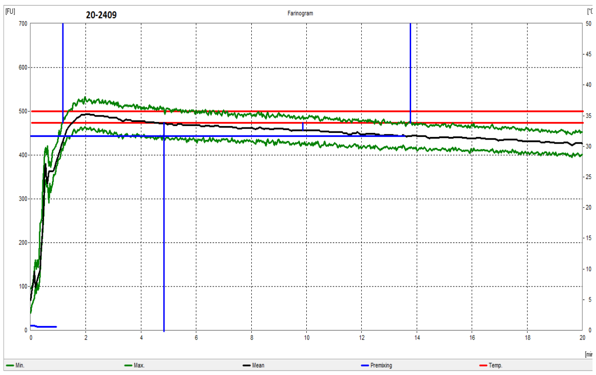
Test Entry Number	20-2409	20-2410	20-2411	20-2412
Sample Identification	Jagalene (CC03)	DH11HRW55-4	LCH13DH-47-1675	LCH15ACC-13-4
MIXOGRAPH				
Flour Abs (% as-is)	64.1	64.6	70.2	64.7
Flour Abs (14% mb)	62.6	63.1	68.7	63.6
Mix Time (min)	5.5	5.8	6.4	4.8
Mix tolerance (0-6)	3	4	4	3
FARINOGRAPH				
Flour Abs (% as-is)	61.1	60.8	66.7	60.8
Flour Abs (14% mb)	59.6	59.3	65.2	59.6
Peak time (min)	4.9	6.5	7.4	5.0
Mix stability (min)	12.6	16.7	14.0	13.1
Mix Tolerance Index (FU)	18	11	23	19
Breakdown time (min)	13.6	17.0	14.3	14.2
ALVEOGRAPH				
P(mm): Tenacity	116	114	151	124
L(mm): Extensibility	41	58	29	42
G(mm): Swelling index	14.2	16.9	12.0	14.4
W(10^{-4} J): strength (curve area)	199	269	197	217
P/L: curve configuration ratio	2.83	1.97	5.21	2.95
Ie(P_{200}/P): elasticity index	51.7	60.3	0.0	48.8
EXTENSIGRAPH				
Resist (BU at 45/90/135 min)	581/835/989	540/891/876	523/909/945	492/757/980
Extensibility (mm at 45/90/135 min)	122/99/89	132/117/104	121/90/93	122/100/88
Energy (cm^2 at 45/90/135 min)	112/114/111	122/158/122	101/101/110	96/107/108
Resist $_{max}$ (BU at 45/90/135 min)	719/949/1062	719/1096/959	663/956/1016	601/871/1035
Ratio (at 45/90/135 min)	4.8/8.4/11.1	4.1/7.6/8.4	4.3/10.2/10.2	4.0/7.5/11.1
PROTEIN ANALYSIS				
HMW-GS Composition	1,2*, 17+18, 5+10	2*, 7+8, 5+10	1, 7+8, 5+10	2*, 7+8, 5+10
TPP/TMP	0.95	0.83	0.84	0.81
SEDIMENTATION TEST				
Volume (ml)	45.3	53.2	45.3	39.5

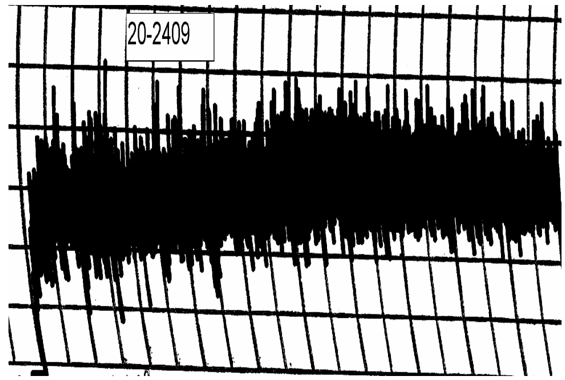
Physical Dough Tests

2020 (Small Scale) Samples – Limagrain

Farinograms

Mixograms

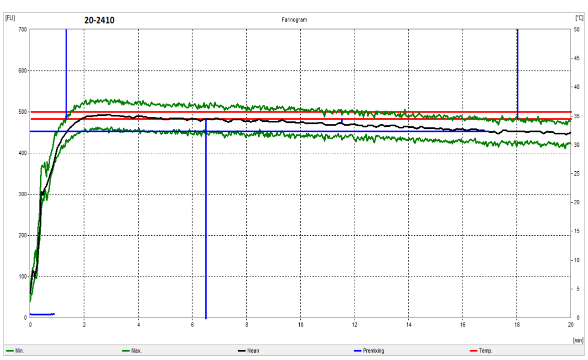


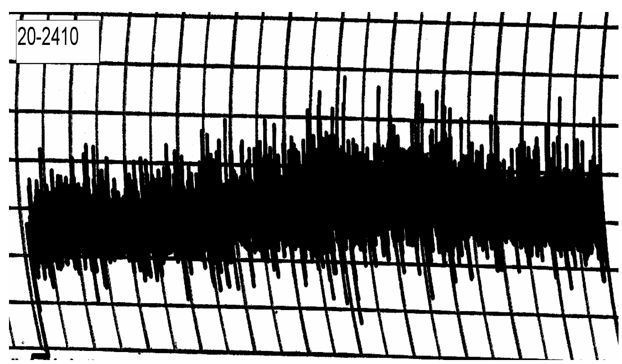


Water abs = 59.6%, Peak time = 4.9 min
Mix stab = 12.6 min, MTI = 18 FU

Water abs = 62.6%
Mix time = 5.5 min

20-2409, Jagalene (CC03)





Water abs = 59.3%, Peak time = 6.5 min,
Mix stab = 16.7 min, MTI = 11 FU

Water abs = 63.1%
Mix time = 5.8 min

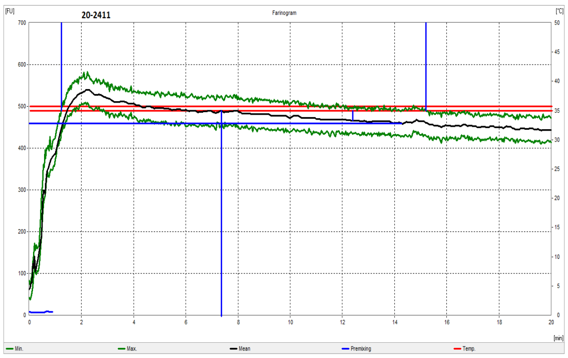
20-2410, DH11HRW55-4

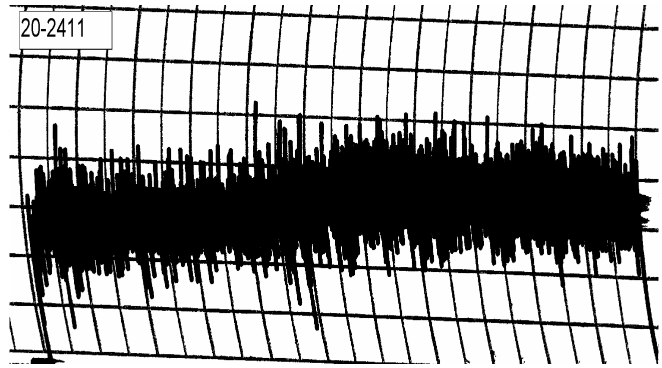
Physical Dough Tests

2020 (Small Scale) Samples – Limagrain (continued)

Farinograms

Mixograms

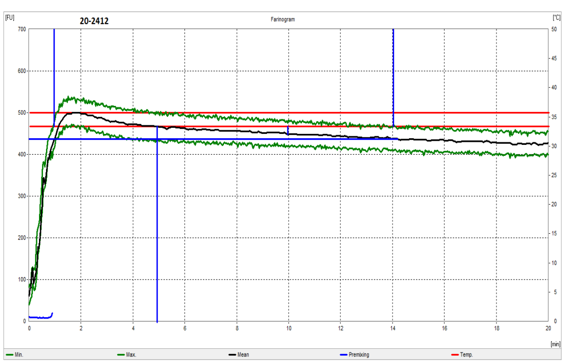


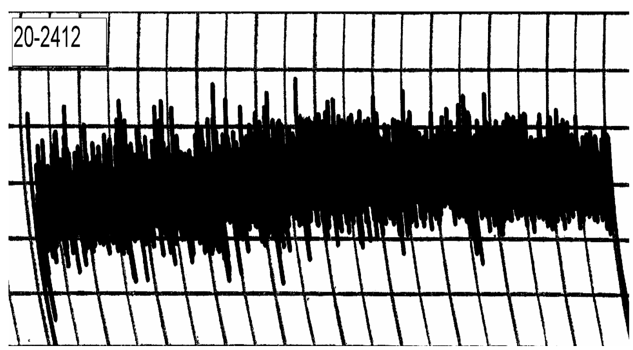


Water abs. = 65.2%, Peak time = 7.4 min,
Mix stab = 14.0 min, MTI = 23 FU

Water abs = 68.7%
Mix time = 6.4 min

20-2411, LCH13DH-47-1675



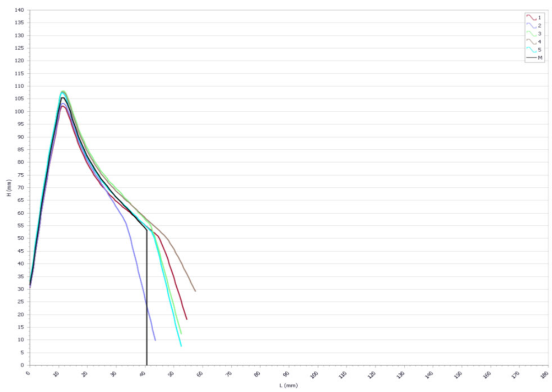


Water abs. = 59.6%, Peak time = 5.0 min,
Mix stab = 13.1 min, MTI = 19 FU

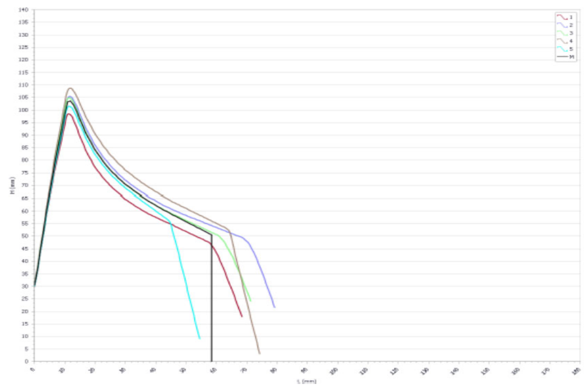
Water abs = 63.6%
Mix time = 4.8 min

20-2412, LCH15ACC-13-4

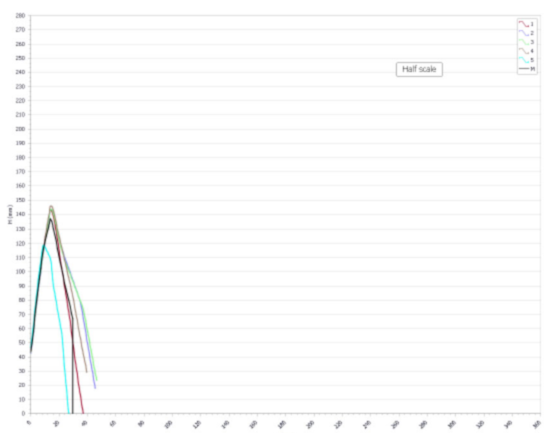
Physical Dough Tests - Alveograph
2020 (Small Scale) Samples – Limagrain



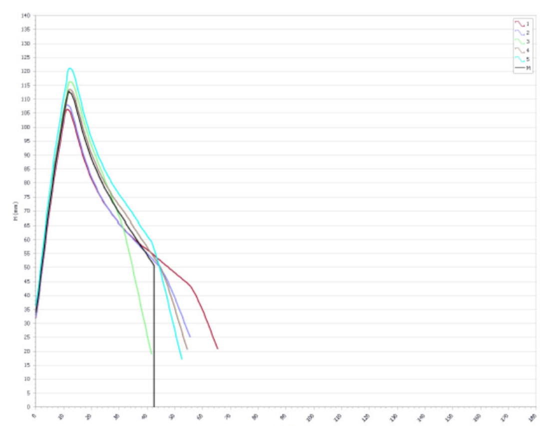
20-2409, Jagalene (CC03)
P (mm H_20) = 116, L (mm) = 41, W ($10E^{-4}J$) = 199



20-2410, DH11HRW55-4
P (mm H_20) = 114, L (mm) = 58, W ($10E^{-4}J$) = 269



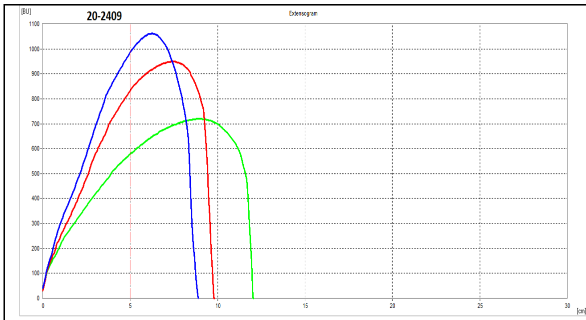
20-2411, LCH13DH-47-1675
P (mm H_20) = 151, L (mm) = 29, W ($10E^{-4}J$) = 197



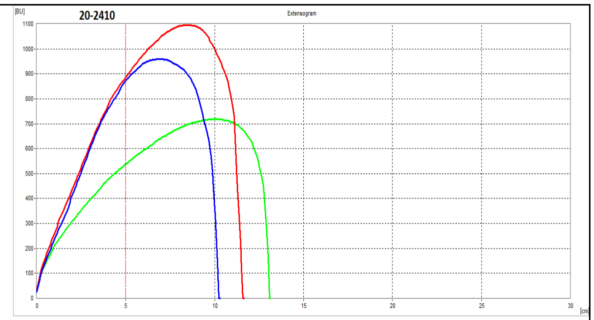
20-2412, LCH15ACC-13-4
P (mm H_20) = 124, L (mm) = 42, W ($10E^{-4}J$) = 217

Physical Dough Tests - Extensigraph

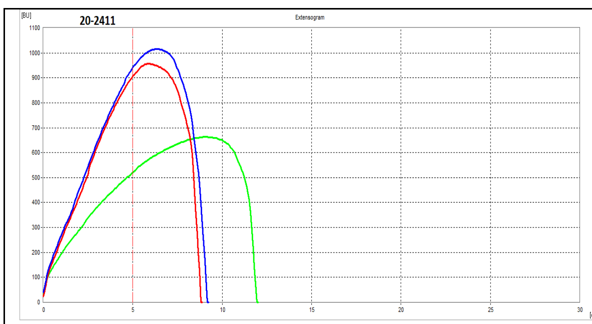
2020 (Small Scale) Samples – Limagrain



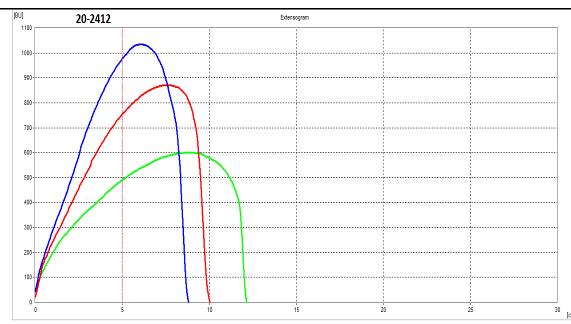
20-2409, Jagalene (CC03)
R (BU) = 835, E (mm) = 99, W (cm^2) = 114
Rmax (BU) = 949, Ratio = 8.4 at 90 min



20-2410, DH11HRW55-4
R (BU) = 891, E (mm) = 117, W (cm^2) = 158
Rmax (BU) = 1096, Ratio = 7.6 at 90 min



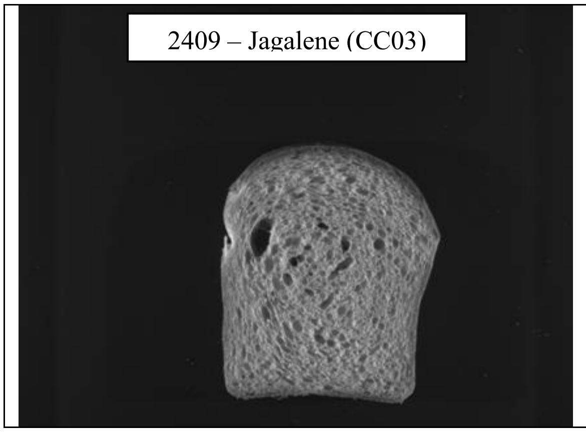
20-2411, LCH13DH-47-1675
R (BU) = 909, E (mm) = 90, W (cm^2) = 101
Rmax (BU) = 956, Ratio = 10.2 at 90 min



20-2412, LCH15ACC-13-4
R (BU) = 757, E (mm) = 100, W (cm^2) = 107
Rmax (BU) = 871, Ratio = 7.5 at 90 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Limagrain: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples

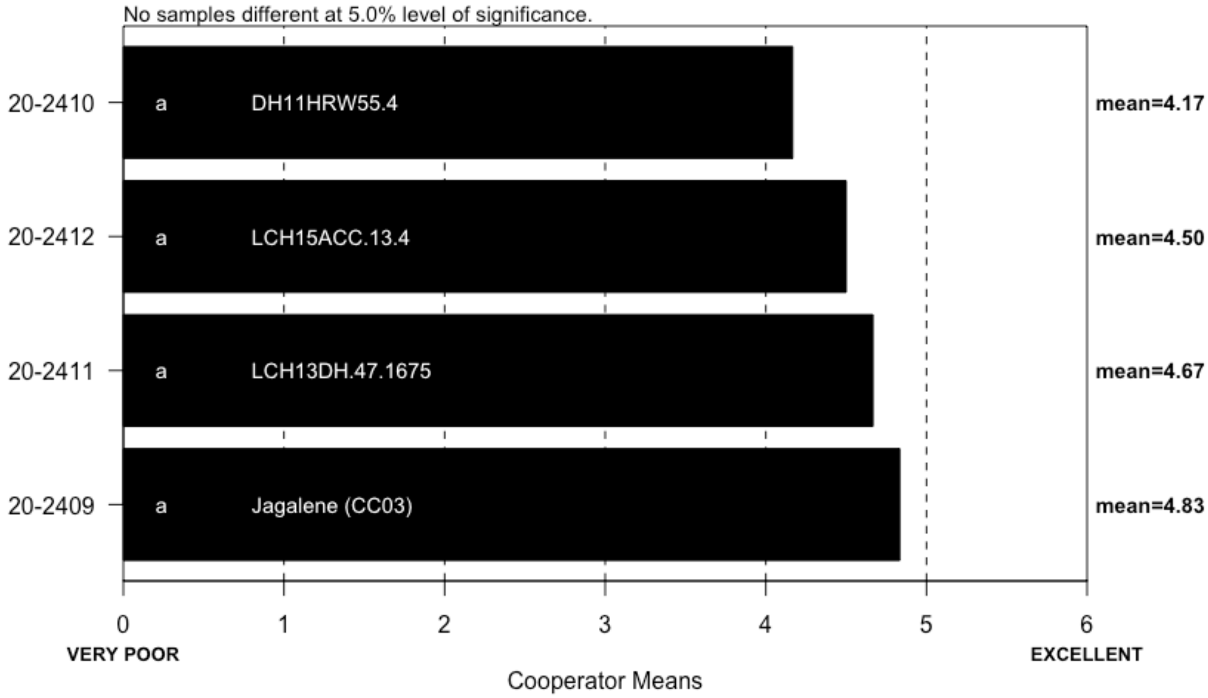


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2409	5388	113	3314	0.425	1.942	3.110	1.812	-6.94
2410	6038	117	3397	0.429	2.169	6.398	1.822	-7.45

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	5470	122	3200	0.432	1.999	4.995	1.772	-3.91
2412	5746	119	3480	0.430	1.997	1.138	1.793	-2.63

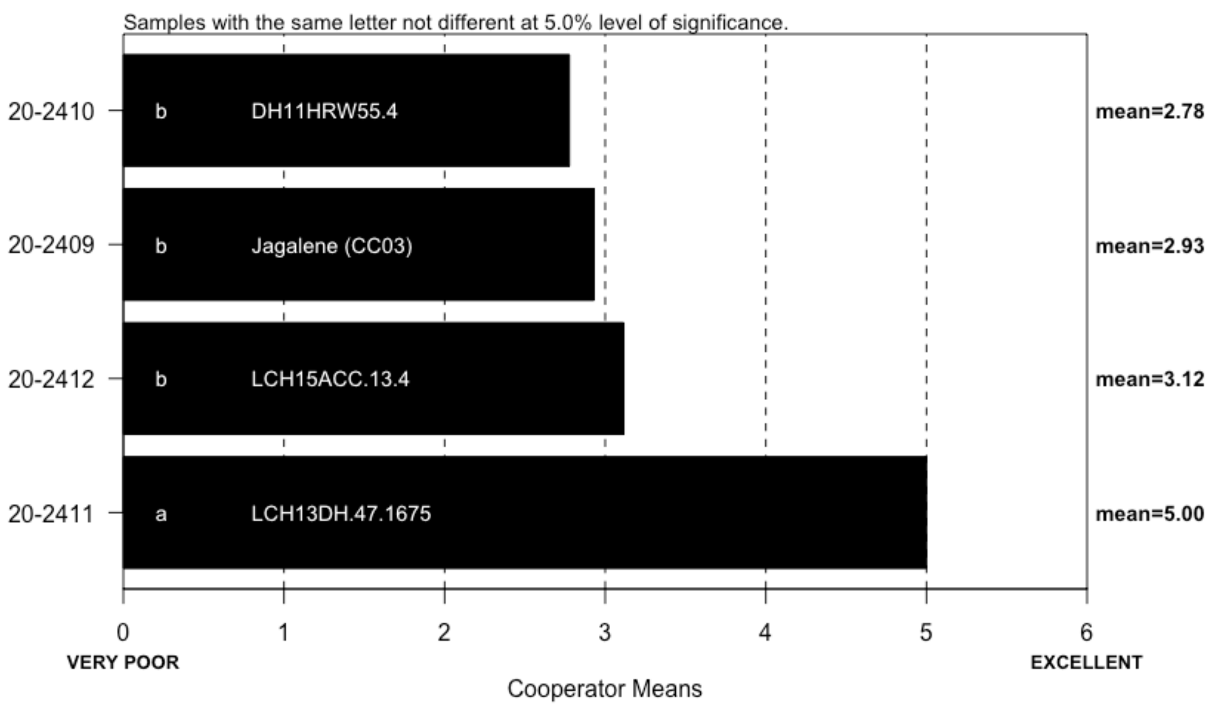
SPONGE CHARACTERISTICS
(Small Scale) Limagrain

Cooperators = 3
ChiSqCalc = 0.5
ChiSqTab = 7.8
P Value = 0.912



BAKE ABSORPTION
(Small Scale) Limagrain

Cooperators = 13
ChiSqCalc = 24.5
ChiSqTab = 7.8
P Value = <0.001

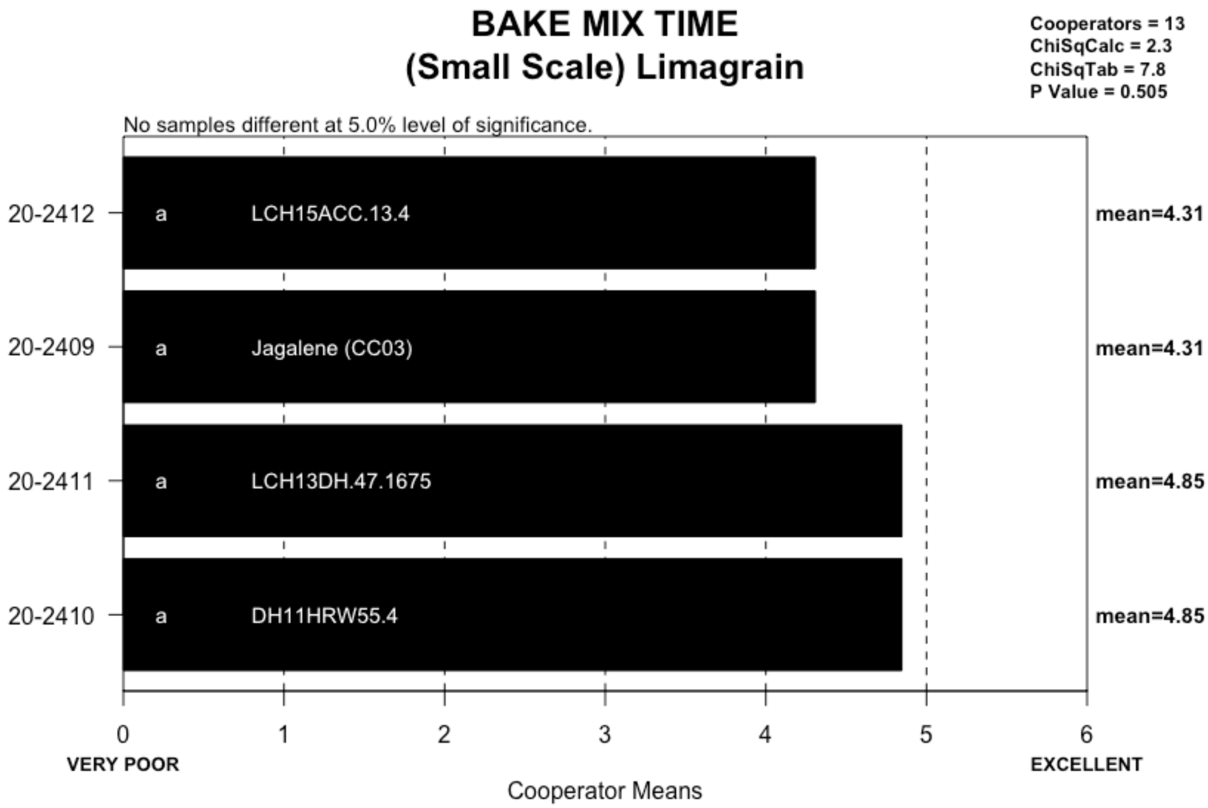


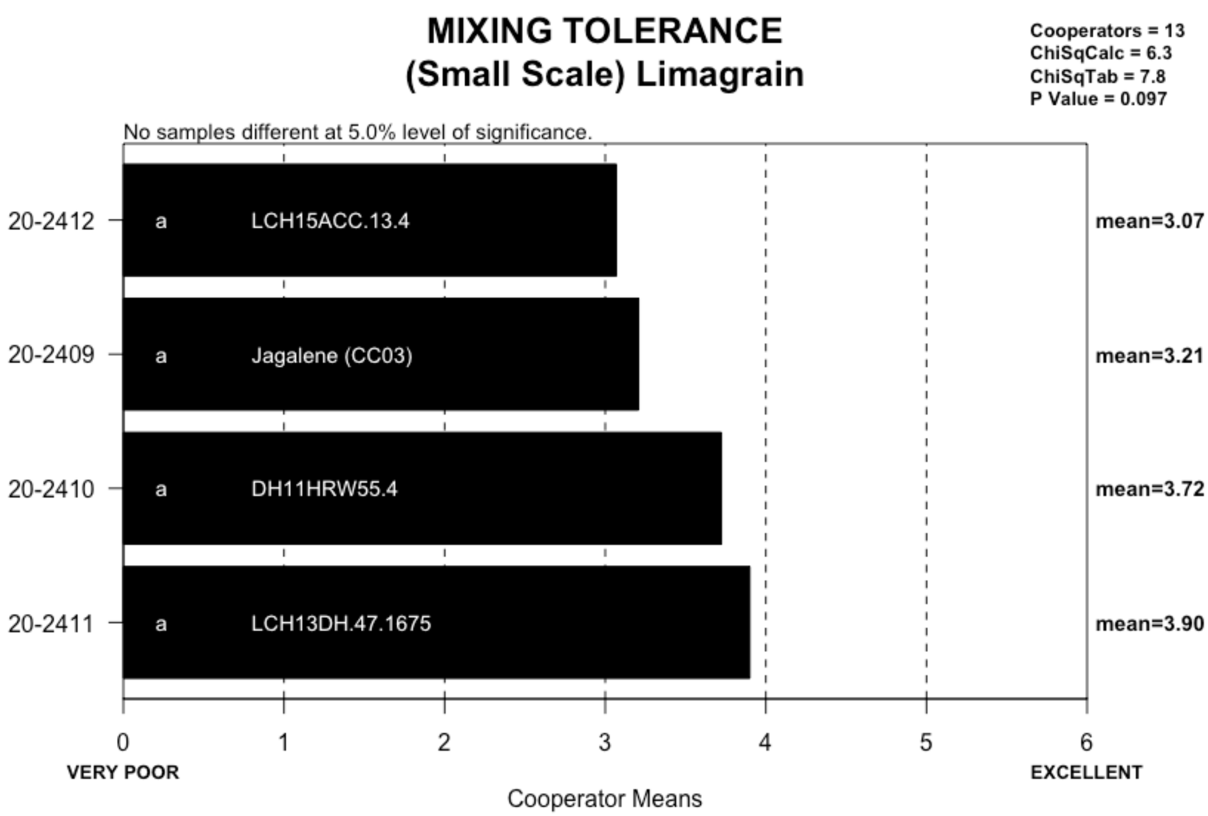
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Limagrain
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2409	Jagalene (CC03)	56	65.1	64.0	62.7	61.2	62.1	63.1	62.2	61.1	59.6	57.5	62.6	61.6
20-2410	DH11HRW55-4	56	65.8	64.5	63.2	61.6	61.6	61.0	63.2	59.9	59.3	56.5	63.1	61.3
20-2411	LCH13DH-47-1675	56	70.7	70.1	68.7	64.0	62.5	65.9	68.7	66.2	65.2	62.5	68.7	67.2
20-2412	LCH15ACC-13-4	56	66.6	64.7	65.0	62.3	62.5	62.4	63.6	61.1	59.6	56.9	63.6	61.6

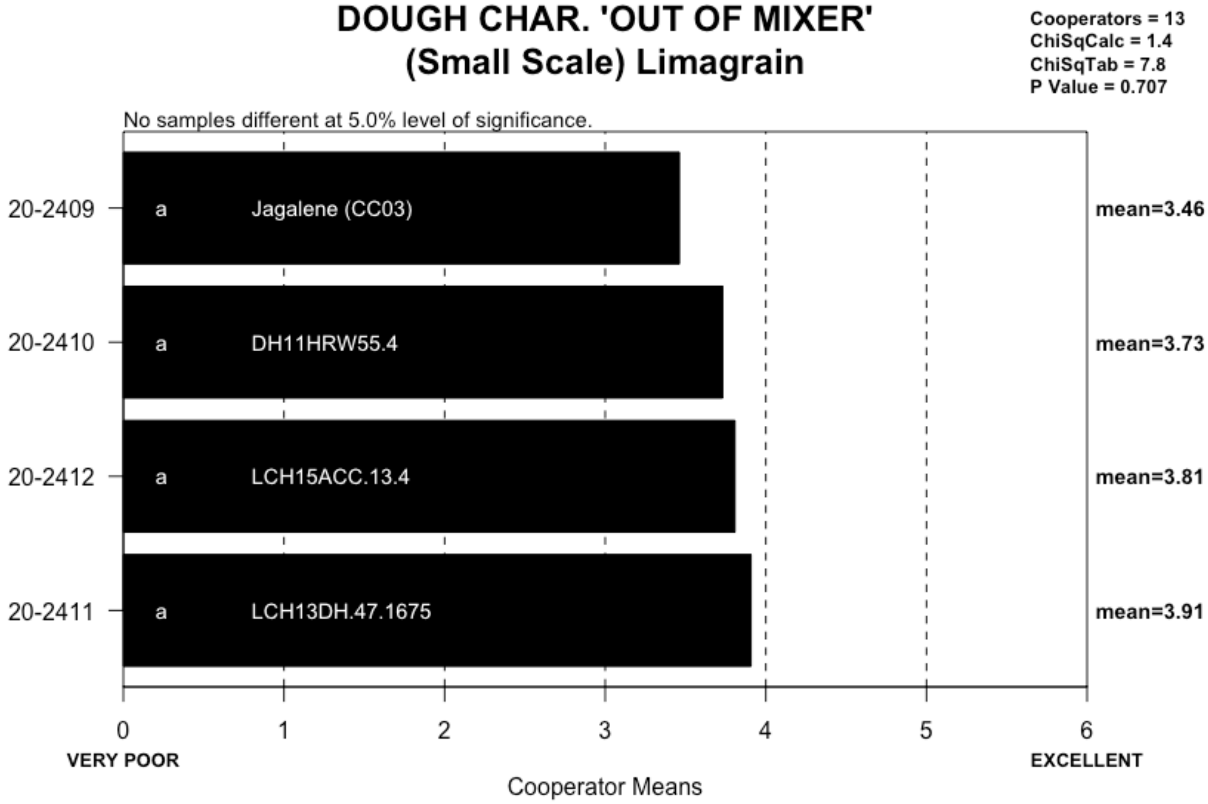
BAKE MIX TIME, ACTUAL
(Small Scale) Limagrain
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2409	Jagalene (CC03)	6	6.0	6.5	6.0	3	10.0	5.8	8.0	6.0	8	5	5.5	17
20-2410	DH11HRW55-4	8	6.5	7.3	6.3	5	7.8	5.5	7.5	6.5	8	6	5.8	20
20-2411	LCH13DH-47-1675	9	5.5	8.0	6.6	5	10.1	6.5	7.5	7.0	8	6	6.4	20
20-2412	LCH15ACC-13-4	6	6.0	6.3	5.1	3	8.4	5.8	6.8	6.3	8	5	4.8	17


BAKE MIX TIME
(Small Scale) Limagrain
Cooperators = 13
ChiSqCalc = 2.3
ChiSqTab = 7.8
P Value = 0.505
No samples different at 5.0% level of significance.
20-2412
a
LCH15ACC.13.4
mean=4.31
20-2409
a
Jagalene (CC03)
mean=4.31
20-2411
a
LCH13DH.47.1675
mean=4.85
20-2410
a
DH11HRW55.4
mean=4.85
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

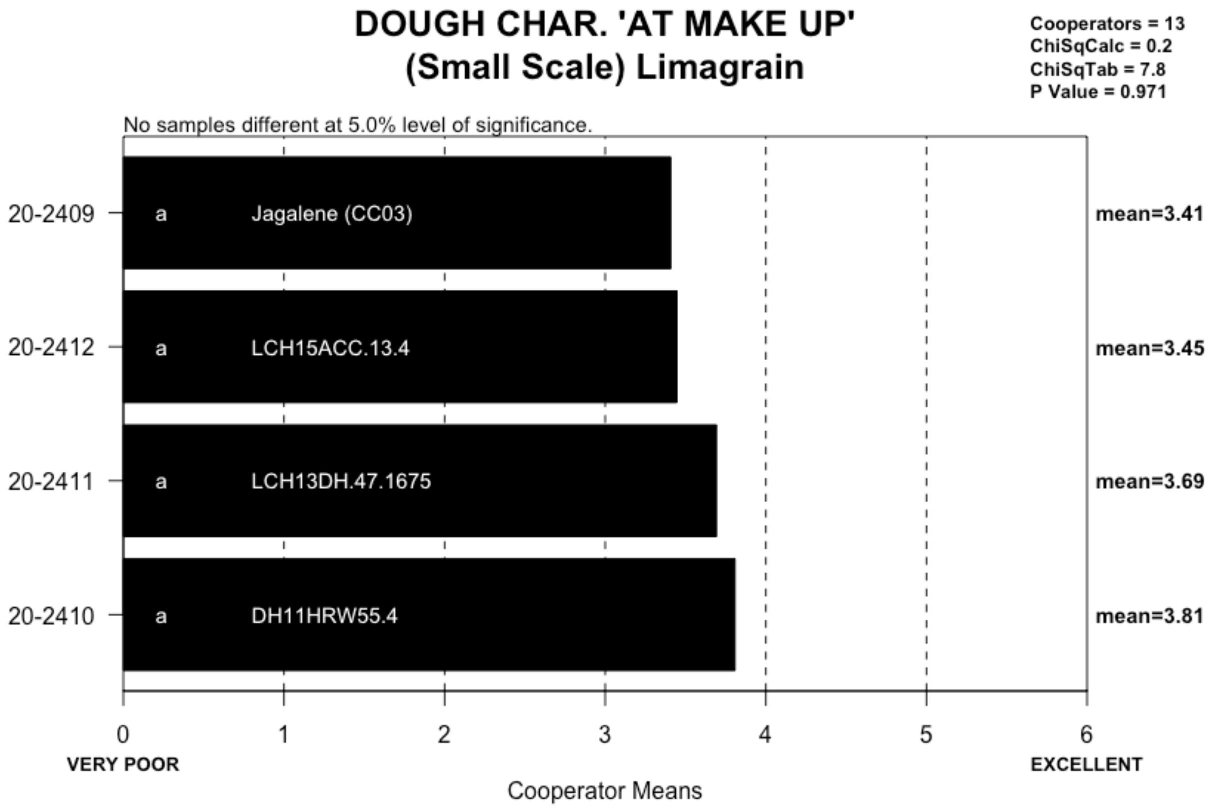

MIXING TOLERANCE
(Small Scale) Limagrain
Cooperators = 13
ChiSqCalc = 6.3
ChiSqTab = 7.8
P Value = 0.097
No samples different at 5.0% level of significance.
20-2412
a
LCH15ACC.13.4
mean=3.07
20-2409
a
Jagalene (CC03)
mean=3.21
20-2410
a
DH11HRW55.4
mean=3.72
20-2411
a
LCH13DH.47.1675
mean=3.90
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

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



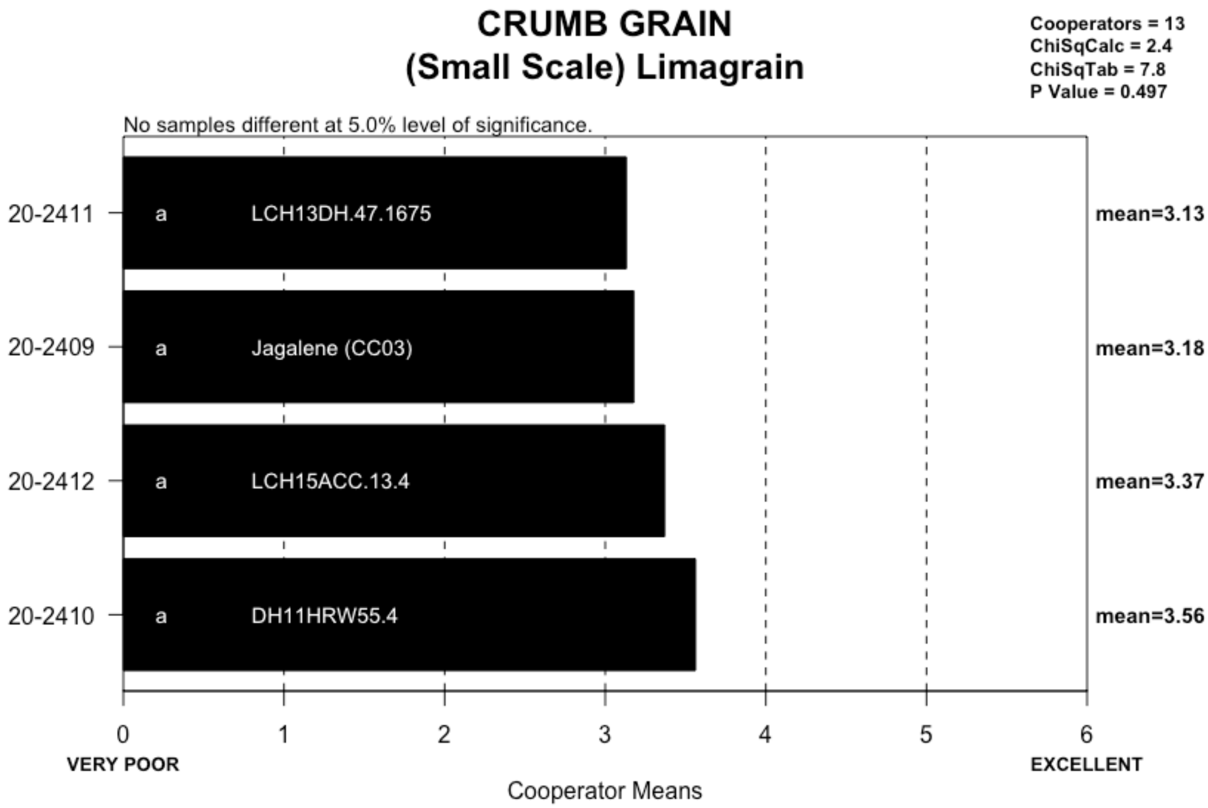
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Limagrain

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2409	Jagalene (CC03)	3	0	3	7	0
20-2410	DH11HRW55-4	2	1	4	6	0
20-2411	LCH13DH-47-1675	2	2	4	5	0
20-2412	LCH15ACC-13-4	1	0	4	7	1



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2409	Jagalene (CC03)	2	0	4	7	0
20-2410	DH11HRW55-4	1	0	5	5	2
20-2411	LCH13DH-47-1675	3	0	4	5	1
20-2412	LCH15ACC-13-4	2	0	4	6	1

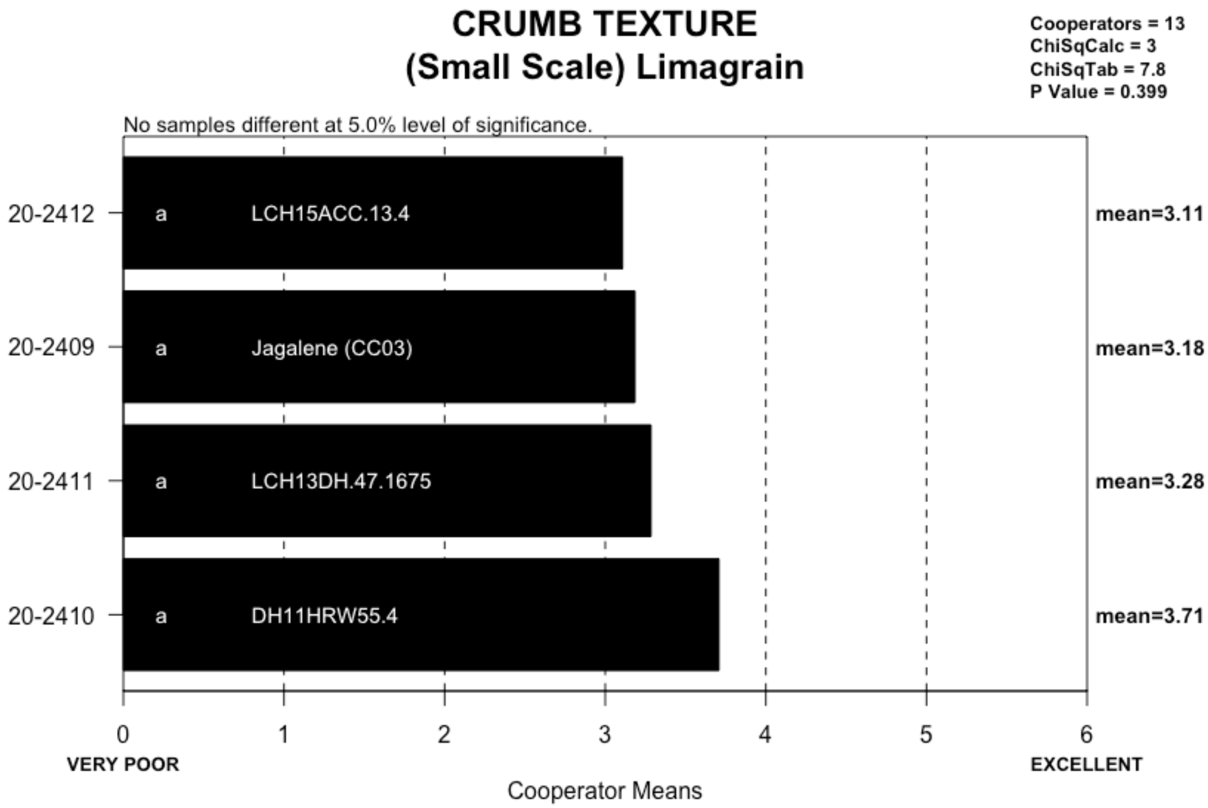


CRUMB GRAIN, DESCRIBED
(Small Scale) Limagrain

IDCODE	ID	Open	Fine	Dense
20-2409	Jagalene (CC03)	2	6	5
20-2410	DH11HRW55-4	6	6	1
20-2411	LCH13DH-47-1675	1	7	5
20-2412	LCH15ACC-13-4	4	8	1

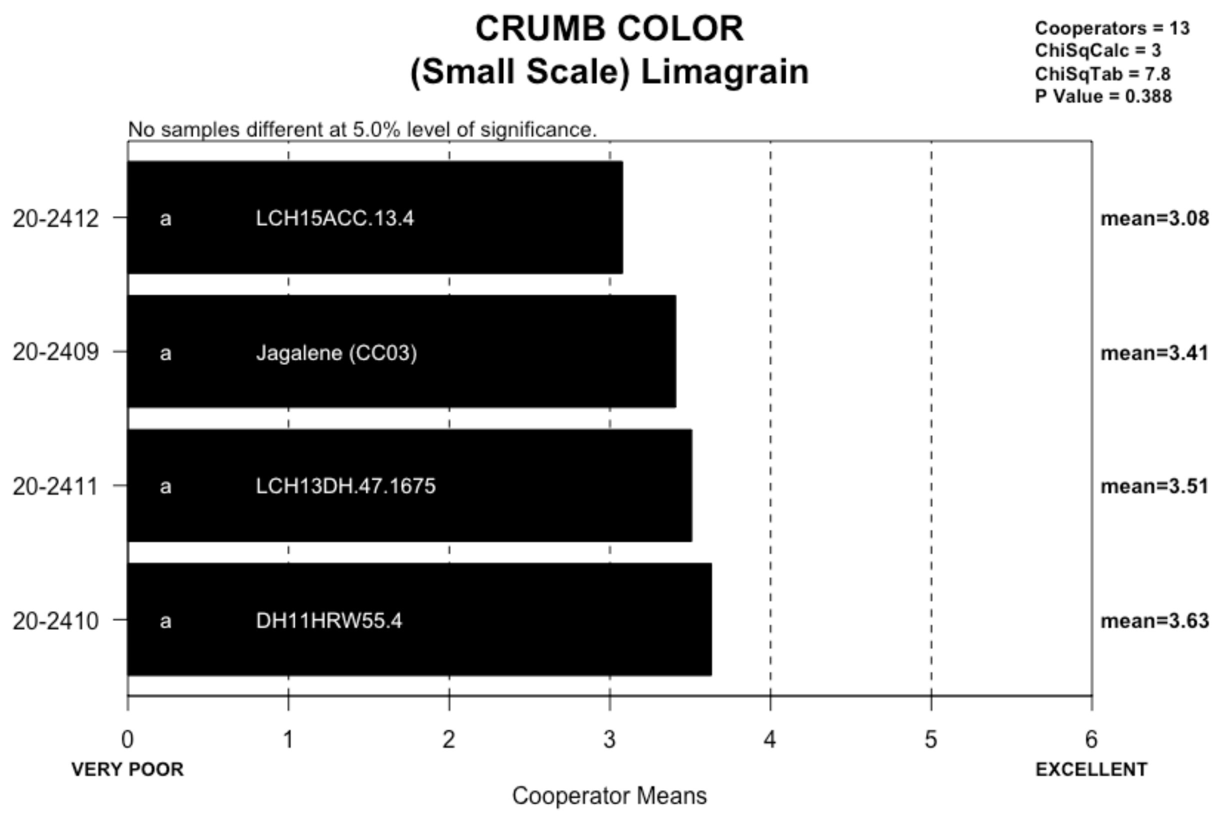
CELL SHAPE, DESCRIBED
(Small Scale) Limagrain

IDCODE	ID	Round	Irregular	Elongated
20-2409	Jagalene (CC03)	4	8	1
20-2410	DH11HRW55-4	2	9	2
20-2411	LCH13DH-47-1675	6	5	2
20-2412	LCH15ACC-13-4	4	5	4



CRUMB TEXTURE, DESCRIBED
(Small Scale) Limagrain

IDCODE	ID	Harsh	Smooth	Silky
20-2409	Jagalene (CC03)	4	8	1
20-2410	DH11HRW55-4	3	8	2
20-2411	LCH13DH-47-1675	4	7	2
20-2412	LCH15ACC-13-4	4	8	1



CRUMB COLOR, DESCRIBED
(Small Scale) Limagrain

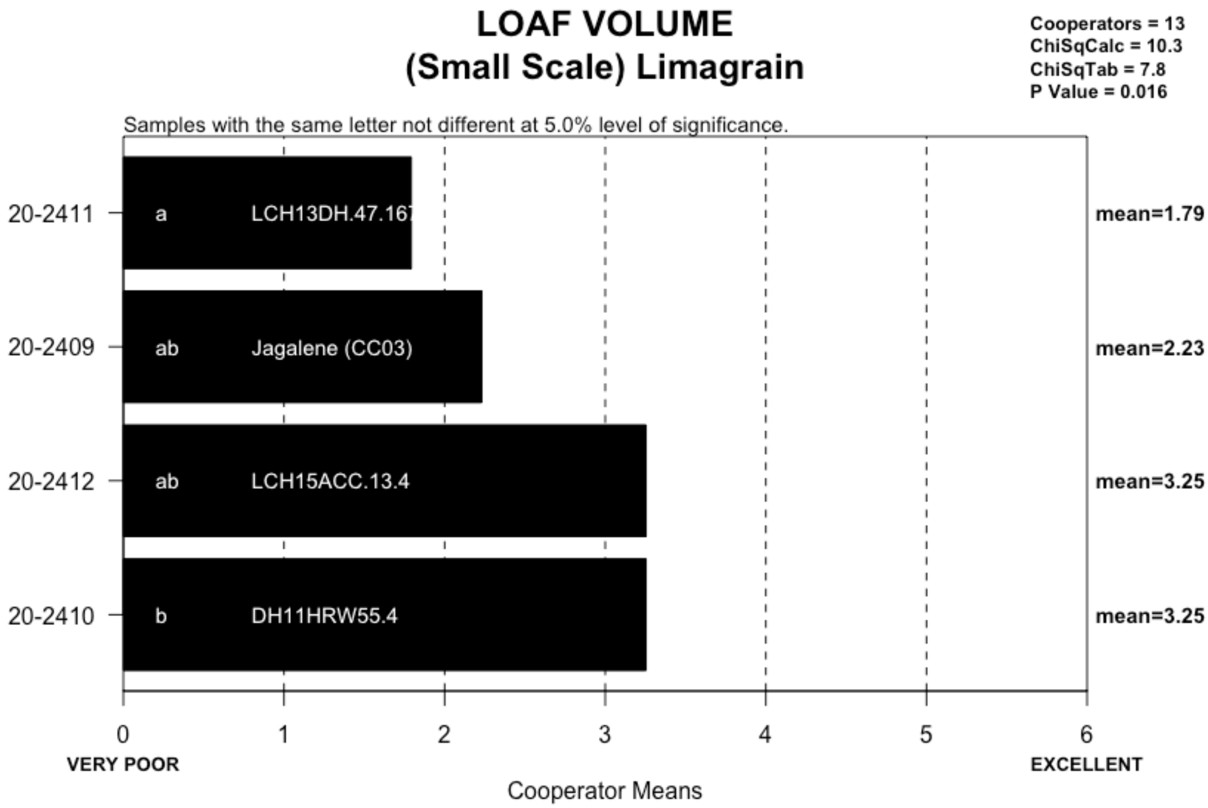
IDCODE	ID	Gray	Dark_Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2409	Jagalene (CC03)	0	0	2	6	5	0	0
20-2410	DH11HRW55-4	0	0	3	2	8	0	0
20-2411	LCH13DH-47-1675	0	0	2	4	7	0	0
20-2412	LCH15ACC-13-4	0	0	5	5	3	0	0

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

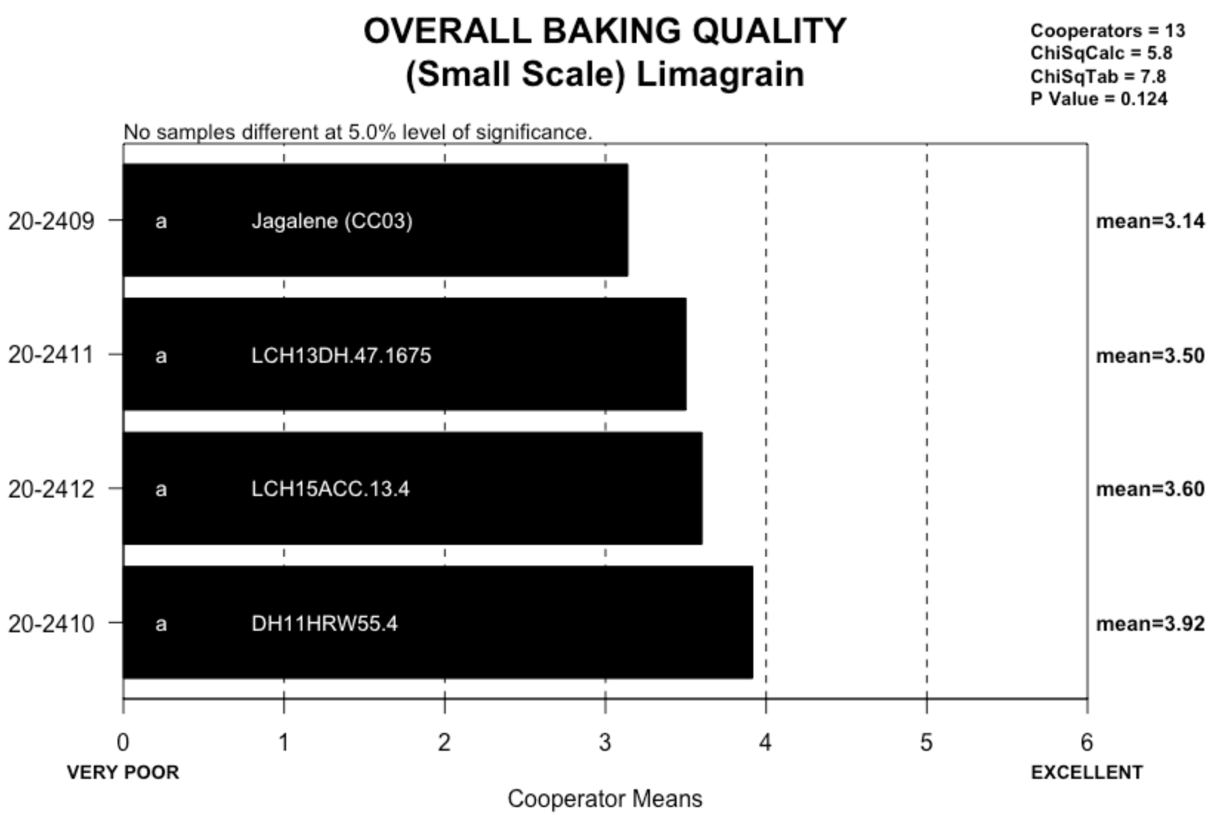
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2409	Jagalene (CC03)	414	134.2	139.7	149.2	145.3	139.0	142.1	147.2	142	458.9	477.6	142.8	427.4
20-2410	DH11HRW55-4	411	137.3	139.4	145.3	141.1	137.4	140.3	148.0	140	460.6	479.7	141.5	424.9
20-2411	LCH13DH-47-1675	410	140.0	139.6	154.6	145.8	140.4	144.1	155.8	144	459.6	477.6	145.2	421.4
20-2412	LCH15ACC-13-4	411	134.2	138.8	153.2	143.7	136.5	141.3	151.1	138	458.7	478.8	141.8	421.1

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2409	Jagalene (CC03)	2750	730	798	805	640	813	895	685	620	2327	2625	780	2275
20-2410	DH11HRW55-4	2875	775	848	898	775	880	945	840	713	2412	2563	770	2850
20-2411	LCH13DH-47-1675	2450	730	686	759	620	760	845	700	602	2314	2413	760	2500
20-2412	LCH15ACC-13-4	2900	780	793	858	710	865	915	735	662	2687	2613	740	2900



LOAF VOLUME
(Small Scale) Limagrain
Cooperators = 13
ChiSqCalc = 10.3
ChiSqTab = 7.8
P Value = 0.016
Samples with the same letter not different at 5.0% level of significance.
20-2411 a LCH13DH.47.167 mean=1.79
20-2409 ab Jagalene (CC03) mean=2.23
20-2412 ab LCH15ACC.13.4 mean=3.25
20-2410 b DH11HRW55.4 mean=3.25
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



OVERALL BAKING QUALITY
(Small Scale) Limagrain
Cooperators = 13
ChiSqCalc = 5.8
ChiSqTab = 7.8
P Value = 0.124
No samples different at 5.0% level of significance.
20-2409 a Jagalene (CC03) mean=3.14
20-2411 a LCH13DH.47.1675 mean=3.50
20-2412 a LCH15ACC.13.4 mean=3.60
20-2410 a DH11HRW55.4 mean=3.92
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Limagrain

COOP. **20-2409 Jagalene (CC03)**

A. No comment.
B. No comment.
C. No comment.
D. Long mix time but dough generally weaker looking, volume very low with weaker looking crumb grain but performed well for protein level.
E. Protein and absorption do not meet targets.
F. Low Protein, Low Water Abs, Very Long MT, Slight Sticky & Weak Dough, Low Volume, Yellow Crumb, Dense Round Cells, Resilient & Slightly Harsh Texture.
G. Slight cap, rough break.
H. Low protein flour, long mix time, dense grain, tough doughs, very low volume.
I. No comment.
J. No comment.
K. Low absorption, good grain, good volume.
L. No comment.
M. Low protein, fair absorption, good dough notes and mix time, dough did not perform well in the final product. Needs blending.

COOP. **20-2410 DH11HRW55-4**

A. No comment.
B. No comment.
C. No comment.
D. Good performance for low protein, good volume and crumb grain for such low protein.
E. Protein does not meet target, best of set.
F. Low Protein, Low Water Abs, Long MT, Slight Sticky & Weak Dough, OK Volume, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Long time to pick up, excellent loaf externals.
H. Low protein flour, long mix time, open grain, avg volume.
I. Bright creamy crumb color.
J. No comment.
K. Low absorption, avg grain and volume.
L. No comment.
M. Low protein and open crumb, fair absorption, high mix time, great dough notes and performance. Recommend.

COOP. 20-2411 LCH13DH-47-1675

A. No comment.
B. Uneven crust color.
C. No comment.
D. Good performance for low protein, good volume and crumb grain for such low protein.
E. Protein does not meet target.
F. Low Protein, Low Water Abs, Very Long MT, Slight Sticky & Weak Dough, Low Volume, Creamy Crumb, Slightly Open Round Cells, Resilient & Slightly Harsh Texture.
G. White dough, slight cap.
H. Low protein flour, long mix time, high absorption, dense grain, very low volume.
I. No comment.
J. No comment.
K. High absorption, avg grain, low volume.
L. No comment.
M. Low protein, fair volume, high absorption and mix time.

COOP. 20-2412 LCH15ACC-13-4

A. No comment.
B. No comment.
C. No comment.
D. Good performance for low protein, good volume and crumb grain for such low protein.
E. Protein does not meet target.
F. Low Protein, Low Water Abs, Very Long MT, Slight Sticky & Weak Dough, Normal Volume, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Rough break.
H. Low protein flour, dense grain, tough doughs, very low volume.
I. No comment.
J. No comment.
K. Low absorption, good grain, tough sticky dough at makeup, good volume.
L. No comment.
M. Low protein, overall good notes and performance. Recommend.

Notes: **A, K, and M** conducted sponge and dough bake tests

KANSAS-HAYS

20-2413	Jagalene (CC04)
20-2414	Danby
20-2415	KS15H137-2-2

Description of Test Plots and Breeder Entries

Kansas-Hays – Guorong Zhang

The samples submitted were grown at Hays experimental station in 2020. Jagalene, Danby, and KS15H137-2-2 were planted on Sept. 26, 2019 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 2020 crop year was dry in the spring and little disease was observed. The plots was damaged by fall armyworm in April though. Insecticide was sprayed and plants grew back eventually. However, their yield was affected.

Jagalene (common check)

Danby (local check)

KS15H137-2-2 (KS Hamilton)

KS15H137-2-2 was released as KS Hamilton in August 2020. It is a hard red winter wheat with medium maturity and medium height. It has competitive yield in western Kansas, which is comparable to Joe. It has moderate grain shattering resistance and average straw strength. It has good resistances to wheat streak mosaic virus, stem rust, soilborne mosaic virus, and Hessian fly; and intermediate resistance to stripe rust, leaf rust, barley yellow dwarf virus, and acid soil. Its wheat streak mosaic virus resistance is similar as KS Dallas, which can hold up to 21ºC. It has average test weight. Its milling and baking quality is mostly similar to Joe, which is about average.

Kansas-Hays: 2020 (Small-Scale) Samples

Test entry number	20-2413	20-2414	20-2415
Sample identification	Jagalene (CC04)	Danby	KS15H137-2-2
Wheat Data			
GIPSA classification	1 HRW	1 HDWH	1 HRW
Test weight (lb/bu) Hectoliter weight (kg/hl)	63.3 83.2	64.1 84.2	62.1 81.7
1000 kernel weight (gm)	33.2	31.1	31.8
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 79.3 20.7 0.0	 68.9 31.1 0.0	 72.3 27.5 0.2
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	 76.8/15.9 33.2/9.2 2.79/0.31 11.6/0.3 00-04-09-87-01 Hard	 68.2/13.7 31.1/8.1 2.68/0.29 11.7/0.3 01-04-22-73-01 Hard	 78.5/15.4 31.8/9.6 2.60/0.38 11.6/0.3 00-02-08-90-01 Hard
Wheat protein (12% mb) Wheat ash (12% mb)	15.0 1.34	13.3 1.25	13.8 1.24
Milling and Flour Quality Data			
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 78.0 70.8	 75.0 69.6	 78.0 70.2
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.8 13.9 0.53	13.5 12.0 0.49	13.0 12.7 0.49
Rapid Visco-Analyser Peak Time (min) Peak Viscosity (RVU) Breakdown (RVU) Final Viscosity at 13 min (RVU)	 6.2 184.1 59.6 222.9	 6.2 239.3 105.8 224.2	 6.1 222.6 94.9 225.6
Minolta color meter L* a* b* **PPO**	 90.38 -0.91 8.56 0.583	 91.69 -1.23 7.86 0.632	 90.50 -1.09 9.02 0.665
Falling number (sec)	415	398	407
Damaged Starch (AI%) (AACC76-31)	 98.3 8.2	 97.1 7.2	 98.0 7.9

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Kansas-Hays: Physical Dough Tests and Gluten Analysis For 2020 (Small-Scale) Samples

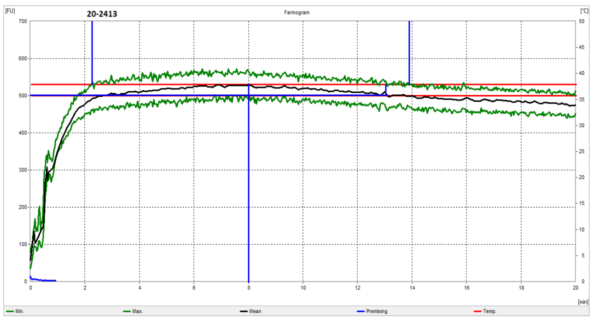
Test Entry Number	20-2413	20-2414	20-2415
Sample Identification	**Jagalene (CC04)**	**Danby**	**KS15H137-2-2**
MIXOGRAPH			
Flour Abs (% as-is)	71.4	66.6	70.1
Flour Abs (14% mb)	70.1	66.0	69.0
Mix Time (min)	4.5	3.0	5.0
Mix tolerance (0-6)	4	2	4
FARINOGRAPH			
Flour Abs (% as-is)	67.9	64.2	68.0
Flour Abs (14% mb)	66.5	63.6	66.8
Peak time (min)	8.0	5.2	5.5
Mix stability (min)	11.6	6.8	12.8
Mix Tolerance Index (FU)	23	38	16
Breakdown time (min)	13.1	9.5	12.8
ALVEOGRAPH			
P(mm): Tenacity	167	99	161
L(mm): Extensibility	62	77	54
G(mm): Swelling index	17.5	19.5	16.3
W(10^{-4} J): strength (curve area)	420	250	354
P/L: curve configuration ratio	2.69	1.29	2.98
Ie(P_{200}/P): elasticity index	62.8	50.4	58.4
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	473/639/721	248/383/460	428/510/557
Extensibility (mm at 45/90/135 min)	132/136/121	139/132/122	134/132/124
Energy (cm^2 at 45/90/135 min)	102/145/139	59/85/89	95/110/107
Resist $_{max}$ (BU at 45/90/135 min)	608/877/969	317/492/571	528/659/683
Ratio (at 45/90/135 min)	3.6/4.7/6.0	1.8/2.9/3.8	3.2/3.9/4.5
PROTEIN ANALYSIS			
HMW-GS Composition	1,2*, 17+18/, 5+10	1,2*, 7+9, 5+10	1, 7+8, 5+10
TPP/TMP	0.82	0.91	0.78
SEDIMENTATION TEST			
Volume (ml)	68.1	59.7	62.3

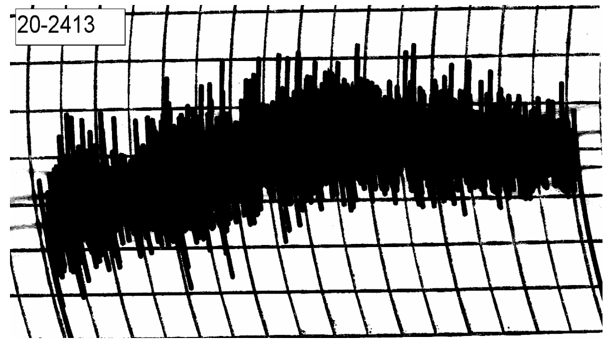
Physical Dough Tests

2020 (Small Scale) Samples – Kansas-Hays

Farinograms

Mixograms

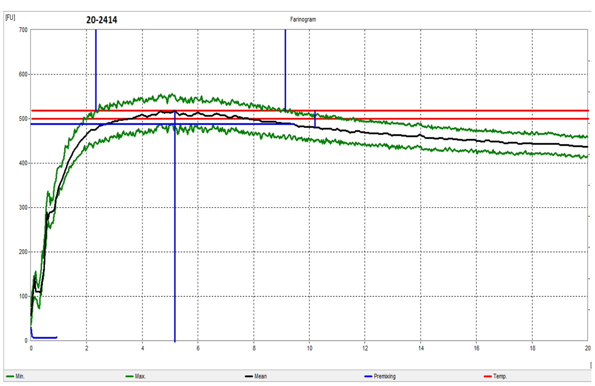


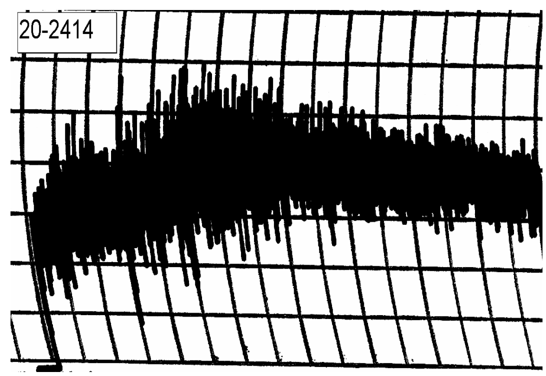


Water abs = 66.5%, Peak time = 8.0 min,
Mix stab = 11.6 min, MTI = 23 FU

Water abs = 70.1%
Mix time = 4.5 min

20-2413, Jagalene (CC04)





Water abs = 63.6%, Peak time = 5.2 min,
Mix stab = 6.8 min, MTI = 38 FU

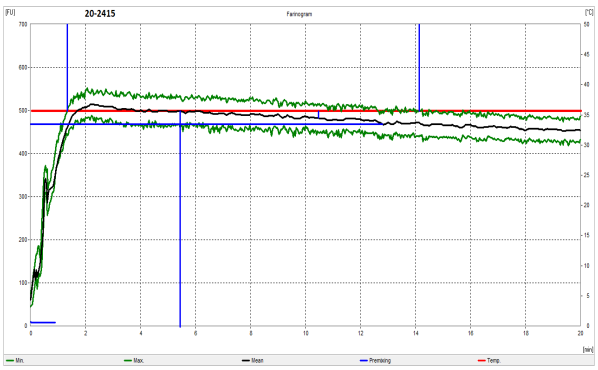
Water abs = 66.0%
Mix time = 3.0 min

20-2414, Danby

Physical Dough Tests

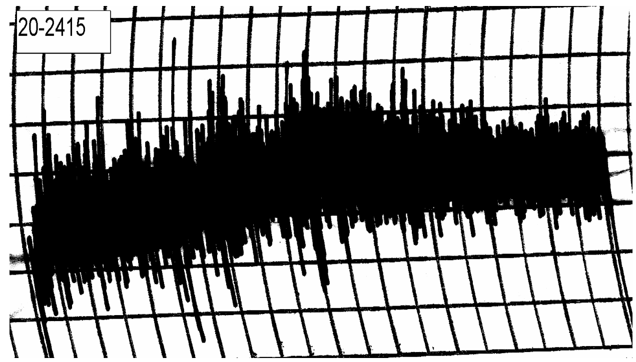
2020 (Small Scale) Samples – Kansas-Hays

Farinograms



Water abs = 66.8%, Peak time = 5.0 min,
Mix stab = 12.8 min, MTI = 16 FU

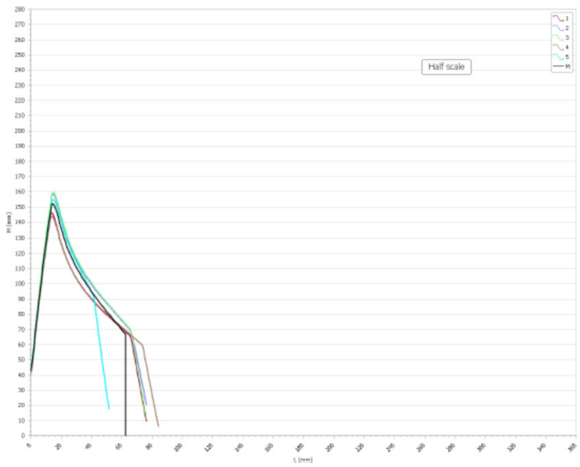
Mixograms



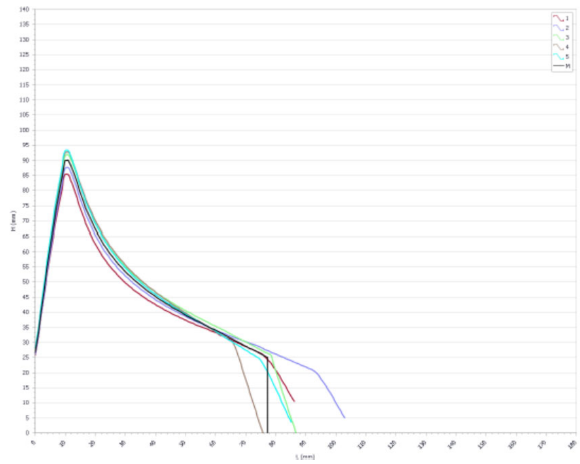
Water abs = 69.0%
Mix time = 5.0 min

20-2415, KS15H137-2-2

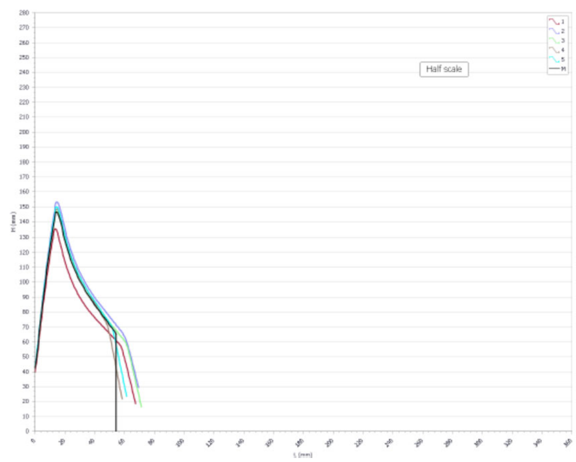
Physical Dough Tests - Alveograph
2020 (Small Scale) Samples – Kansas-Hays



20-2413, Jagalene (CC04)
P (mm $H_2$0) = 167, L (mm) = 62, W ($10E^{-4}$J) = 420



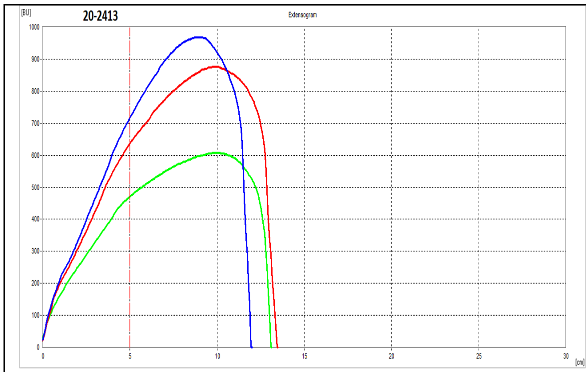
20-2414, Danby
P (mm $H_2$0) = 99, L (mm) = 77, W ($10E^{-4}$J) = 250



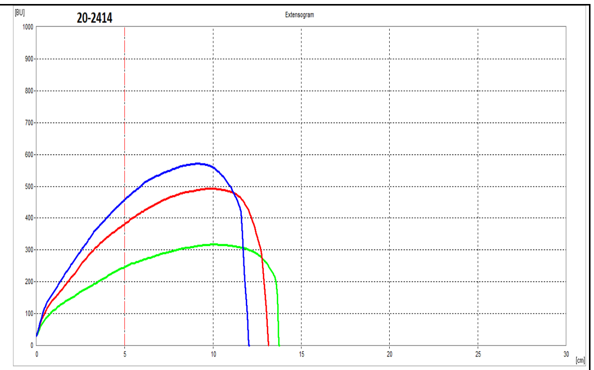
20-2415, KS15H137-2-2
P (mm $H_2$0) = 161, L (mm) = 54, W ($10E^{-4}$J) = 354

Physical Dough Tests - Extensigraph

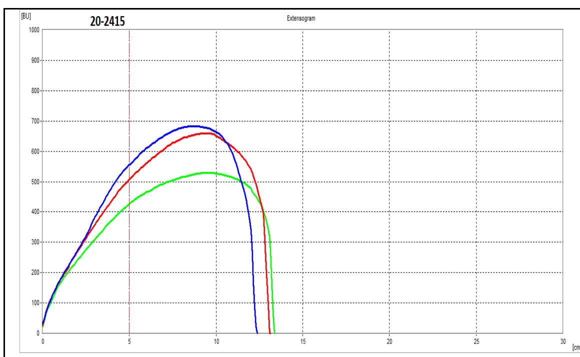
2020 (Small Scale) Samples – Kansas-Hays



20-2413, Jagalene (CC04)
R (BU) = 639, E (mm) = 136, W (cm^2) = 145
Rmax (BU) = 877, Ratio = 4.7 at 90 min



20-2414, Danby
R (BU) = 383, E (mm) = 132, W (cm^2) = 85
Rmax (BU) = 492, Ratio = 2.9 at 90 min



20-2415, KS15H137-2-2
R (BU) = 510, E (mm) = 132, W (cm^2) = 110
Rmax (BU) = 659, Ratio = 3.9 at 90 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Kansas-Hays: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples

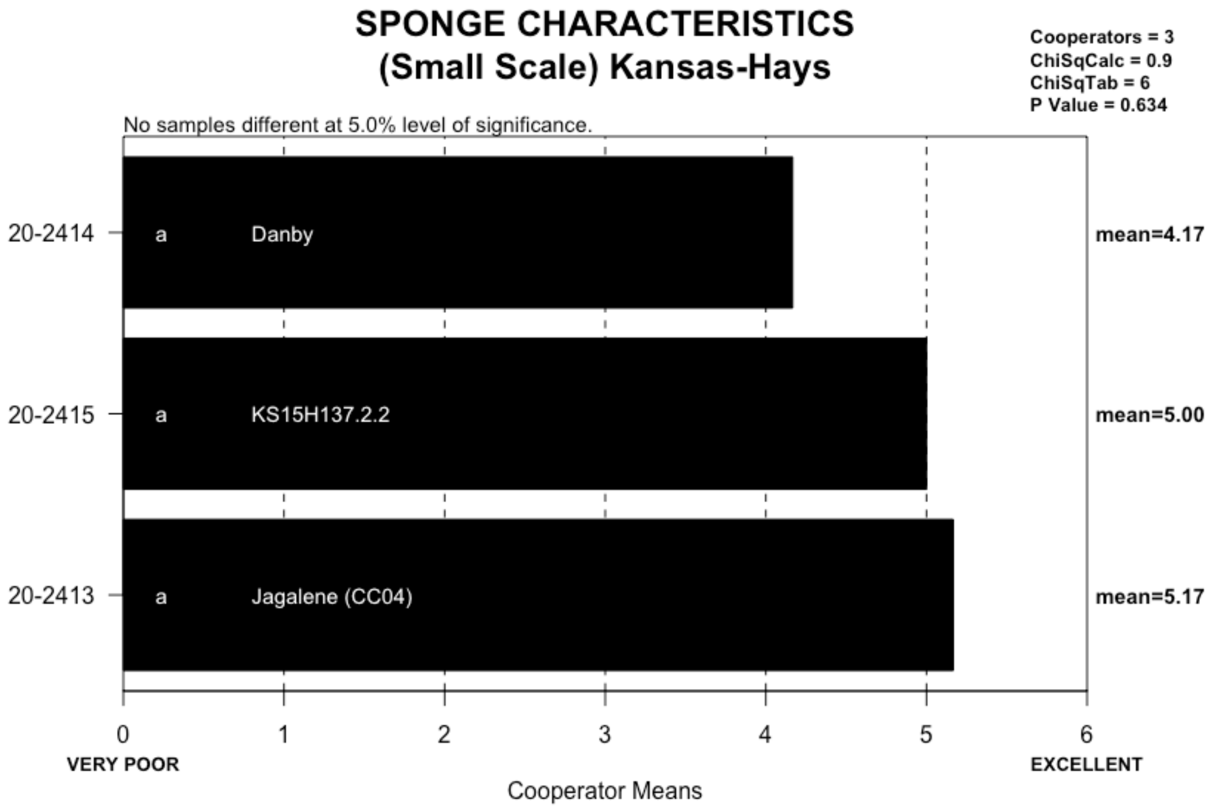

2413 – Jagalene (CC04)

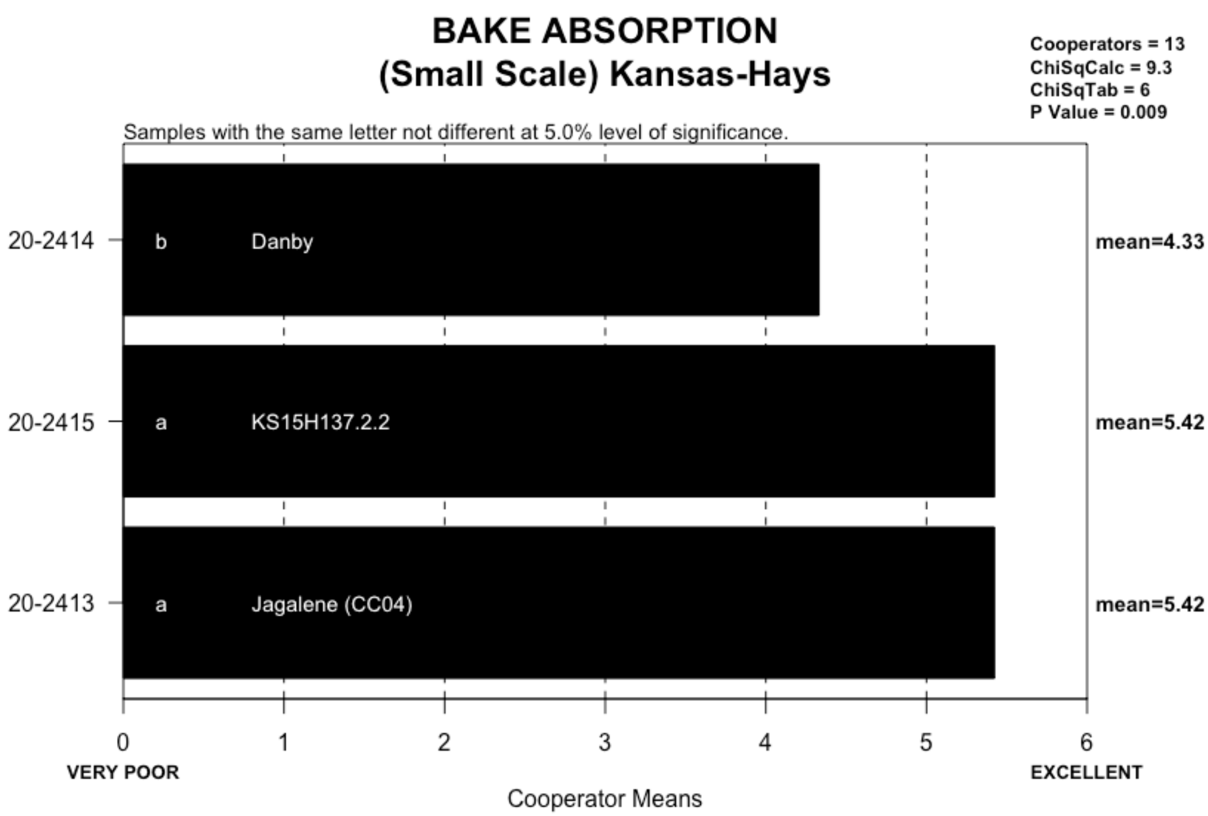

2414– Danby

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	6594	109	3407	0.440	2.477	12.657	1.823	-9.04
2414	6691	122	3412	0.450	2.518	2.247	1.742	-8.27


2415 – KS15H137-2-2

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	6372	112	3237	0.449	2.429	2.213	1.760	-7.36


SPONGE CHARACTERISTICS
(Small Scale) Kansas-Hays
Cooperators = 3
ChiSqCalc = 0.9
ChiSqTab = 6
P Value = 0.634
No samples different at 5.0% level of significance.
20-2414
a
Danby
mean=4.17
20-2415
a
KS15H137.2.2
mean=5.00
20-2413
a
Jagalene (CC04)
mean=5.17
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

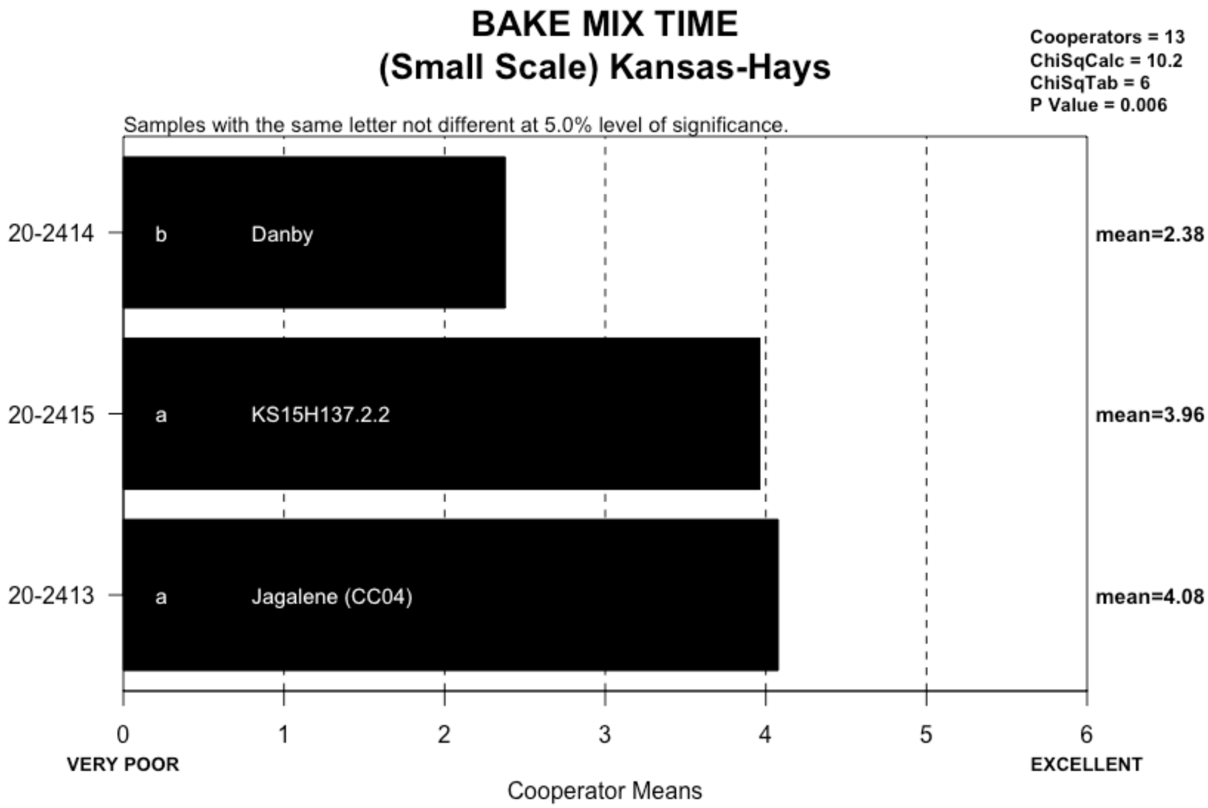

BAKE ABSORPTION
(Small Scale) Kansas-Hays
Cooperators = 13
ChiSqCalc = 9.3
ChiSqTab = 6
P Value = 0.009
Samples with the same letter not different at 5.0% level of significance.
20-2414
b
Danby
mean=4.33
20-2415
a
KS15H137.2.2
mean=5.42
20-2413
a
Jagalene (CC04)
mean=5.42
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

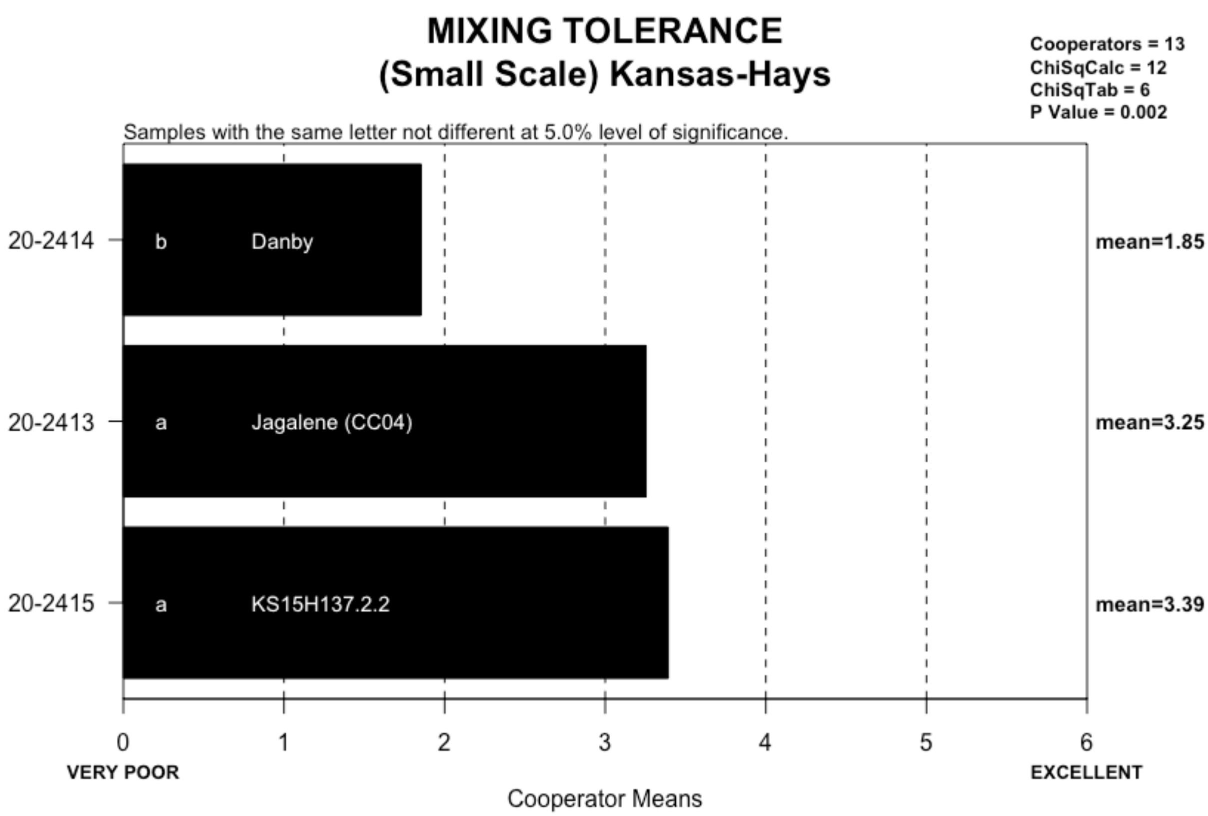
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Kansas-Hays
Cooperators A – M

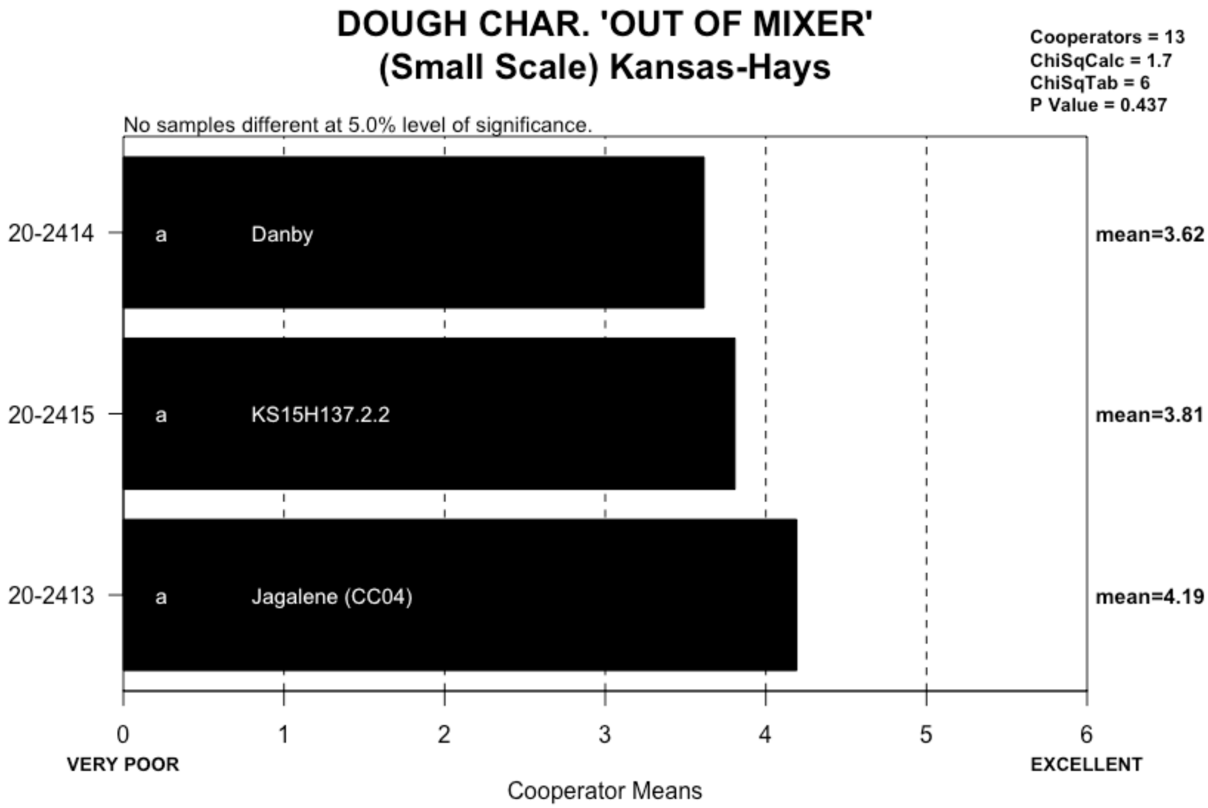
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2413	Jagalene (CC04)	60	71.9	71.5	71.8	67.9	66.3	69.3	70.4	67.3	66.5	60.7	70.1	68.5
20-2414	Danby	58	69.6	66.4	65.6	64.3	63.8	63.5	66.1	64.1	63.6	61.4	66.0	65.6
20-2415	KS15H137-2-2	59	73.8	70.3	70.0	65.7	66.0	69.4	68.6	67.6	66.8	62.9	69.0	68.8

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2413	Jagalene (CC04)	6	4.8	5.6	5.4	4	6.8	4.5	5.0	4.8	8	5	4.5	17
20-2414	Danby	4	3.5	3.2	3.4	3	4.4	3.3	3.5	2.8	8	4	3.0	11
20-2415	KS15H137-2-2	6	4.5	5.0	5.5	5	7.4	4.5	5.5	4.5	8	4	5.0	14

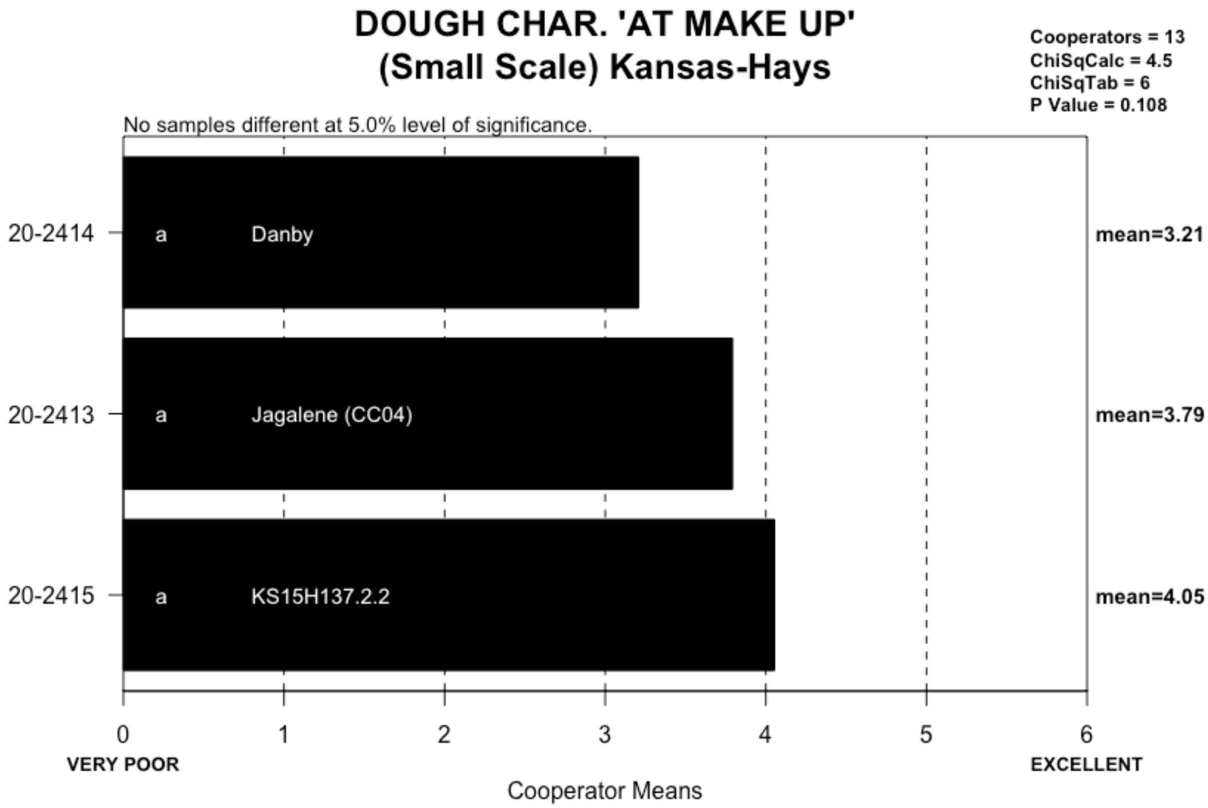

BAKE MIX TIME
(Small Scale) Kansas-Hays
Cooperators = 13
ChiSqCalc = 10.2
ChiSqTab = 6
P Value = 0.006
Samples with the same letter not different at 5.0% level of significance.
20-2414
b
Danby
mean=2.38
20-2415
a
KS15H137.2.2
mean=3.96
20-2413
a
Jagalene (CC04)
mean=4.08
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Kansas-Hays
Cooperators = 13
ChiSqCalc = 12
ChiSqTab = 6
P Value = 0.002
Samples with the same letter not different at 5.0% level of significance.
20-2414
b
Danby
mean=1.85
20-2413
a
Jagalene (CC04)
mean=3.25
20-2415
a
KS15H137.2.2
mean=3.39
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



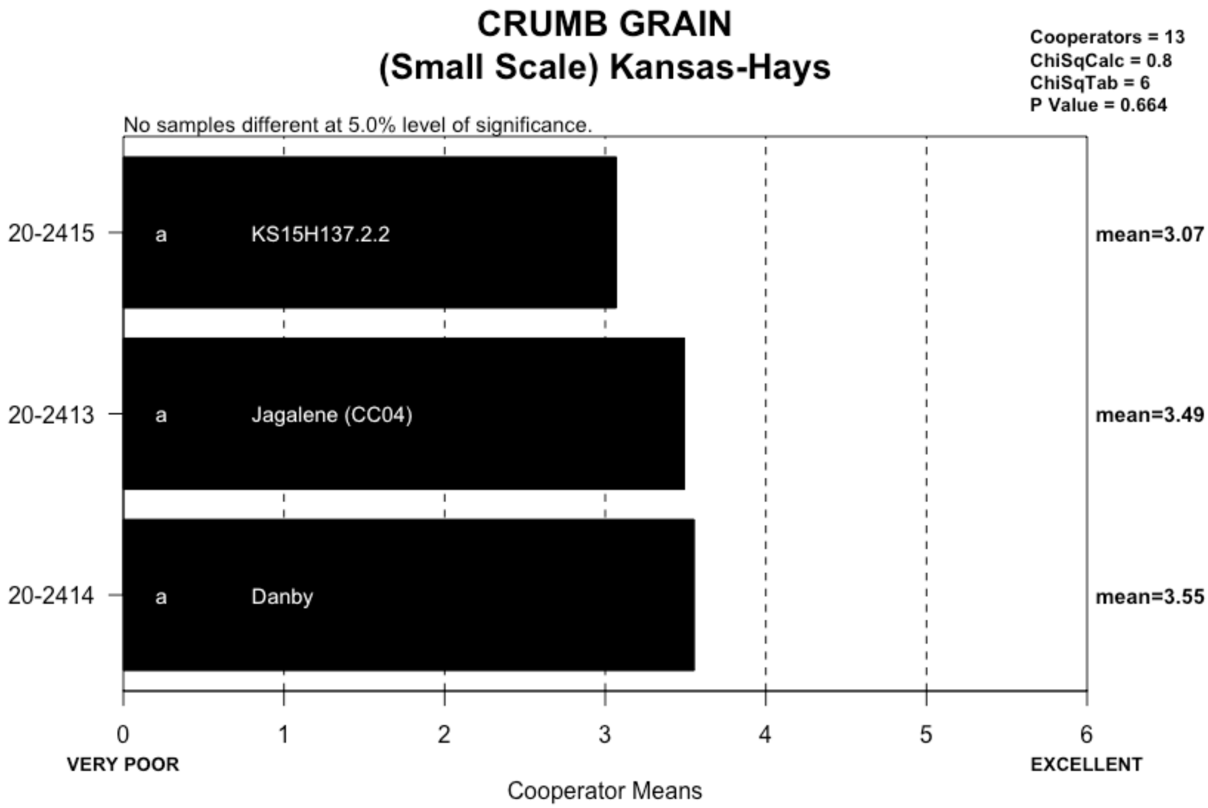
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Kansas-Hays

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2413	Jagalene (CC04)	1	0	2	10	0
20-2414	Danby	4	1	2	6	0
20-2415	KS15H137-2-2	1	0	3	9	0



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2413	Jagalene (CC04)	2	0	2	9	0
20-2414	Danby	3	4	0	5	1
20-2415	KS15H137-2-2	2	2	1	7	1

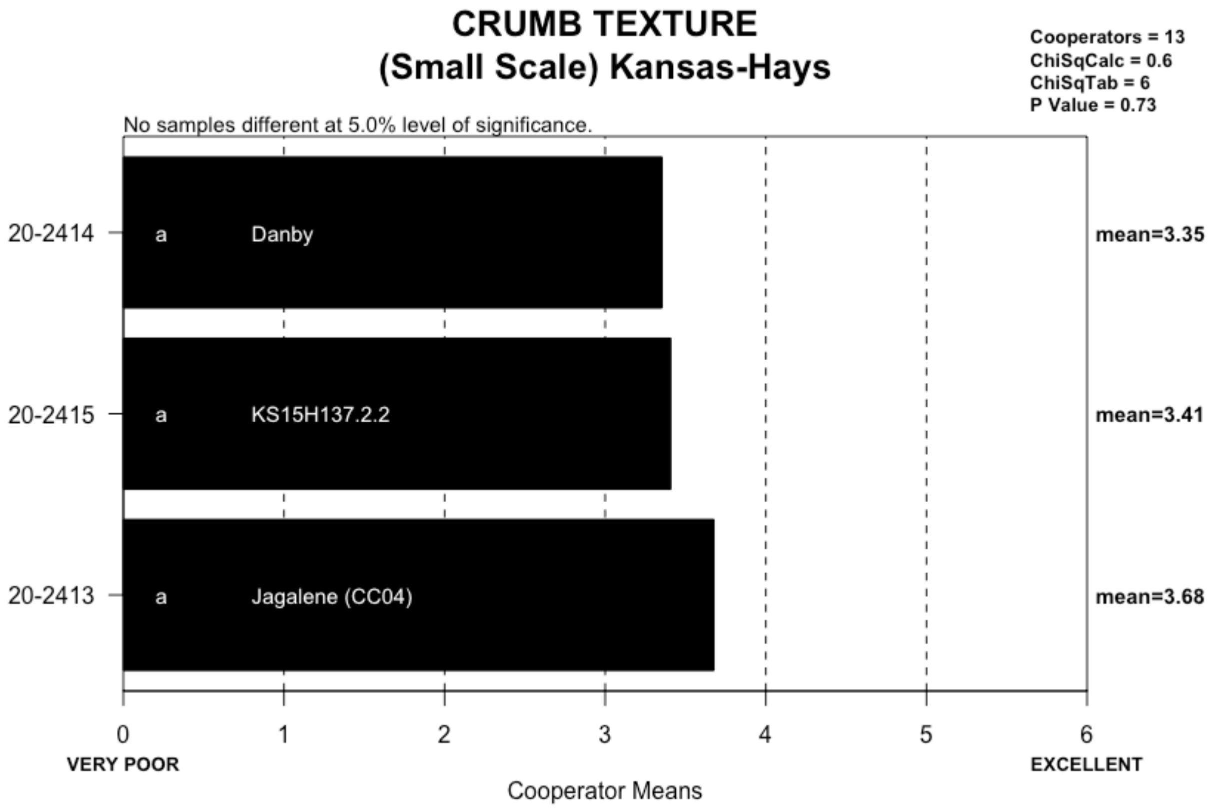


CRUMB GRAIN, DESCRIBED
(Small Scale) Kansas-Hays

IDCODE	ID	Open	Fine	Dense
20-2413	Jagalene (CC04)	7	6	0
20-2414	Danby	8	2	3
20-2415	KS15H137-2-2	9	4	0

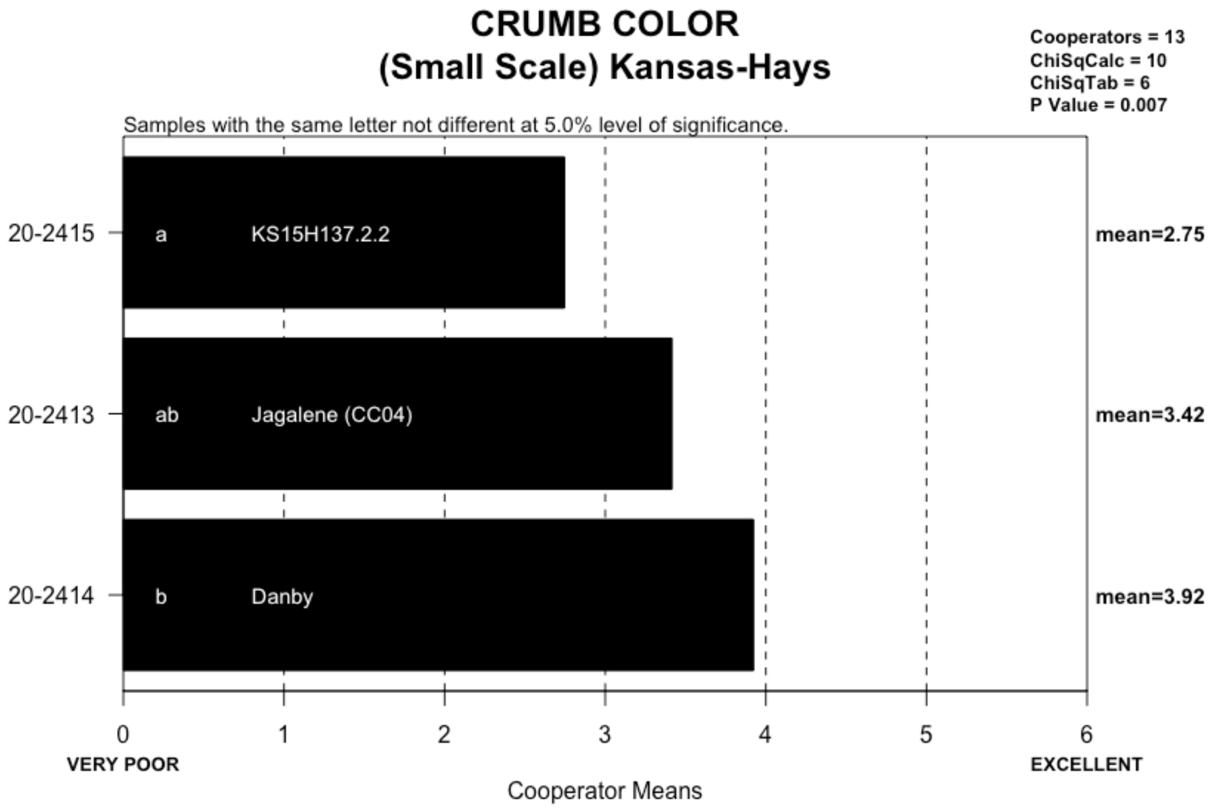
CELL SHAPE, DESCRIBED
(Small Scale) Kansas-Hays

IDCODE	ID	Round	Irregular	Elongated
20-2413	Jagalene (CC04)	5	5	3
20-2414	Danby	7	4	2
20-2415	KS15H137-2-2	4	5	4



CRUMB TEXTURE, DESCRIBED
(Small Scale) Kansas-Hays

IDCODE	ID	Harsh	Smooth	Silky
20-2413	Jagalene (CC04)	2	9	2
20-2414	Danby	4	7	2
20-2415	KS15H137-2-2	5	7	1



CRUMB COLOR, DESCRIBED
(Small Scale) Kansas-Hays

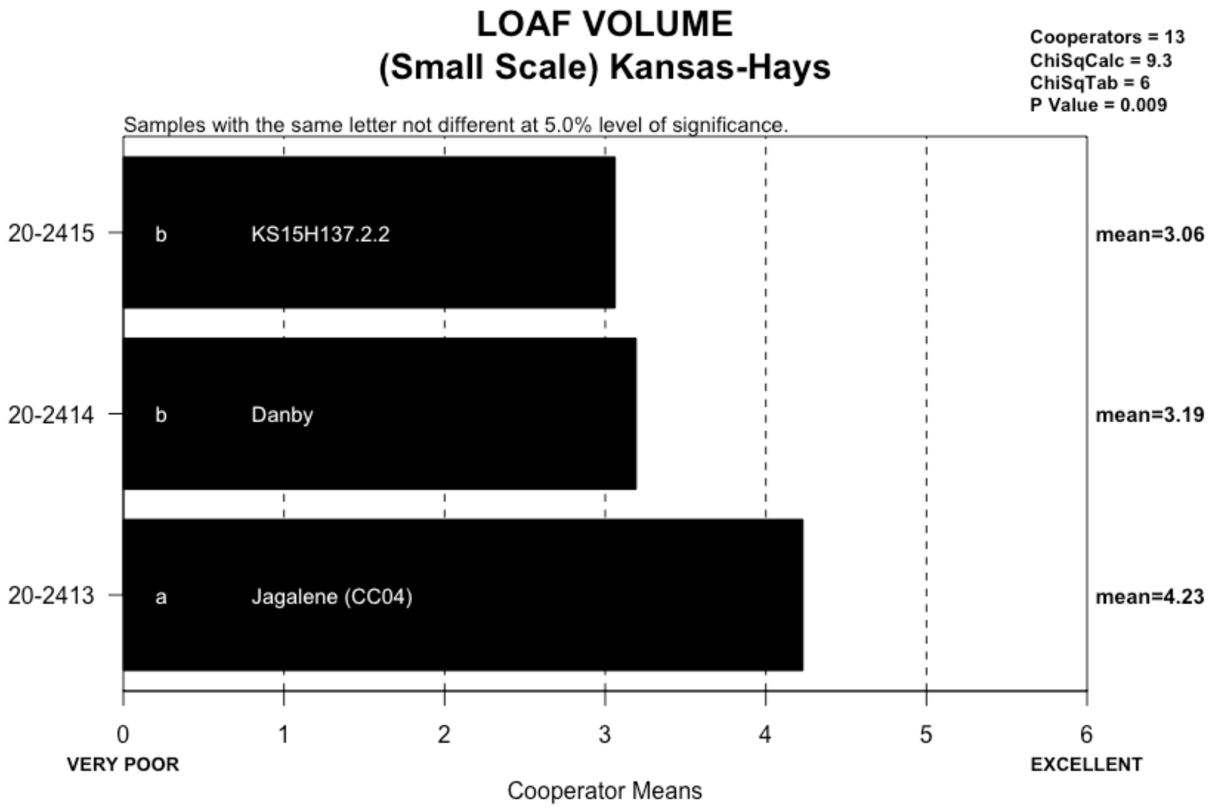
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2413	Jagalene (CC04)	1	1	1	2	7	1	0
20-2414	Danby	0	1	1	1	8	2	0
20-2415	KS15H137-2-2	1	0	4	6	2	0	0

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

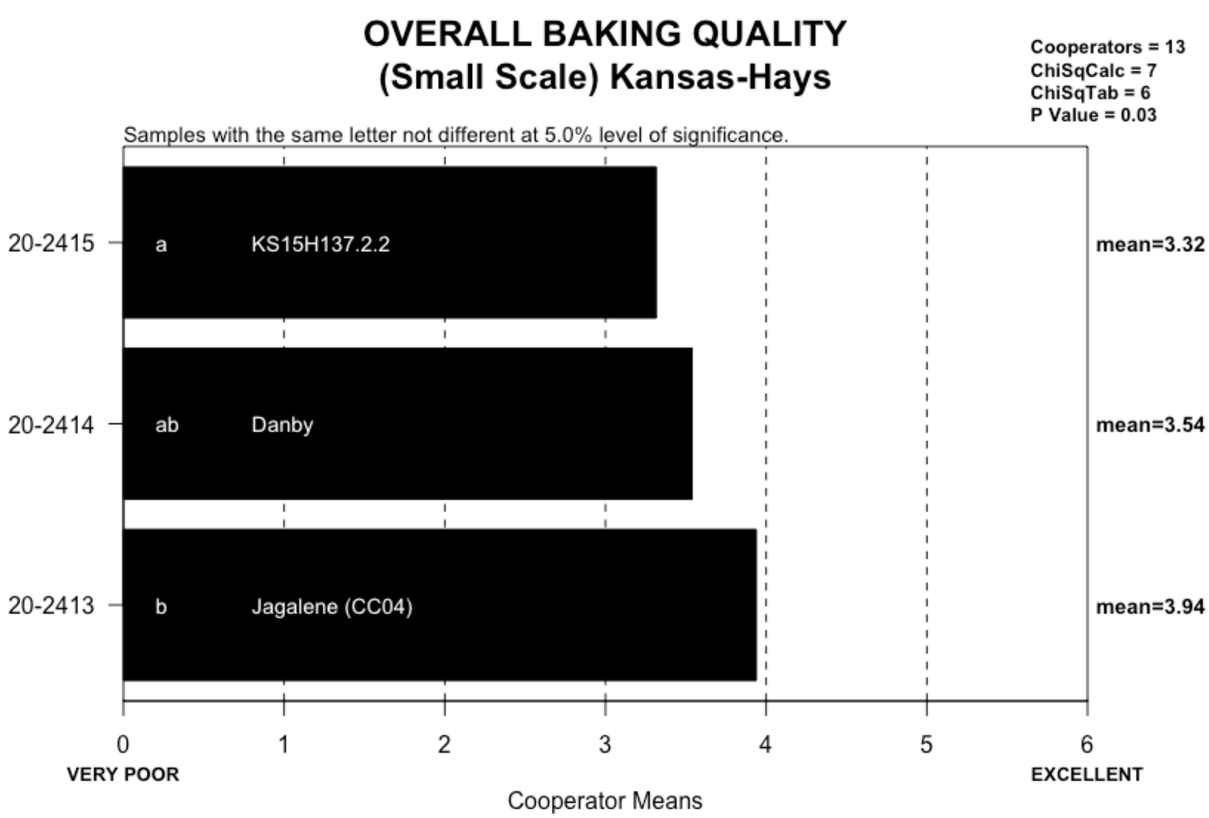
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2413	Jagalene (CC04)	417	136.8	136.7	156.4	145.2	140.5	145.6	155.4	142	459.0	475.9	146.9	419.9
20-2414	Danby	417	134.2	138.8	148.6	143.9	139.5	143.2	153.1	141	457.0	478.3	145.3	417.9
20-2415	KS15H137-2-2	418	136.1	137.8	153.8	145.2	140.3	146.7	154.8	145	457.8	469.3	148.6	418.4

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2413	Jagalene (CC04)	2850	885	898	973	850	930	1040	950	780	2501	2700	840	2775
20-2414	Danby	2525	960	824	948	800	980	855	920	874	2357	2400	745	2500
20-2415	KS15H137-2-2	2650	825	826	830	750	975	910	895	763	2282	2500	845	2500



LOAF VOLUME
(Small Scale) Kansas-Hays
Cooperators = 13
ChiSqCalc = 9.3
ChiSqTab = 6
P Value = 0.009
Samples with the same letter not different at 5.0% level of significance.
20-2415
b
KS15H137.2.2
mean=3.06
20-2414
b
Danby
mean=3.19
20-2413
a
Jagalene (CC04)
mean=4.23
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



OVERALL BAKING QUALITY
(Small Scale) Kansas-Hays
Cooperators = 13
ChiSqCalc = 7
ChiSqTab = 6
P Value = 0.03
Samples with the same letter not different at 5.0% level of significance.
20-2415
a
KS15H137.2.2
mean=3.32
20-2414
ab
Danby
mean=3.54
20-2413
b
Jagalene (CC04)
mean=3.94
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Kansas-Hays

COOP. 20-2413 Jagalene (CC04)

A. No comment.
B. No comment.
C. No comment.
D. Good dough properties and absorption, loaf volume somewhat low for protein level but crumb grain was good.
E. Should have had higher loaf volume given high protein, meets target, best in set.
F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Dark Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Excellent loaf externals.
H. Very high absorption (70%), avg grain, tough doughs, good volume.
I. Undesirable crumb grain-open, large cells, loaf center had a dull sheen.
J. No comment.
K. Avg absorption, avg grain, creamy crumb, excellent volume.
L. No comment.
M. High protein and absorption, good volume.

COOP. 20-2414 Danby

A. No comment.
B. No comment.
C. No comment.
D. Good dough performance although somewhat low in mix time, bread volume and crumb grain performed as expected.
E. Average, low mixograph tolerance.
F. Normal Protein, Normal Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Creamy Crumb, Open Elongated Cells, Soft & Resilient & Slightly Harsh Texture.
G. No comment.
H. High absorption, open grain, good volume.
I. Nice crumb color-bright, slightly creamy.
J. No comment.
K. Low mixing tolerance, avg absorption, dense grain, dark yellow crumb, sticky wet doughs, low volume.
L. No comment.
M. Good protein and absorption, lower mix time.

COOP. 20-2415 KS15H137-2-2

A. No comment.
B. Good symmetry.
C. No comment.
D. Good water absorption but generally weaker looking dough, volume very low for protein level.
E. Rheology good, did not bake as expected.
F. Very High Protein & Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Yellow Crumb, Slight Open Elongated Cells with Keyhole, Resilient & Smooth Texture.
G. Good loaf externals.
H. High absorption, poor grain, avg volume.
I. Poor crumb color.
J. No comment.
K. High absorption, good grain, avg volume.
L. No comment.
M. Higher protein and absorption, lower mix time, volume has room for improvement.

Notes: **A, K, and M** conducted sponge and dough bake tests

BAYER
(WESTBRED)

20-2416	Jagalene (CC05)
20-2417	MODI4-6036
20-2418	NEDI4-5064

Description of Test Plots and Breeder Entries

Bayer/Westbred – Adam Bray

The test samples were grown in Filer, Idaho. The plots were planted on October 18, 2019. Pre-plant N was applied via granular application targeting 125 bushel per acre yields. Top dressing was applied March 18, 2020. Liquid 32 was applied at a rate of 40 units/acre on June 10, 2020. The growth regulator Palisade EC was applied at jointing. Fungicide 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)

NEDI4-5064 (WB4401)

NEDI4-5064 is a hard red winter wheat, with medium maturity, good straw strength, and average test weight. It has good winterhardiness and is well adapted to the central and southern plains region. It has a strong disease package with very good powdery mildew and stripe rust resistance, as well as good FHB, soil-borne mosaic virus, and leaf rust resistance. It is moderately resistant to hessian fly and wheat streak mosaic virus. Additionally, it has very good aluminum tolerance for low pH soils. Internal quality testing indicates below average protein, but good to very good functionality. NEDI4-5064 is being marketed as WB4401, targeting broad acres across the central and southern plains.

MODI4-6036CL

MODI4-6036CL is a two gene Clearfield hard red winter wheat, with medium maturity, average straw strength, and average test weight. It has good winterhardiness and is well adapted to the northern plains and Montana. It is moderately resistant to stripe and leaf rust, FHB, and wheat streak mosaic virus. It is susceptible to wheat stem sawfly. Internal quality testing indicates MODI4-6036CL to have excellent protein and great functionality. MODI4-6036CL is a sister line of the new release WB4510CLP, targeting non-sawfly acres of Montana and the western Dakotas.

Bayer (Westbred): 2020 (Small-Scale) Samples

Test entry number	20-2416	20-2417	20-2418
Sample identification	**Jagalene (CC05)**	**MODI4-6036**	**NEDI4-5064**
Wheat Data			
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	65.4	63.5	64.5
Hectoliter weight (kg/hl)	85.9	83.5	84.8
1000 kernel weight (gm)	42.7	39.8	47.8
Wheat kernel size (Rotap)			
Over 7 wire (%)	95.1	89.6	97.7
Over 9 wire (%)	4.9	10.4	2.3
Through 9 wire (%)	0.0	0.0	0.0
Single kernel (skcs)[a]			
Hardness (avg /s.d)	67.5/13.1	70.6/13.0	69.6/15.1
Weight (mg) (avg/s.d)	42.7/8.5	39.8/7.9	47.8/10.0
Diameter (mm)(avg/s.d)	3.12/0.35	2.92/0.33	3.00/0.37
Moisture (%) (avg/s.d)	8.7/0.8	8.6/1.1	9.0/1.0
SKCS distribution	01-04-19-76-01	01-01-15-83-01	01-05-18-76-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb)	12.6	12.8	11.4
Wheat ash (12% mb)	1.47	1.71	1.54
Milling and Flour Quality Data			
Flour yield (%, str. grade)			
Miag Multomat Mill	78.6	74.5	76.1
Quadrumat Sr. Mill	70.7	68.0	64.3
Flour moisture (%)	12.9	12.8	12.5
Flour protein (14% mb)	11.5	11.7	10.4
Flour ash (14% mb)	0.57	0.52	0.65
Rapid Visco-Analyser			
Peak Time (min)	6.1	6.1	6.1
Peak Viscosity (RVU)	139.8	158.8	152.0
Breakdown (RVU)	51.2	61.4	55.7
Final Viscosity at 13 min (RVU)	166.5	181.3	177.5
Minolta color meter			
L*	90.80	91.45	90.49
a*	-1.02	-0.89	-1.34
b*	8.40	6.82	9.86
PPO	0.266	0.105	0.278
Falling number (sec)	357	353	337
Damaged Starch			
(AI%)	99.2	98.9	99.3
(AACC76-31)	9.0	8.8	9.1

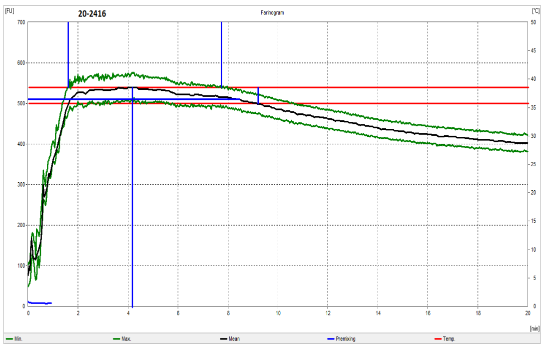
[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Bayer: Physical Dough Tests and Gluten Analysis For 2020 (Small-Scale) Samples

Test Entry Number	20-2416	20-2417	20-2418
Sample Identification	Jagalene (CC05)	MODI4-6036	NEDI4-5064
MIXOGRAPH			
Flour Abs (% as-is)	74.3	76.4	75.0
Flour Abs (14% mb)	73.1	75.0	73.3
Mix Time (min)	3.0	2.8	3.9
Mix tolerance (0-6)	1	1	2
FARINOGRAPH			
Flour Abs (% as-is)	75.0	75.8	78.0
Flour Abs (14% mb)	73.7	74.4	76.3
Peak time (min)	4.2	6.3	4.5
Mix stability (min)	6.1	9.6	4.7
Mix Tolerance Index (FU)	41	17	56
Breakdown time (min)	8.5	13.8	6.9
ALVEOGRAPH			
P(mm): Tenacity	179	181	202
L(mm): Extensibility	48	47	73
G(mm): Swelling index	15.4	15.2	19.0
W(10^{-4} J): strength (curve area)	335	331	311
P/L: curve configuration ratio	3.73	3.85	2.77
Ie(P_{200}/P): elasticity index	46.1	44.3	14.5
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	258/278/320	292/347/372	286/319/399
Extensibility (mm at 45/90/135 min)	133/134/134	149/144/139	110/122/110
Energy (cm^2 at 45/90/135 min)	55/64/72	77/91/91	49/61/64
Resist $_{max}$ (BU at 45/90/135 min)	299/356/406	375/479/497	312/364/443
Ratio (at 45/90/135 min)	1.9/2.1/2.4	2.0/2.4/2.7	2.6/2.6/3.6
PROTEIN ANALYSIS			
HMW-GS Composition	1,2*, 17+18, 5+10	2*, 7+8, 5+10	2*, 7+8, 5+10
TPP/TMP	0.82	0.86	0.91
SEDIMENTATION TEST			
Volume (ml)	49.9	50.3	43.3

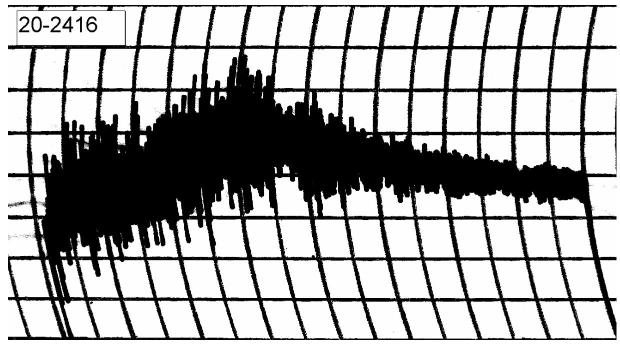
Physical Dough Tests
2020 (Small Scale) Samples – Bayer

Farinograms



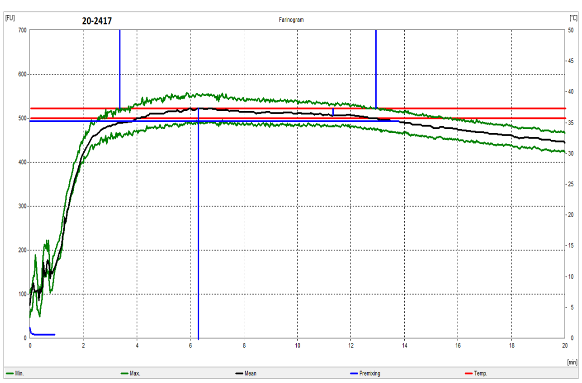
Water abs = 73.7%, Peak time = 4.2 min,
Mix stab = 6.1 min, MTI = 41 FU

Mixograms

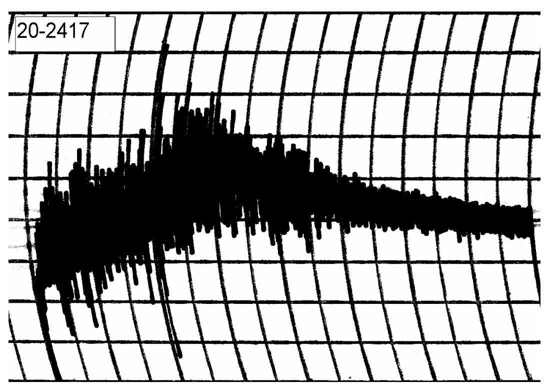


Water abs = 73.1%
Mix time = 3.0 min

20-2416, Jagalene (CC05)



Water abs = 74.4%, Peak time = 6.3 min,
Mix stab = 9.6 min, MTI = 17 FU



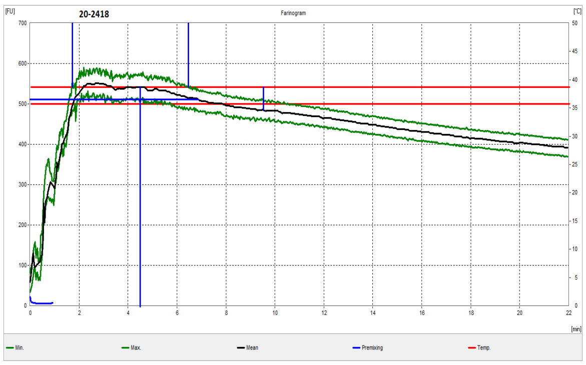
Water abs = 75.0%
Mix time = 2.8 min

20-2417, MODI4-6036

Physical Dough Tests

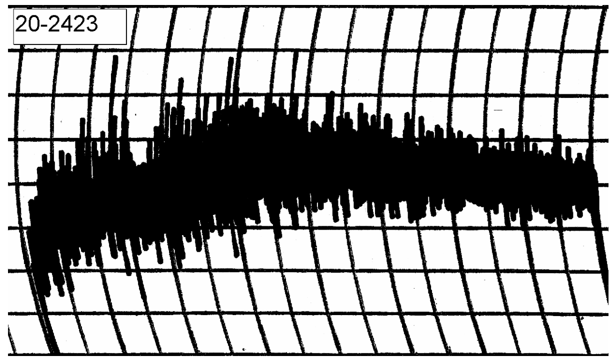
2020 (Small Scale) Samples – Bayer

Farinograms



Water abs = 76.3%, Peak time = 4.5 min,
Mix stab = 4.7 min, MTI = 56 FU

Mixograms

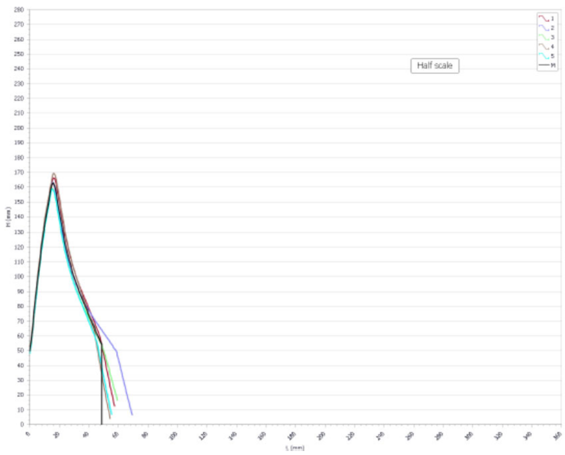


Water abs = 73.3%
Mix time = 3.9 min

20-2418, NEDI4-5064

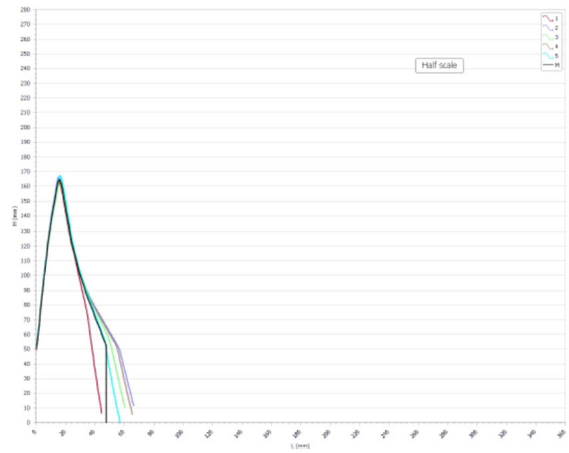
Physical Dough Tests - Alveograph

2020 (Small Scale) Samples – Bayer



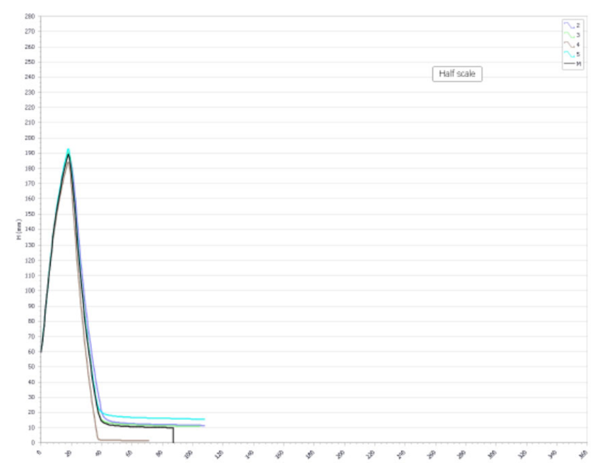
20-2416, Jagalene (CC05)

P (mm H_20) = 179, L (mm) = 48, W ($10E^{-4}$J) = 335



20-2417, MODI4-6036

P (mm H_20) = 181, L (mm) = 47, W ($10E^{-4}$J) = 331

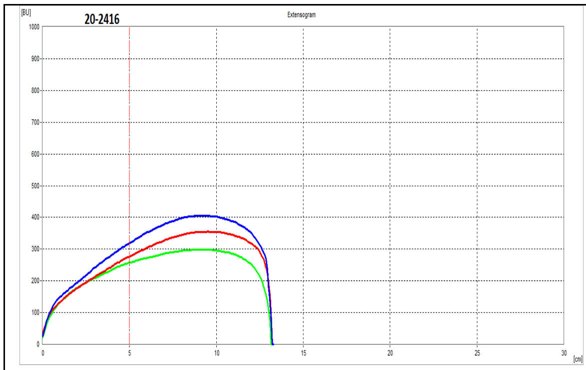


20-2418, NEDI4-5064

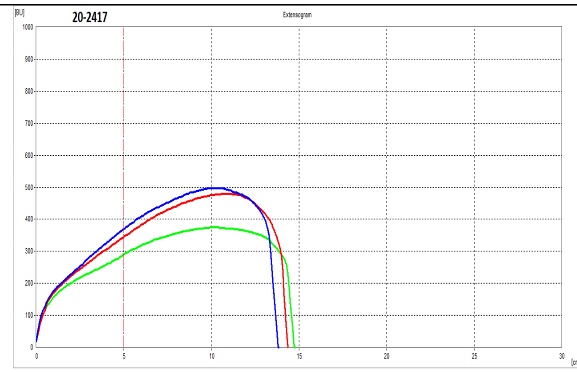
P (mm H_20) = 202, L (mm) = 73, W ($10E^{-4}$J) = 331

Physical Dough Tests - Extensigraph

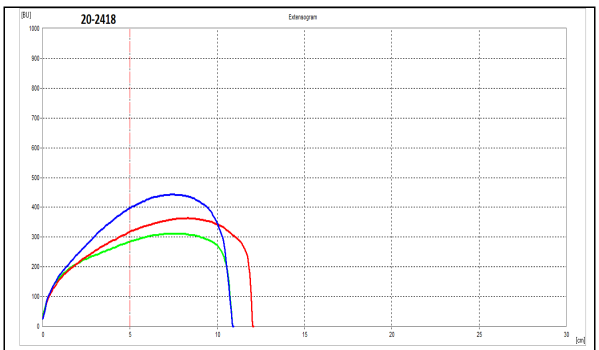
2020 (Small Scale) Samples – Bayer



20-2416, Jagalene (CC05)
R (BU) = 278, E (mm) = 134, W (cm^2) = 64
Rmax (BU) = 356, Ratio = 2.1 at 90 min



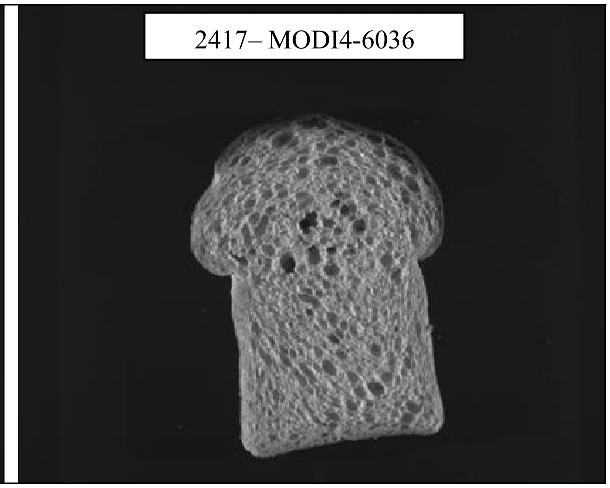
20-2417, MODI4-6036
R (BU) = 347, E (mm) = 144, W (cm^2) = 91
Rmax (BU) = 479, Ratio = 2.4 at 90 min



20-2418, NEDI4-5064
R (BU) = 319, E (mm) = 122, W (cm^2) = 61
Rmax (BU) = 364, Ratio = 2.6 at 90 min

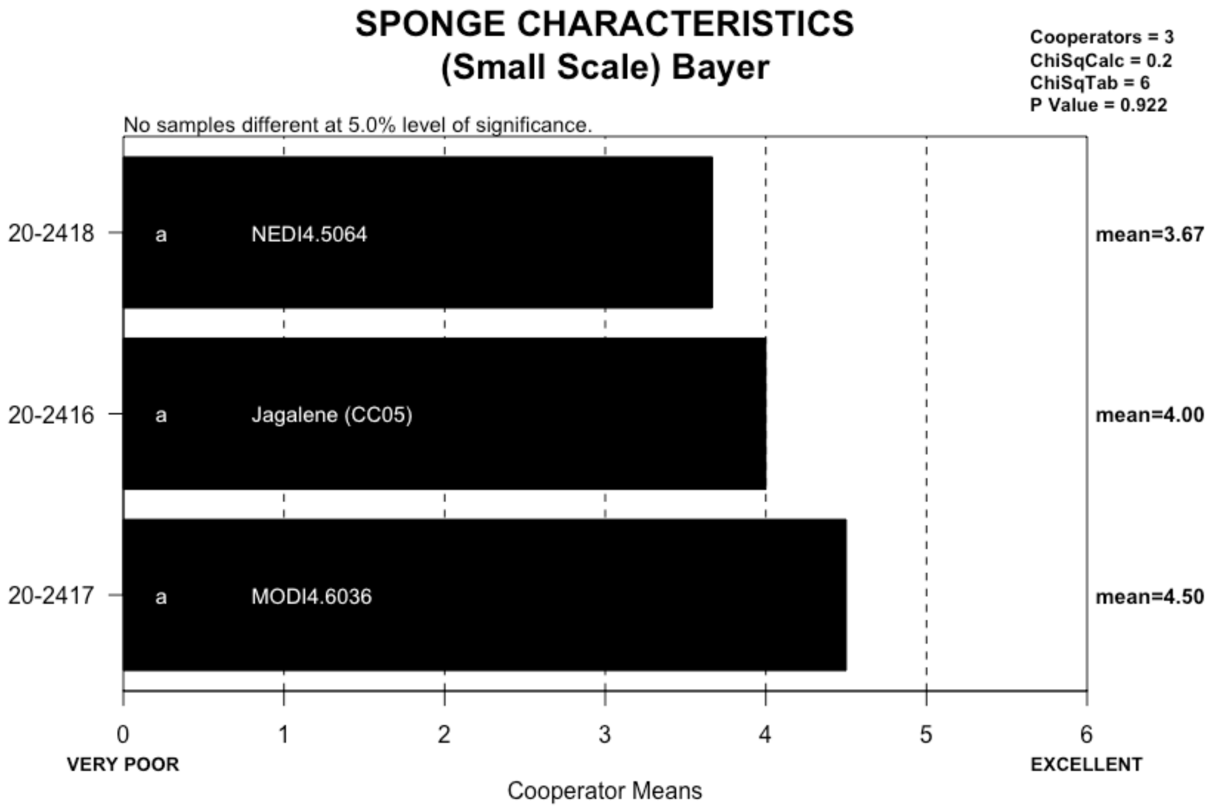
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

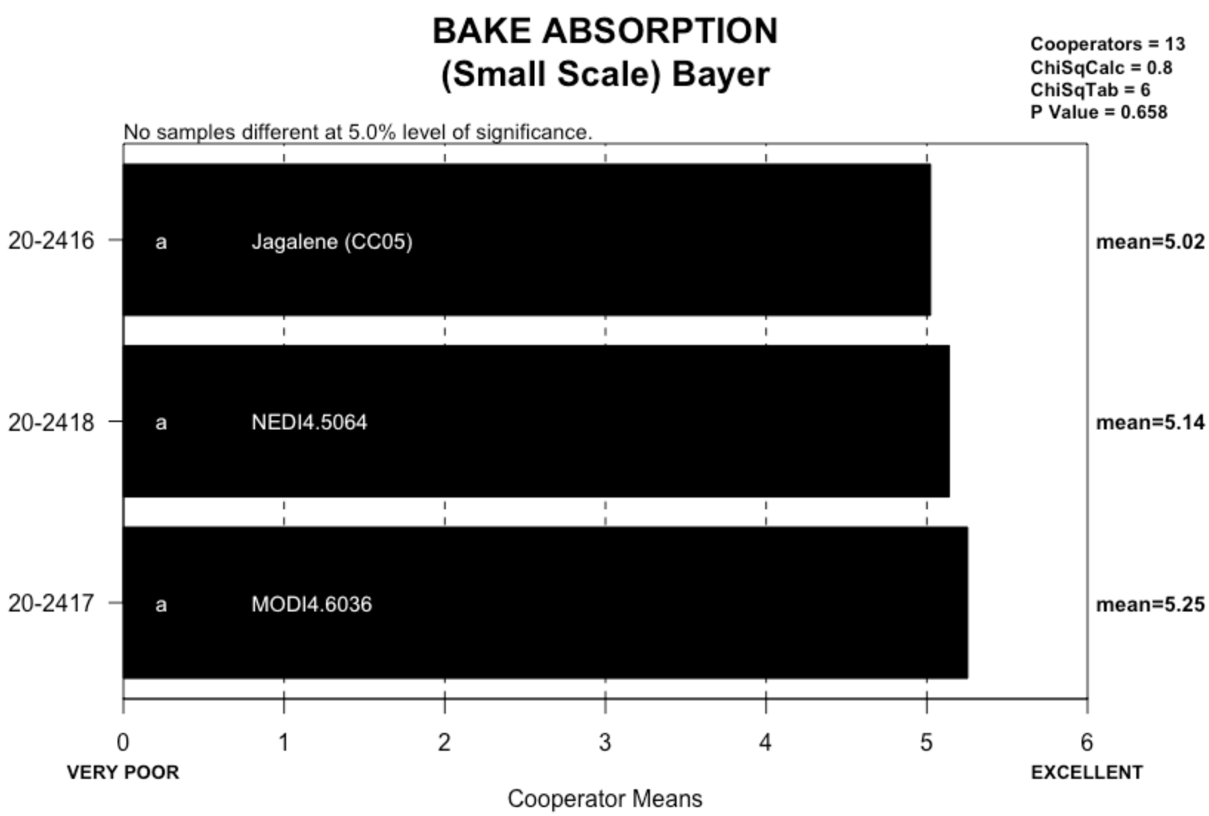
Bayer: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples



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})
2416	6024	113	2732	0.465	2.812	1.848	1.783	-0.98
2417	6125	114	2934	0.465	2.729	2.964	1.718	-1.15

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})
2418	4782	110	2449	0.458	2.304	1.354	1.677	-2.97


SPONGE CHARACTERISTICS
(Small Scale) Bayer
Cooperators = 3
ChiSqCalc = 0.2
ChiSqTab = 6
P Value = 0.922
No samples different at 5.0% level of significance.
20-2418
a
NEDI4.5064
mean=3.67
20-2416
a
Jagalene (CC05)
mean=4.00
20-2417
a
MODI4.6036
mean=4.50
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

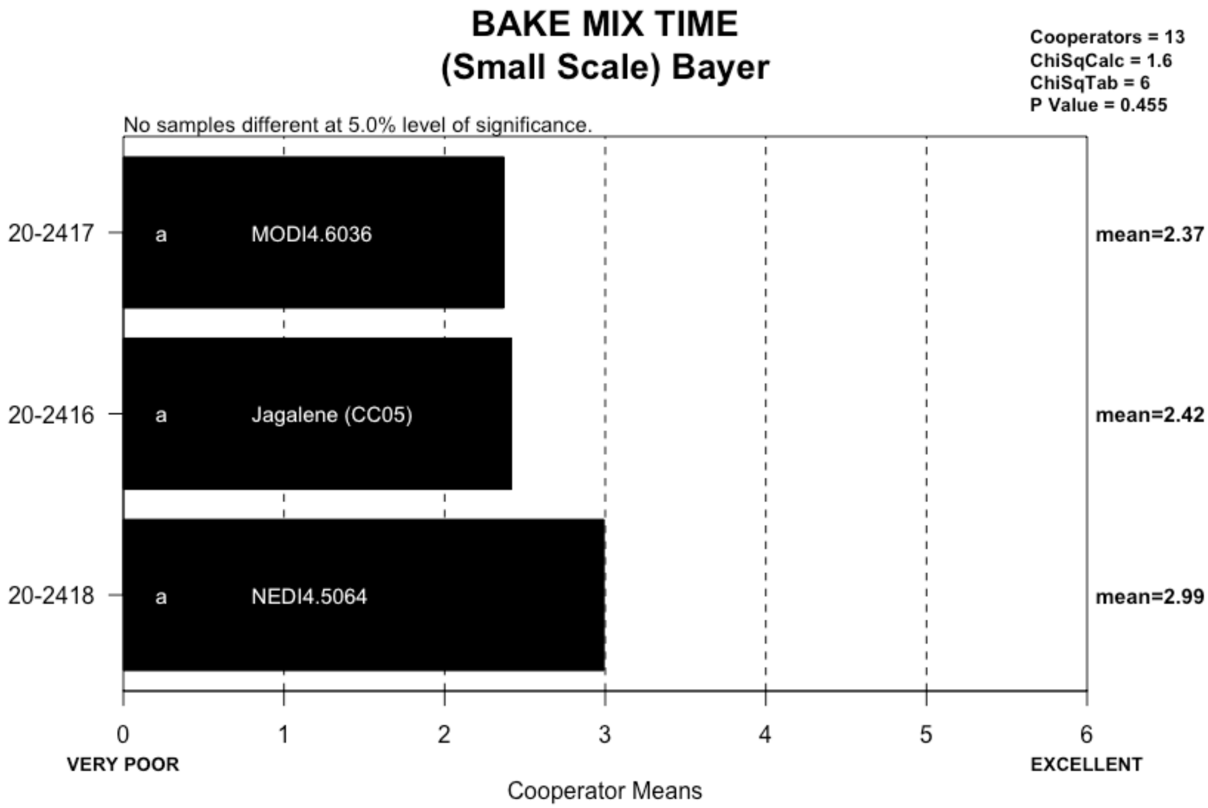

BAKE ABSORPTION
(Small Scale) Bayer
Cooperators = 13
ChiSqCalc = 0.8
ChiSqTab = 6
P Value = 0.658
No samples different at 5.0% level of significance.
20-2416
a
Jagalene (CC05)
mean=5.02
20-2418
a
NEDI4.5064
mean=5.14
20-2417
a
MODI4.6036
mean=5.25
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

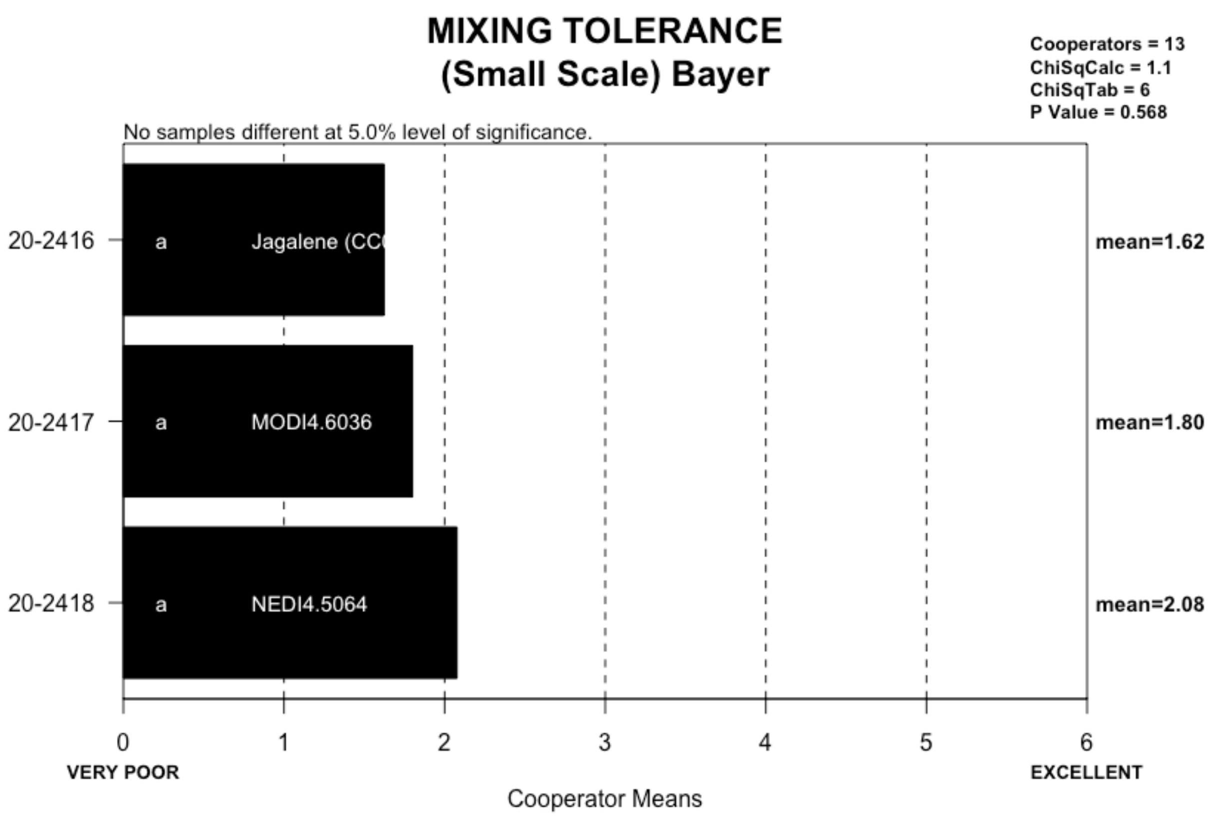
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Bayer
Cooperators A – M

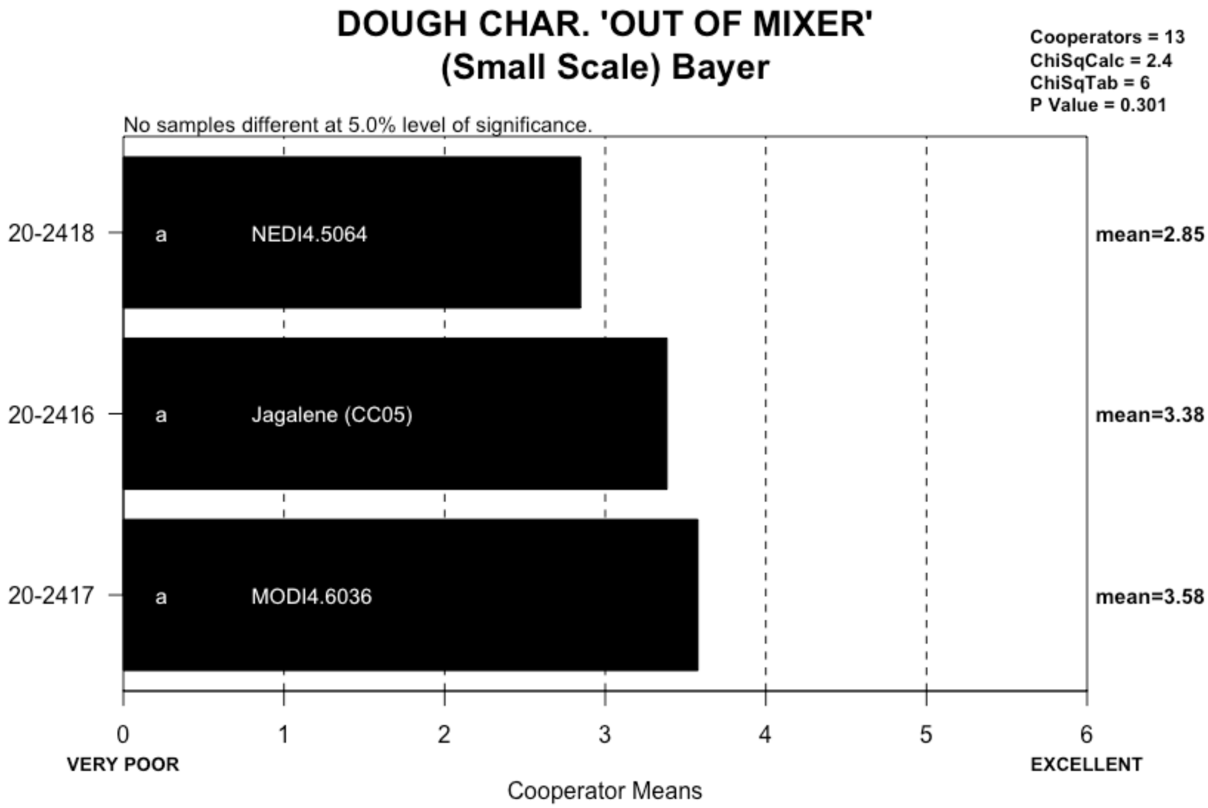
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2406	Jagalene (CC02)	60	71.1	70.2	71.3	68.0	64.8	68.6	72.7	65.0	64.5	63.0	69.3	66.5
20-2407	BASF1	58	62.4	68.6	68.1	65.2	64.3	64.4	67.1	60.4	59.8	57.4	67.1	61.8
20-2408	BASF2	59	71.6	69.6	68.6	66.4	64.8	66.9	68.1	64.9	63.9	60.4	67.9	65.9

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2416	Jagalene (CC05)	5	3.8	3.0	2.7	3.5	3.4	3.0	3.3	3.0	8	4	3.0	8
20-2417	MODI4-6036	6	3.3	3.4	3.1	3.2	3.8	3.0	3.3	2.8	8	4	2.8	8
20-2418	NEDI4-5064	6	4.5	4.0	3.7	3.3	4.9	3.8	5.0	4.3	8	4	3.9	8

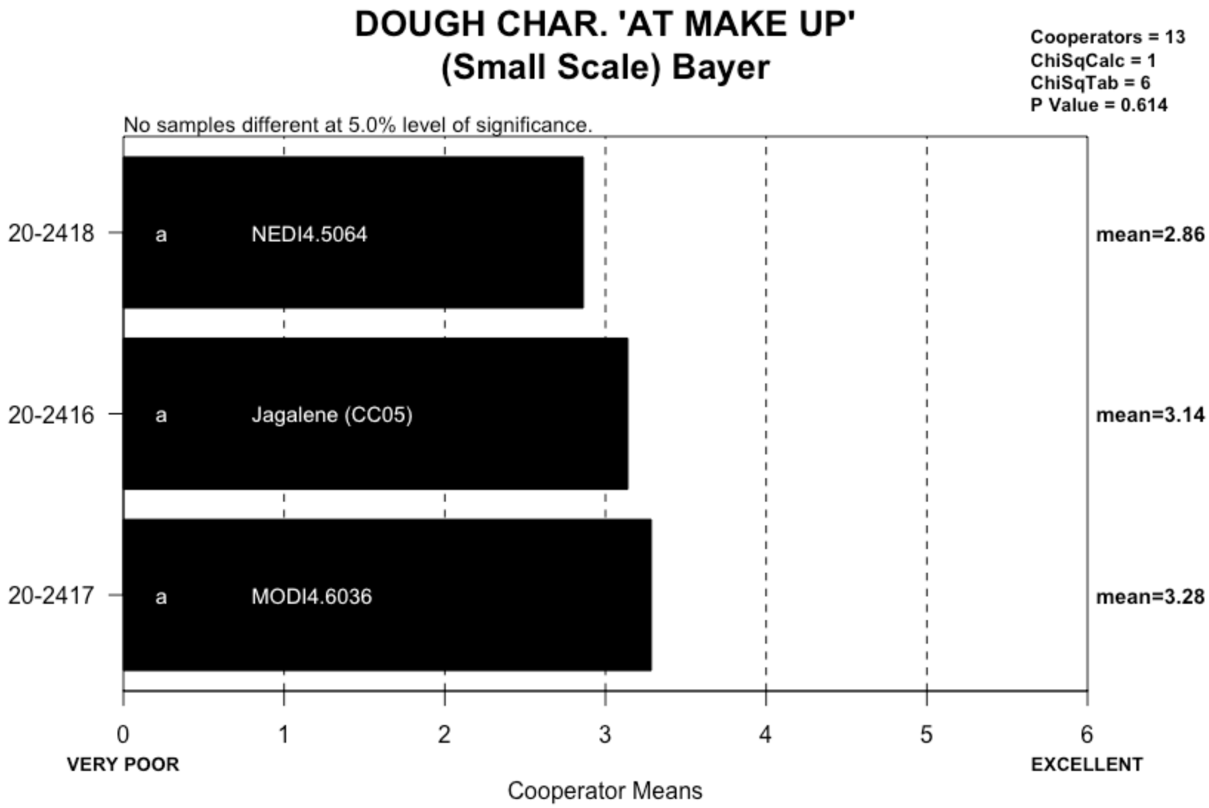

BAKE MIX TIME
(Small Scale) Bayer
Cooperators = 13
ChiSqCalc = 1.6
ChiSqTab = 6
P Value = 0.455
No samples different at 5.0% level of significance.
20-2417
a
MODI4.6036
mean=2.37
20-2416
a
Jagalene (CC05)
mean=2.42
20-2418
a
NEDI4.5064
mean=2.99
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Bayer
Cooperators = 13
ChiSqCalc = 1.1
ChiSqTab = 6
P Value = 0.568
No samples different at 5.0% level of significance.
20-2416
a
Jagalene (CC
mean=1.62
20-2417
a
MODI4.6036
mean=1.80
20-2418
a
NEDI4.5064
mean=2.08
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



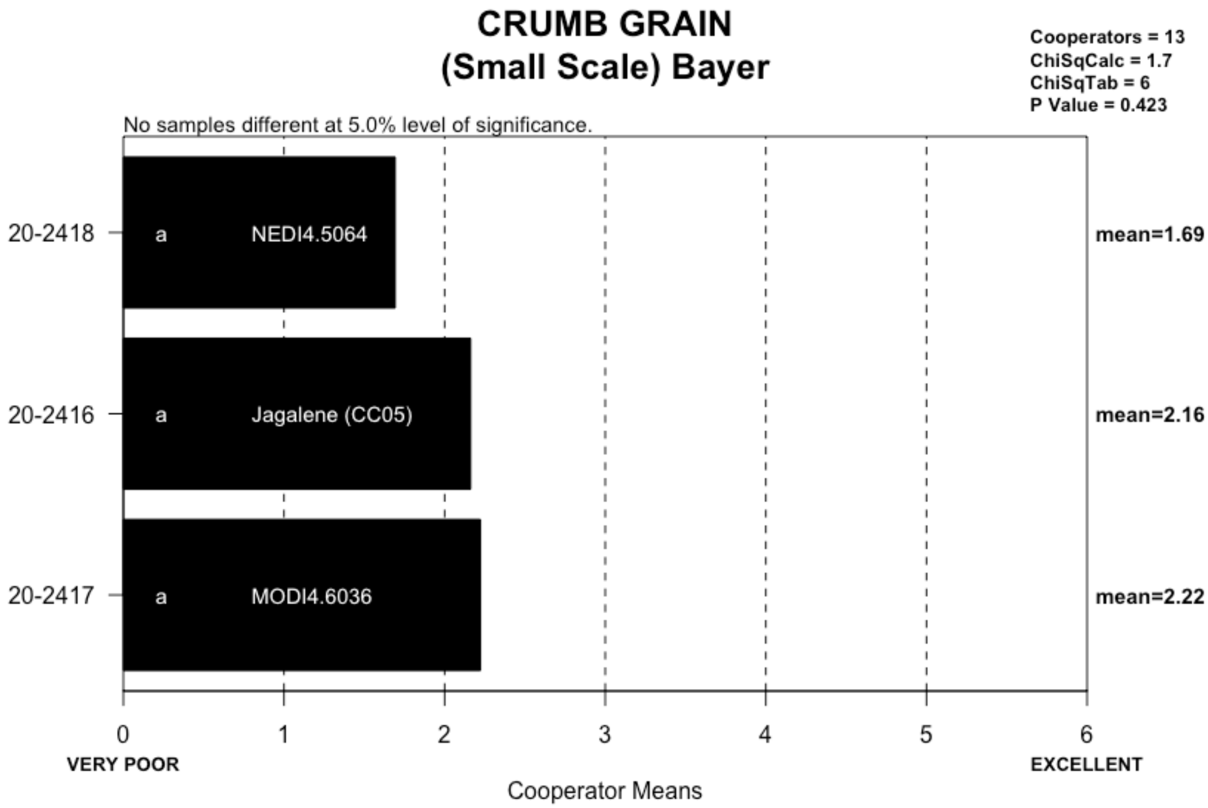
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Bayer

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2416	Jagalene (CC05)	5	1	3	4	0
20-2417	MODI4-6036	3	1	2	6	1
20-2418	NEDI4-5064	4	1	4	4	0



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2416	Jagalene (CC05)	5	1	1	6	0
20-2417	MODI4-6036	3	1	2	7	0
20-2418	NEDI4-5064	4	2	3	4	0

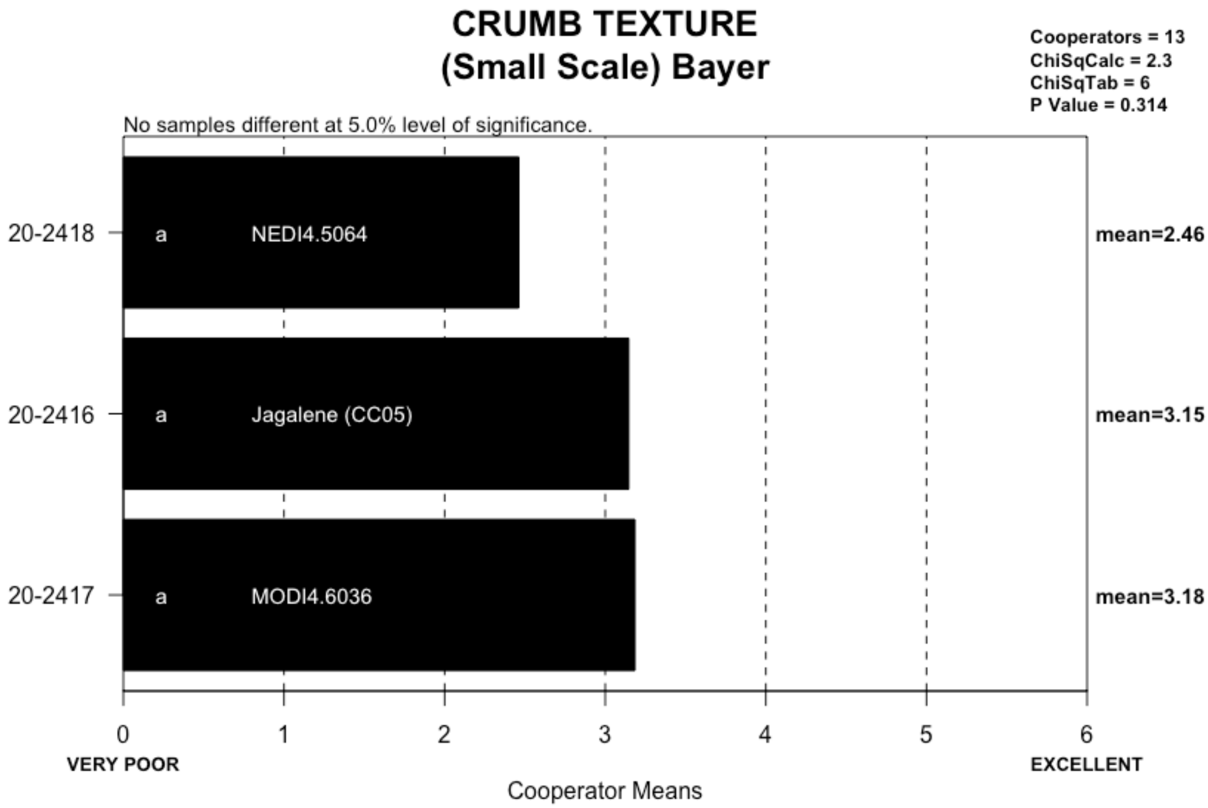


CRUMB GRAIN, DESCRIBED
(Small Scale) Bayer

IDCODE	ID	Open	Fine	Dense
20-2416	Jagalene (CC05)	8	2	3
20-2417	MODI4-6036	9	3	1
20-2418	NEDI4-5064	6	2	5

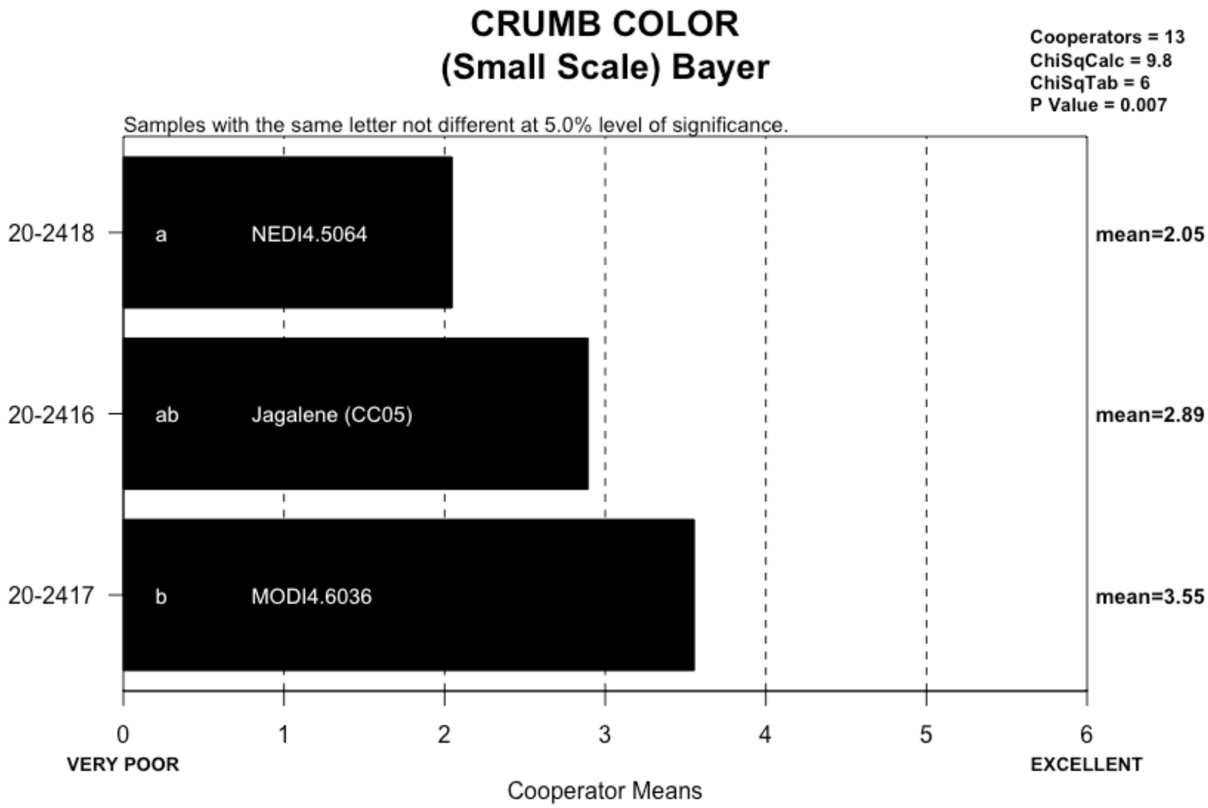
CELL SHAPE, DESCRIBED
(Small Scale) Bayer

IDCODE	ID	Round	Irregular	Elongated
20-2416	Jagalene (CC05)	6	6	1
20-2417	MODI4-6036	5	5	3
20-2418	NEDI4-5064	9	3	1



CRUMB TEXTURE, DESCRIBED
(Small Scale) Bayer

IDCODE	ID	Harsh	Smooth	Silky
20-2416	Jagalene (CC05)	7	2	4
20-2417	MODI4-6036	6	4	3
20-2418	NEDI4-5064	8	3	2



CRUMB COLOR, DESCRIBED
(Small Scale) Bayer

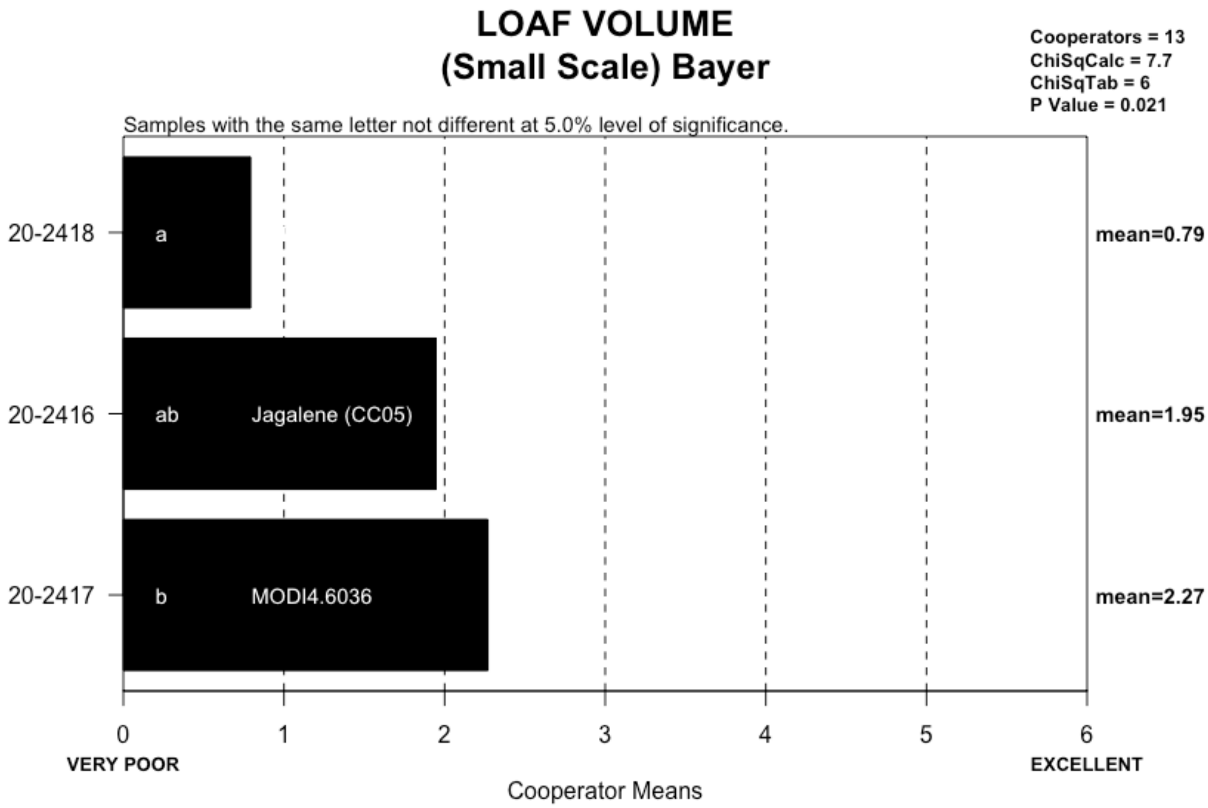
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2416	Jagalene (CC05)	0	1	3	5	4	0	0
20-2417	MODI4-6036	0	1	1	4	5	2	0
20-2418	NEDI4-5064	0	5	3	4	1	0	0

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

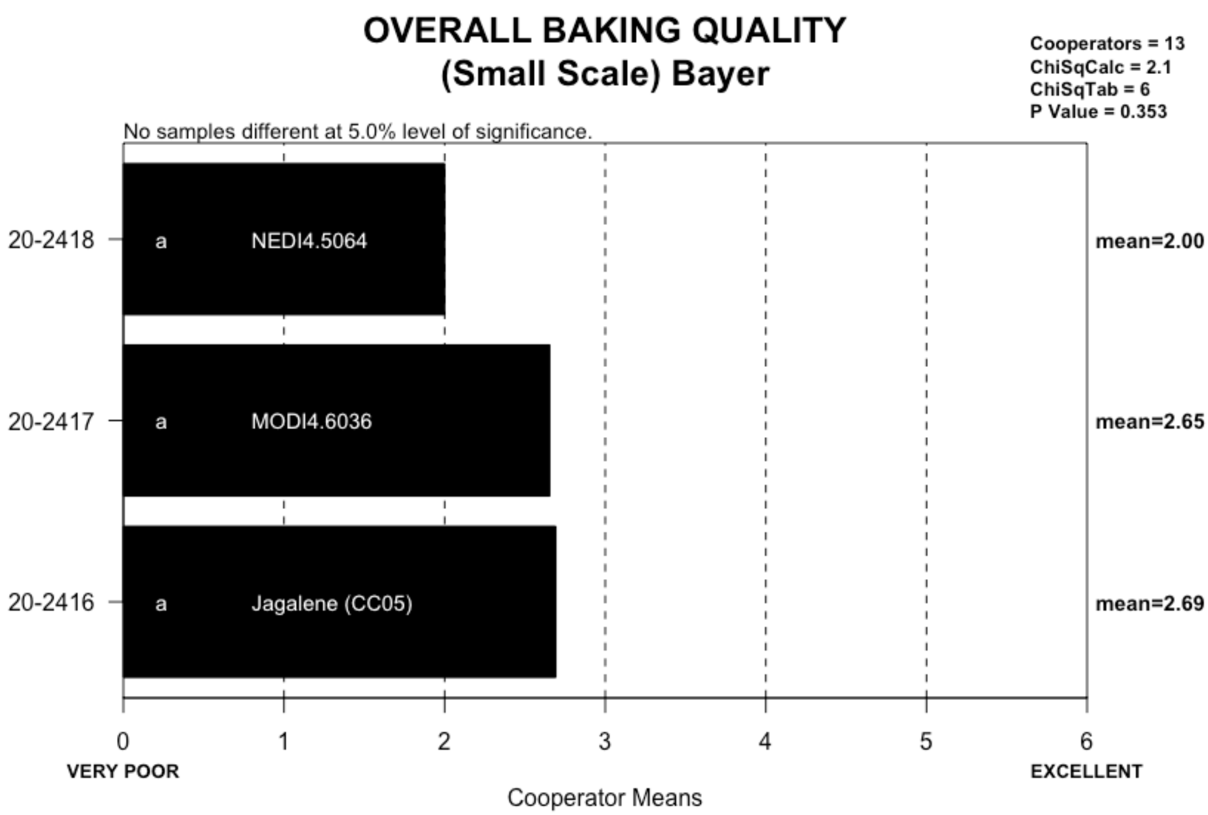
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2416	Jagalene (CC05)	410	140.7	137.4	158.5	146.7	141.5	144.2	158.8	147	442.8	477.0	149.3	409.9
20-2417	MODI4-6036	413	144.0	138.8	162.9	145.6	140.9	144.8	161.3	149	450.0	475.7	147.7	416.9
20-2418	NEDI4-5064	419	146.7	137.6	159.4	148.6	145.6	146.9	161.3	154	437.9	477.3	148.7	416.0

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2416	Jagalene (CC05)	2550	705	740	733	515	840	780	855	829	1718	2388	740	2600
20-2417	MODI4-6036	2525	930	774	755	590	935	795	855	857	1777	2513	720	2350
20-2418	NEDI4-5064	2300	725	663	595	420	579	725	595	501	1637	2188	660	2200



LOAF VOLUME
(Small Scale) Bayer
Cooperators = 13
ChiSqCalc = 7.7
ChiSqTab = 6
P Value = 0.021
Samples with the same letter not different at 5.0% level of significance.
20-2418
a
mean=0.79
20-2416
ab
Jagalene (CC05)
mean=1.95
20-2417
b
MODI4.6036
mean=2.27
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



OVERALL BAKING QUALITY
(Small Scale) Bayer
Cooperators = 13
ChiSqCalc = 2.1
ChiSqTab = 6
P Value = 0.353
No samples different at 5.0% level of significance.
20-2418
a
NEDI4.5064
mean=2.00
20-2417
a
MODI4.6036
mean=2.65
20-2416
a
Jagalene (CC05)
mean=2.69
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Bayer

COOP. 20-2416 Jagalene (CC05)

A. No comment.
B. Good absorption, small loaf.
C. No comment.
D. Very weak dough, very low volume for protein level with very poor crumb grain.
E. Poor.
F. Normal Protein & Water Abs, Short MT, Slight Sticky & Strong Dough, Medium Volume, Dark Yellow Crumb, Open Round Cells, Resilient & Slightly Harsh Texture.
G. Dark crust.
H. Low mixing tolerance, very high absorption (74%), poor grain, sticky at makeup, avg volume.
I. Considering the crumb grain, the texture exceeded expectations-surprisingly smooth and silky.
J. No comment.
K. Low mixing tolerance, high absorption, open grain, sticky wet doughs, very low volume.
L. No comment.
M. Huge absorption, fair protein and volume, low mix time and tolerance, unfavorable end-product. Recommend for blending.

COOP. 20-2417 MOD14-6036

A. No comment.
B. Open uneven crumb, good symmetry.
C. No comment.
D. Very weak dough, very low volume for protein level with very poor crumb grain.
E. Poor.
F. Normal Protein & Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Dark Yellow Crumb, Open Elongated Cells, Resilient & Slightly Harsh Texture.
G. White dough, dark crust.
H. Low mixing tolerance, very high absorption (75%), poor grain, avg volume.
I. Very soft crumb texture.
J. No comment.
K. High absorption, open grain, creamy crumb, avg volume.
L. No comment.
M. Huge absorption, fair protein, low volume, low mix time and tolerance, undesirable dough notes, unfavorable end-product. Do not recommend.

COOP. 20-2418 NED14-5064

A. No comment.
B. Good absorption, small loaf.
C. No comment.
D. Very weak dough with exceptionally poor bread performance.
E. Protein does not meet target.
F. Low Protein & Water Abs, Normal MT, Slight Sticky & Tough Dough, Very Low Volume, Dark Yellow Crumb, Open Irregular Cells, Resilient & Harsh Texture.
G. No comment.
H. Low protein flour, very high absorption (73%), dense grain, dark yellow crumb, sticky dough at makeup, very low volume.
I. Low protein, high absorption, dough deteriorated throughout the baking process, undesirable end-product.
J. No comment.
K. Low mixing tolerance, very high absorption, open grain, dark yellow crumb, loaf volume too low.
L. No comment.
M. Huge absorption, lower protein, low volume, MTI is higher than most. Blending required.

Notes: **A, K, and M** conducted sponge and dough bake tests

OKLAHOMA

20-2419	Jagalene (CC06)
20-2420	Baker's Ann
20-2421	OK14124-2
20-2422	OK15MASBx7 ARS8-22
20-2423	OK15818
20-2424	OK12716W Comp I

Description of Test Plots and Breeder Entries

Oklahoma – Brett Carver

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 2020 growout was 52 bushels per acre, consistent with the fertilized yield goal of 60 bushels per acre after adjusting for shatter losses. Mean wheat protein concentration in the 2020 growout was 12.1%.

Grain production in this nursery was largely influenced by severe leaf spotting associated with, in part, by spring freeze conditions and presence of Septoria triciti blotch.

Harvest was timely, on June 15, 2020, before rainfall would have influenced milling quality. Differences in test weight largely reflect inherent differences in potential test weight free from weathering bias.

Photographs taken May 11, 2020 during growth stage Feekes 11.2 (soft dough) – Lahoma WQC growout. Note the much earlier maturity of OK14124-2.

Baker's Ann (local check)

Previously tested as sample 17-2429 and 18-2421 in the 2017 and 2018 WQC evaluation programs, Baker's Ann produces a very strong dough manifested in farinograph stabilities exceeding 18 min. Baker's Ann produces smaller seed than Gallagher (similar to Iba) at about one-half percentage point higher wheat protein than Gallagher.

In the field, Baker's Ann has shown a high level of stripe rust resistance, though resistance to early infections (pre-heading) of leaf rust may need to be bolstered with a fungicide application. Baker's Ann will fit best in the Oklahoma panhandle and north central Oklahoma. Maturity is very early. Release approval was provided by OSU in September 2018, and the variety was licensed to Oklahoma Genetics, Inc. (OGI). TX00D1390 and Billings are the proud parents of Baker's Ann.

OK14124-2 (Butler's Gold)

Butler's Gold received release approval in September 2020 and should be attractive to producers who wish to follow a late fall-harvested summer crop or who face season-disrupting conditions and must recover with a late-planted crop. Butler's Gold will be positioned statewide in Oklahoma, but only for grain-only management systems (no grazing). The optimal planting window is pushed back several weeks, spanning late October to early-December in central Oklahoma. Some of the motivation for release came from a desire to deploy a late-planted, accelerated-maturity HRW wheat over a spring-planted spring wheat in a HRW marketing region. Milling and baking quality of Butler's Gold has been extraordinary, with kernel size, test weight, flour protein, water absorption, farinograph stability, and loaf volume all above-average. PPO activity is low and similar to Baker's Ann. Butler's Gold has a high yield potential with a broad disease package, showing moderate susceptibility only to barley yellow dwarf and powdery mildew. Its pedigree is NI04430/OK05303//Fuller.

OK15MASBx7 ARS 8-20

This Gallagher backcross (Gallagher*3/Snowmass) was developed with the express intent to introgress the gene encoding Bx7oe from Snowmass while removing the T1RS·1BL translocation from Gallagher. In comparisons of the mean of 19 sib lines from this cross (including OK15MASBx7 ARS 8-20) to Gallagher, the mixograph tolerance rating increased from 4 to 5, mixogram band width increased from 13 to 19mm, and mixogram stability index decreased from 5.2 to 1.6 (flatter curve). Mixograph peak time increased from 6 to 12 min. OK15MASBx7 ARS 8-20, or one of its siblings, will be released in 2021 as a grain source for blending up crop dough strength. OK15MASBx7 ARS 8-20 has agronomic characteristics similar to Gallagher.

OK15818

Gallagher, the leading planted variety in Oklahoma for the past five years, has been known to segregate for field reaction to stripe rust since its release in 2012. OK15818 is a single-plant selection from Gallagher (made in 2012) with a uniform response to stripe rust, last observed in Oklahoma in 2016. Rather than re-releasing a Gallagher selection, seed producers who wish to continue with Gallagher will do so with OK15818 as a purified Gallagher foundation seed source. Agronomic and end-use properties have been indiscernible outside of stripe rust reaction. The reselection is featured in the WQC this year to provide a contemporary quality analysis of Gallagher moving forward. OK15818 is not intended to undercut the deployment of Smith's Gold, released as an improved single-cross *progeny* of Gallagher.

OK12716W Comp I

This hard white experimental line was formed from a composite of several uniform sib lines of Showdown (OK12716), but with a white bran coat. OK12716W has shown the same high yield performance and adaptation pattern as Showdown. The two lines are phenotypically indistinguishable in the field, and end-use quality patterns appear to be similar. Foundation seed production is ongoing in 2020-2021, with a release decision pending market demand for HW wheat.

Oklahoma: 2020 (Small-Scale) Samples

Test entry number	20-2419	20-2420	20-2421
Sample identification	Jagalene (CC06)	Baker's Ann	OK14124-2
Wheat Data			
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu) Hectoliter weight (kg/hl)	64.3 84.5	63.8 83.8	64.2 84.4
1000 kernel weight (gm)	30.8	32.2	37.7
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 70.4 29.3 0.3	 69.3 30.5 0.2	 90.9 9.0 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	 85.2/16.1 30.8/7.9 2.67/0.33 12.3/0.4 00-01-06-93-01 Hard	 78.6/14.5 32.2/7.8 2.65/0.32 12.1/0.3 00-02-07-91-01 Hard	 79.3/13.7 37.7/9.2 2.90/0.34 13.3/0.2 00-01-07-92-01 Hard
Wheat protein (12% mb) Wheat ash (12% mb)	11.1 1.10	11.5 1.18	12.9 1.26
Milling and Flour Quality Data			
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 77.6 69.2	 76.3 68.8	 76.6 67.6
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.1 10.3 0.48	12.3 10.2 0.42	12.8 11.8 0.48
Rapid Visco-Analyser Peak time (min) Peak viscosity (RVU) Breakdown (RVU) Final viscosity at 13 min (RVU)	 5.9 158.3 58.2 191.9	 5.9 164.3 51.5 217.5	 6.0 156.6 50.0 201.2
Minolta color meter L* a* b* **PPO**	 91.23 -1.42 9.35 0.417	 91.63 -1.48 8.84 0.166	 90.68 -1.01 8.39 0.140
Falling number (sec)	393	399	376
Damaged Starch (AI%) (AACC76-31)	 99.4 9.1	 99.2 9.0	 98.8 8.6

[a]s.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: 2020 (Small-Scale) Samples (Continued)

Test entry number	20-2422	20-2423	20-2424
Sample identification	OK15MASBx7 ARS8-20	OK15818	OK12716W Comp I
Wheat Data			
GIPSA classification	1 HRW	1 HRW	2 HDWH
Test weight (lb/bu) Hectoliter weight (kg/hl)	60.9 80.1	64.2 84.4	62.4 82.0
1000 kernel weight (gm)	29.8	33.6	31.4
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 65.9 33.8 0.3	 77.4 22.5 0.1	 68.4 31.0 0.6
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	 94.0/16.0 29.8/8.4 2.62/0.39 12.6/0.3 00-01-03-96-01 Hard	 89.4/14.0 33.6/8.6 2.76/0.35 12.4/0.3 00-00-02-98-01 Hard	 86.9/16.3 31.4/9.7 2.63/0.37 13.2/0.4 00-01-04-95-01 Hard
Wheat protein (12% mb) Wheat ash (12% mb)	12.0 1.27	11.5 1.14	10.5 1.18
Milling and Flour Quality Data			
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 76.4 65.2	 77.0 68.0	 77.6 69.7
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	12.3 11.4 0.56	12.2 10.7 0.45	12.7 9.7 0.50
Rapid Visco-Analyser Peak time (min) Peak viscosity (RVU) Breakdown (RVU) Final viscosity at 13 min (RVU)	 5.9 167.8 55.9 212.9	 6.1 151.0 47.6 193.8	 5.9 183.5 76.6 208.4
Minolta color meter L* a* b* PPO	 90.08 -0.96 9.08 0.157	 90.99 -1.55 9.92 0.149	 91.13 -1.48 9.28 0.511
Falling number (sec)	466	370	389
Damaged Starch (AI%) (AACC76-31)	 99.1 8.9	 98.9 8.8	 98.5 8.3

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Oklahoma: Physical Dough Tests and Gluten Analysis
2020 (Small-Scale) Samples

Test Entry Number	20-2419	20-2420	20-2421
Sample Identification	Jagalene (CC06)	Baker's Ann	OK15MASBx7 ARS8-20
MIXOGRAPH			
Flour Abs (% as-is)	69.4	69.9	72.1
Flour Abs (14% mb)	67.2	68.0	70.7
Mix Time (min)	4.4	5.4	4.0
Mix tolerance (0-6)	4	6	4
FARINOGRAPH			
Flour Abs (% as-is)	71.2	69.8	72.0
Flour Abs (14% mb)	69.0	67.9	70.6
Peak time (min)	5.4	4.9	6.7
Mix stability (min)	9.5	10.8	11.9
Mix Tolerance Index (FU)	27	24	24
Breakdown time (min)	11.0	12.2	14.3
ALVEOGRAPH			
P(mm): Tenacity	178	191	191
L(mm): Extensibility	41	30	63
G(mm): Swelling index	14.2	12.2	17.6
W(10^{-4} J): strength (curve area)	305	263	467
P/L: curve configuration ratio	4.34	6.37	3.03
Ie(P_{200}/P): elasticity index	45.0	0.0	58.6
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	393/533/572	517/765/926	409/501/498
Extensibility (mm at 45/90/135 min)	124/117/117	144/133/117	156/153/150
Energy (cm^2 at 45/90/135 min)	80/95/101	140/182/165	121/146/141
Resist $_{max}$ (BU at 45/90/135min)	479/638/678	777/1134/1155	596/748/769
Ratio (at 45/90/135 min)	3.2/4.5/4.9	3.6/5.8/7.9	2.6/3.3/3.3
PROTEIN ANALYSIS			
HMW-GS Composition	1,2*, 17+18, 5+10	1, 7+8, 5+10	1, 7+9, 2+12
TPP/TMP	0.79	0.66	0.96
SEDIMENTATION TEST			
Volume (ml)	47.0	58.8	66.1

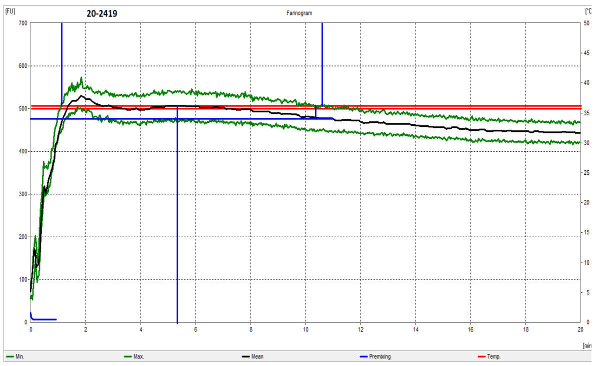
Oklahoma: Physical Dough Tests and Gluten Analysis 2020 (Small-Scale) Samples (continued)

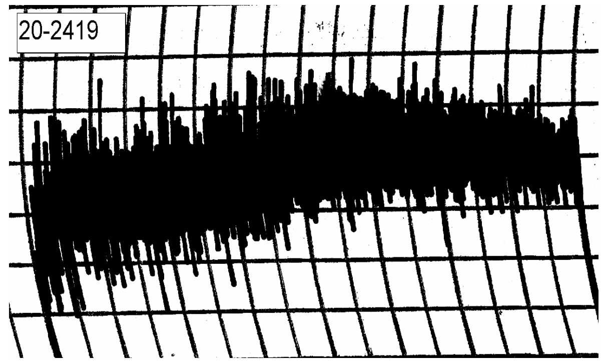
Test Entry Number	20-2422	20-2423	20-2424
Sample Identification	OK15MASBx7 ARS8-20	OK15818	OK12716W Comp I
MIXOGRAPH			
Flour Abs (% as-is)	72.9	69.3	67.5
Flour Abs (14% mb)	71.0	67.3	66.0
Mix Time (min)	10.6	3.3	3.8
Mix tolerance (0-6)	6	3	3
FARINOGRAPH			
Flour Abs (% as-is)	75.3	73.7	67.9
Flour Abs (14% mb)	73.4	71.8	66.4
Peak time (min)	3.7	7.2	4.9
Mix stability (min)	6.4	9.8	8.1
Mix Tolerance Index (FU)	30	22	33
Breakdown time (min)	6.9	14.9	9.1
ALVEOGRAPH			
P(mm): Tenacity	161	183	139
L(mm): Extensibility	155	42	38
G(mm): Swelling index	27.6	14.4	13.7
W(10^{-4} J): strength (curve area)	631	318	218
P/L: curve configuration ratio	1.04	4.36	3.66
Ie(P_{200}/P): elasticity index	37.0	43.0	0.0
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	719/1247/1268	296/383/471	394/509/542
Extensibility (mm at 45/90/135 min)	139/118/106	118/115/120	126/117/124
Energy (cm^2 at 45/90/135 min)	178/204/186	56/66/89	79/93/104
Resist $_{max}$ (BU at 45/90/135min)	1054/1534/1521	347/448/573	472/602/659
Ratio (at 45/90/135 min)	5.2/10.6/12.0	2.5/3.4/3.9	3.1/4.3/4.4
PROTEIN ANALYSIS			
HMW-GS Composition	2*, 7OE+8, 5+10	2*, 7+9, 5+10	1, 7+9, 2+12
TPP/TMP	0.75	0.85	0.96
SEDIMENTATION TEST			
Volume (ml)	57.9	42.1	42.9

Physical Dough Tests

2020 (Small Scale) Samples - Oklahoma

Farinograms	Mixograms

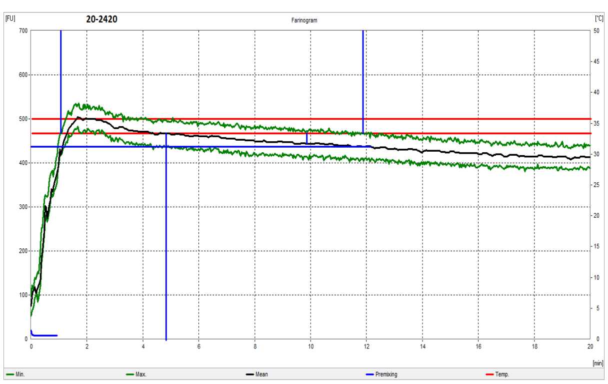


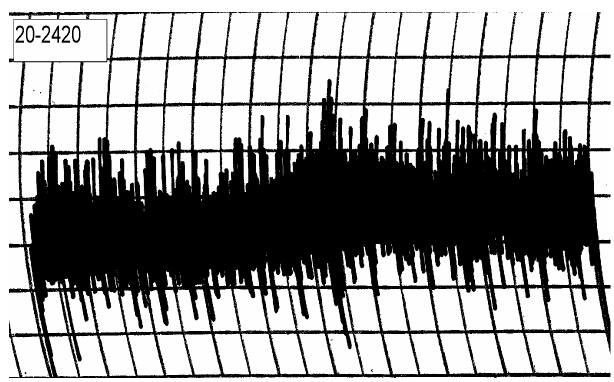


Water abs = 69.0%, Peak time = 5.4 min,
Mix stab = 9.5 min, MTI = 27 FU

Water abs = 67.2%
Mix time = 4.4 min

20-2419, Jagalene (CC06)





Water abs = 67.9%, Peak time = 4.9 min,
Mix stab = 10.8 min, MTI = 24 FU

Water abs = 68.0%
Mix time = 5.4 min

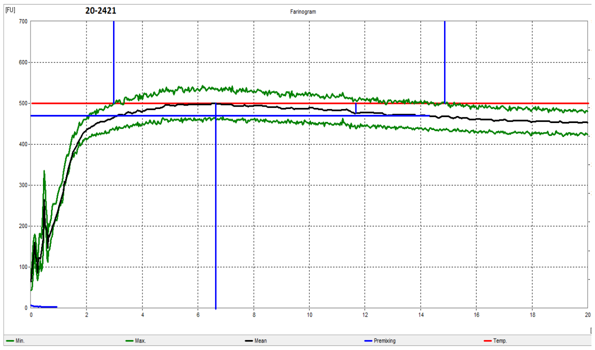
20-2420, Baker's Ann

Physical Dough Tests

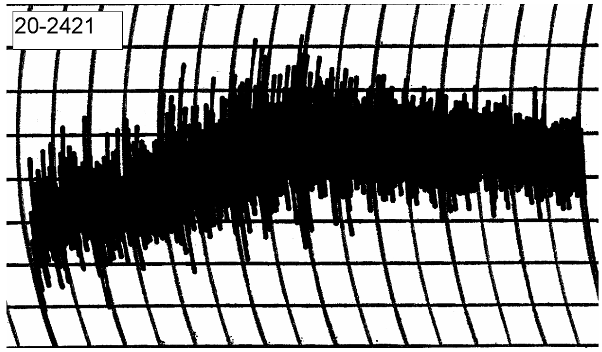
2020 (Small Scale) Samples - Oklahoma

Farinograms

Mixograms

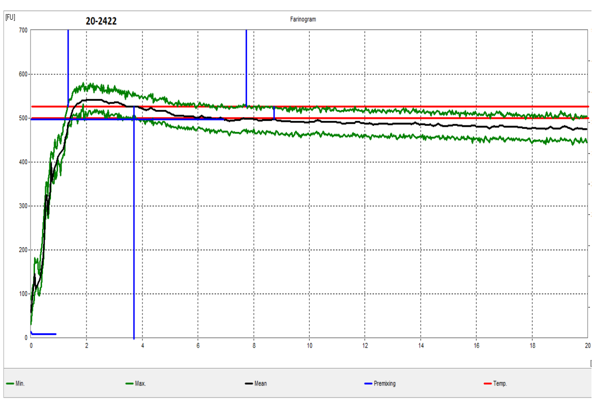


Water abs = 70.6%, Peak time = 6.7 min,
Mix stab = 11.9 min, MTI = 24 FU

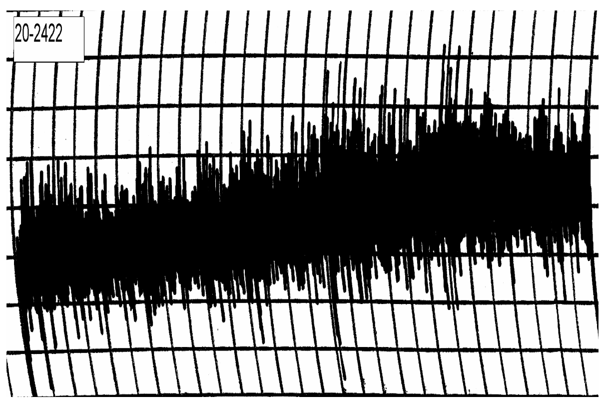


Water abs = 70.7%
Mix time = 4.0 min

20-2421, OK14124-2



Water abs = 73.4%, Peak time = 3.7 min,
Mix stab = 6.4 min, MTI = 30 FU



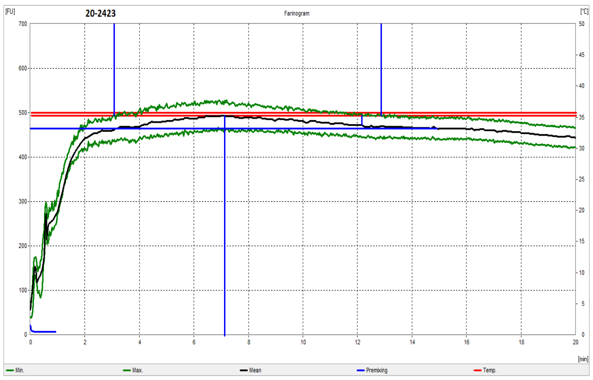
Water abs = 71.0%
Mix time = 10.6 min

20-2422, OK15MASBx7 ARS8-20

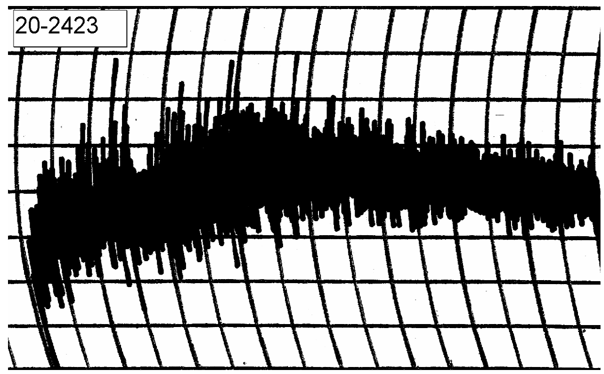
Physical Dough Tests
2020 (Small Scale) Samples - Oklahoma

Farinograms

Mixograms

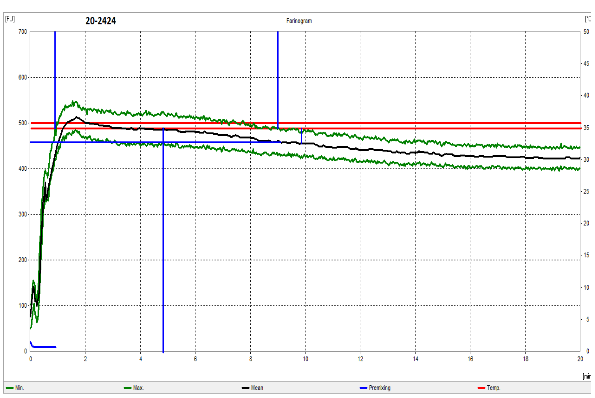


Water abs = 71.8%, Peak time = 7.2 min,
Mix stab = 9.8 min, MTI = 22 FU

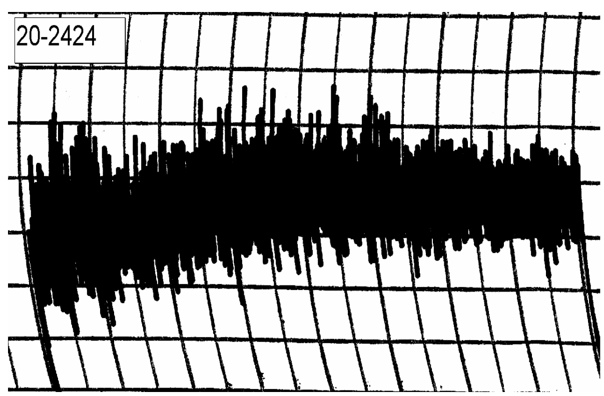


Water abs = 67.3%
Mix time = 3.3 min

20-2423, OK15818



Water abs = 66.4%, Peak time = 4.9 min,
Mix stab = 8.1 min, MTI = 33 FU

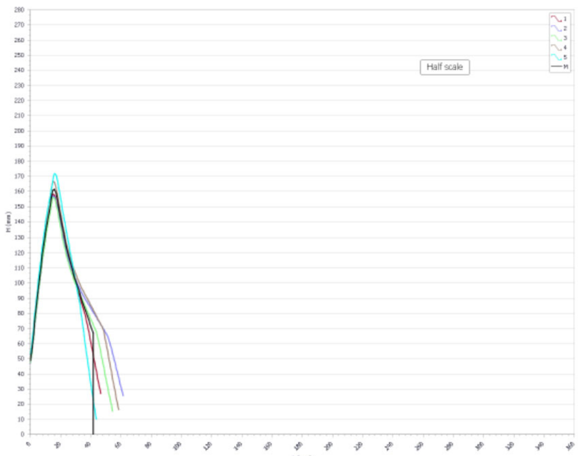


Water abs = 66.0%
Mix time = 3.8 min

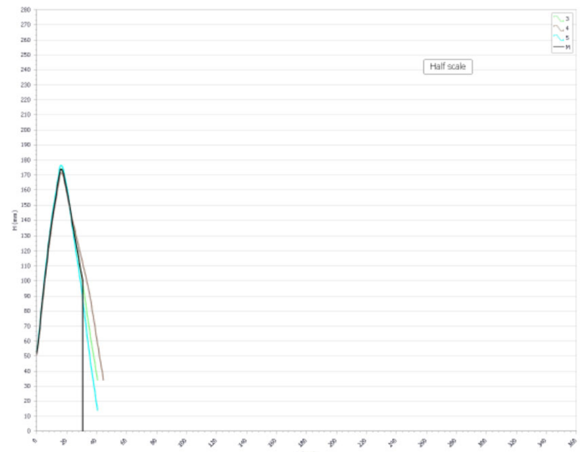
20-2424, OK12716W Comp I

Physical Dough Tests - Alveograph

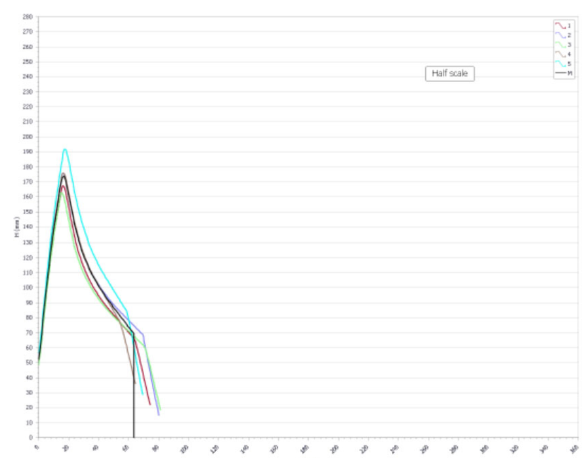
2020 (Small Scale) Samples – Oklahoma



20-2419, Jagalene (CC06)
P(mm H_20) =178, L(mm) = 41, W($10E^{-4}$ J) = 305

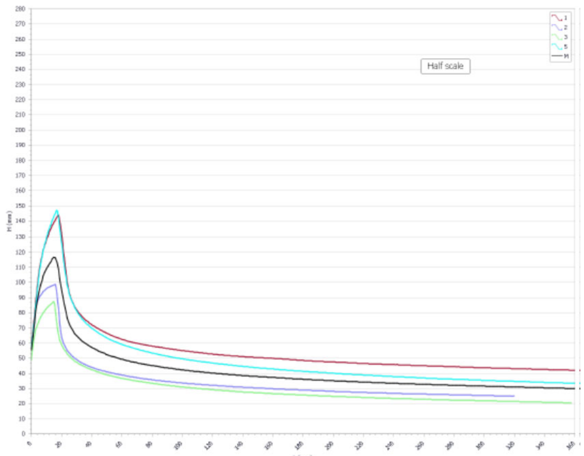


20-2420, Baker's Ann
P(mm H_20) = 191, L(mm) = 30, W($10E^{-4}$ J) = 263

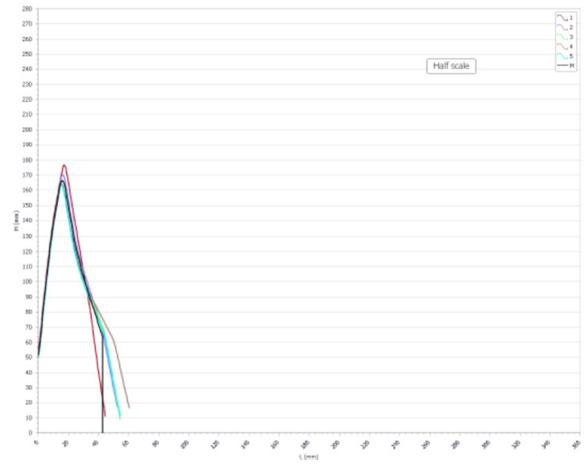


20-2421, OK14124-2
P(mm H_20) = 191, L(mm) = 63, W($10E^{-4}$ J) = 467

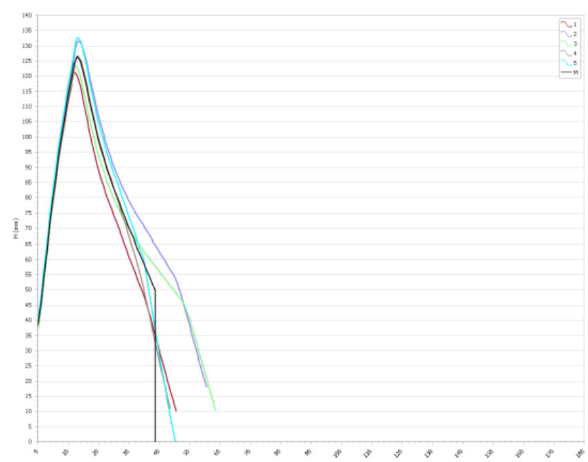
Physical Dough Tests - Alveograph
2020 (Small Scale) Samples – Oklahoma



20-2422, OK15MASBx7 ARS8-20
P(mm H_20) =161, L(mm) = 155, W(10E^{-4} J) = 631



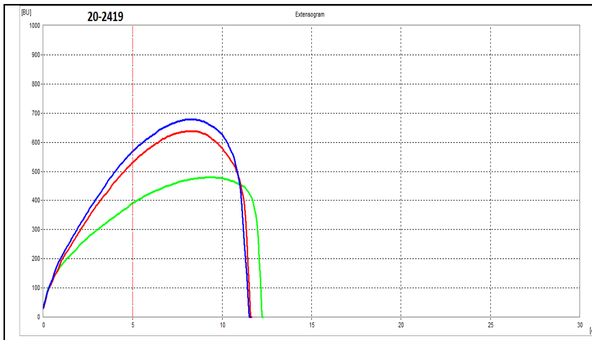
20-2423, OK15818
P(mm H_20) = 183, L(mm) = 42, W(10E^{-4} J) = 318



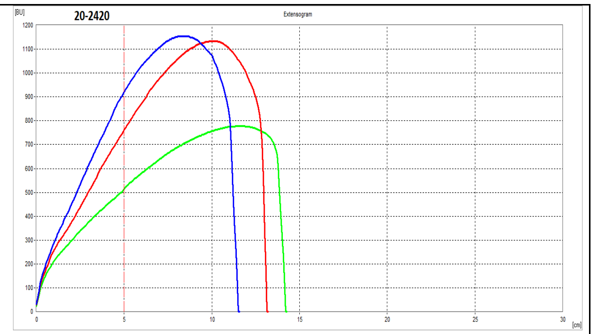
20-2424 OK12716W Comp I
P(mm H_20) =139, L(mm) = 38, W(10E^{-4} J) = 218

Physical Dough Tests - Extensigraph

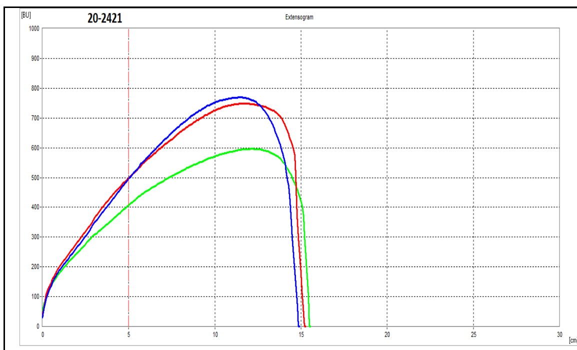
2020 (Small Scale) Samples – Oklahoma



20-2419, Jagalene (CC06)
R (BU) =533, E (mm) = 117, W (cm^2) = 95
Rmax (BU) = 638, Ratio = 4.5 at 90 min



20-2420, Baker's Ann
R (BU) = 765, E (mm) = 133, W (cm^2) = 182
Rmax (BU) = 1134, Ratio = 5.8 at 90 min

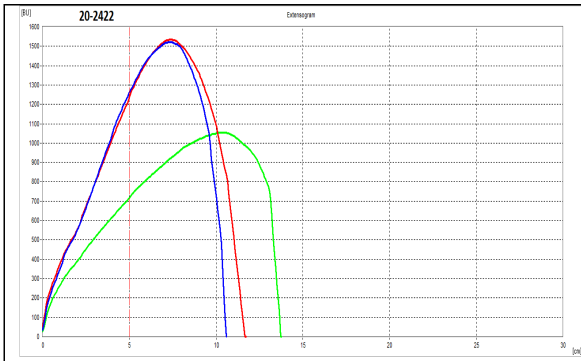


20-2421, OK14124-2
R (BU) = 501, E (mm) = 153, W (cm^2) = 146
Rmax (BU) = 748, Ratio = 3.3 at 90 min

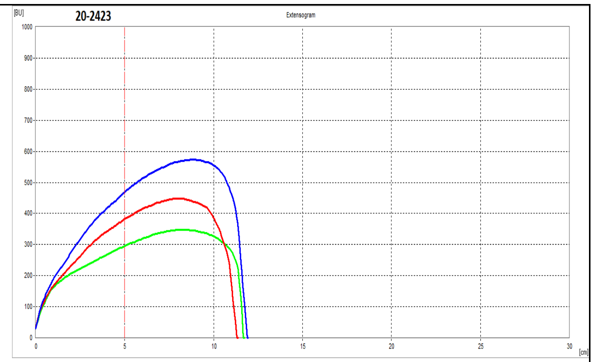
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigraph

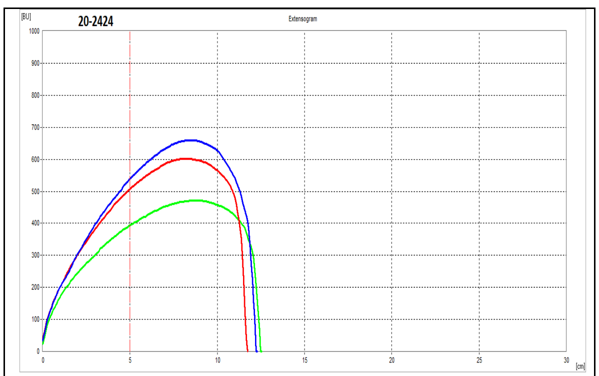
2020 (Small Scale) Samples – Oklahoma



20-2422, OK15MASBx7 ARS8-20
R (BU) = 1247, E (mm) = 118, W (cm^2) = 204
Rmax (BU) = 1534, Ratio = 10.6 at 90 min



20-2423, OK15818
R (BU) = 383, E (mm) = 115, W (cm^2) = 66
Rmax (BU) = 448, Ratio = 3.4 at 90 min

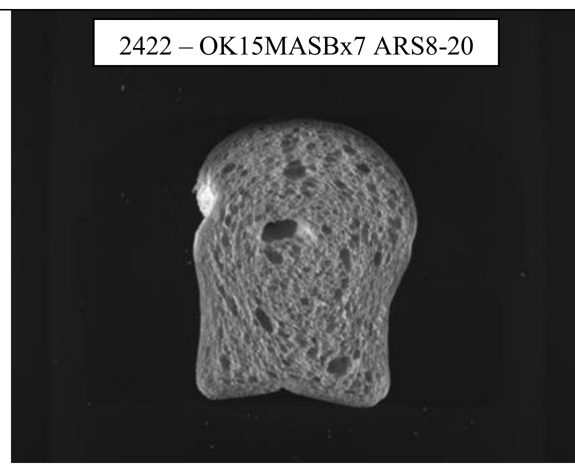


20-2424, OK12716W Comp I
R (BU) = 509, E (mm) = 117, W (cm^2) = 93
Rmax (BU) = 602, Ratio = 4.3 at 90 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

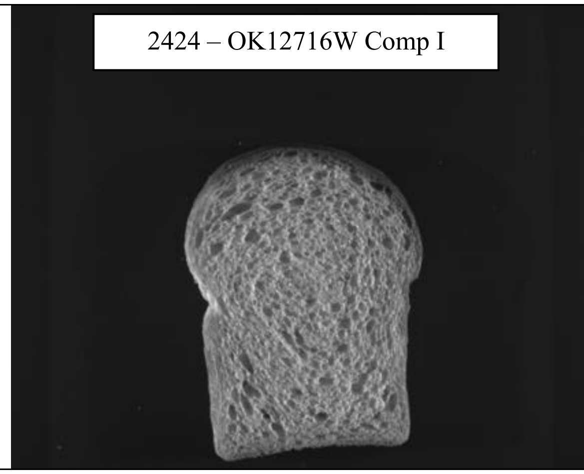
Oklahoma: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples

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})
2419	5646	111	3161	0.436	2.128	1.363	1.728	-5.53
2420	5641	112	3384	0.421	1.955	10.716	1.845	-10.98



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	6265	107	3233	0.441	2.344	4.952	1.839	-5.70
2422	4843	104	2852	0.431	1.926	4.524	1.733	-0.88

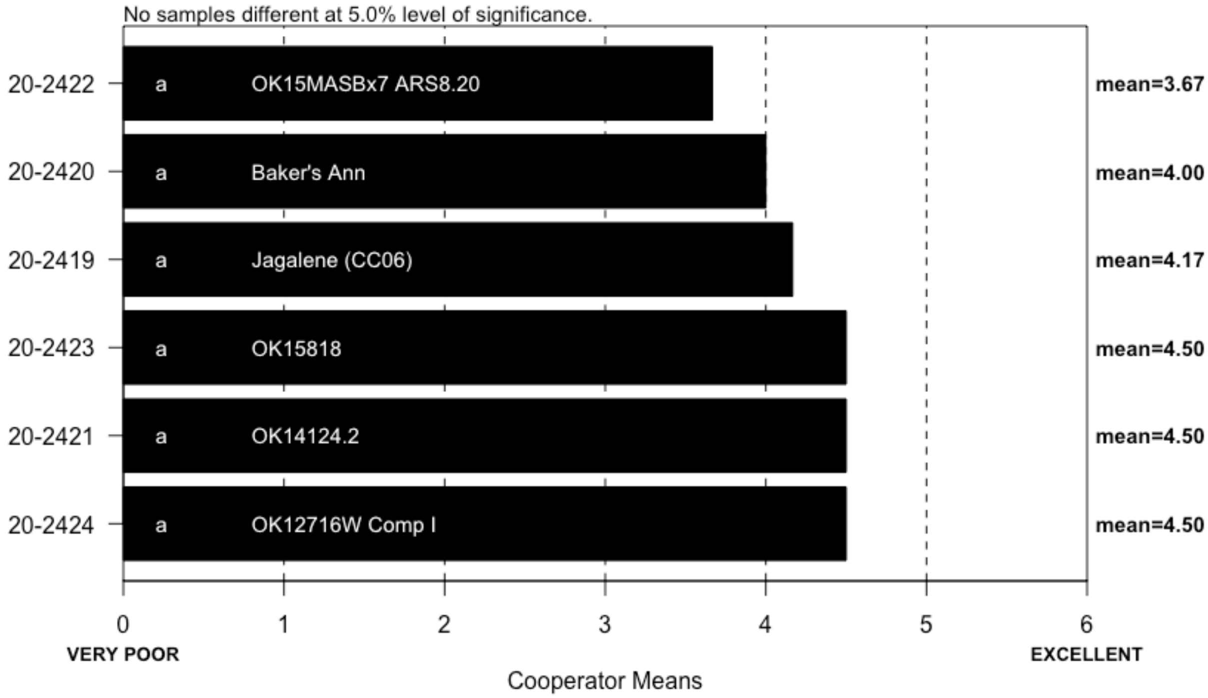
Oklahoma: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples



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})
2423	5536	115	3095	0.437	2.193	0.861	1.771	-0.806
2424	6006	117	3283	0.440	2.193	1.432	1.725	-0.92

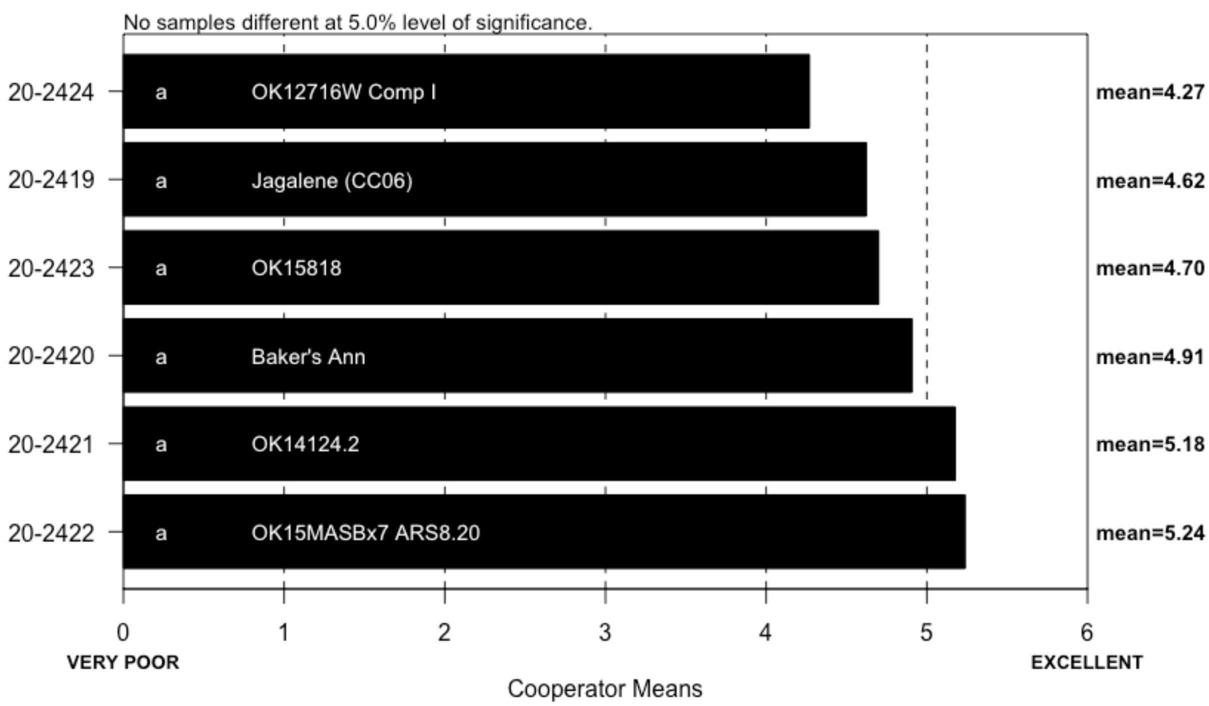
SPONGE CHARACTERISTICS
(Small Scale) Oklahoma

Cooperators = 3
ChiSqCalc = 0.8
ChiSqTab = 11.1
P Value = 0.979



BAKE ABSORPTION
(Small Scale) Oklahoma

Cooperators = 13
ChiSqCalc = 5
ChiSqTab = 11.1
P Value = 0.419

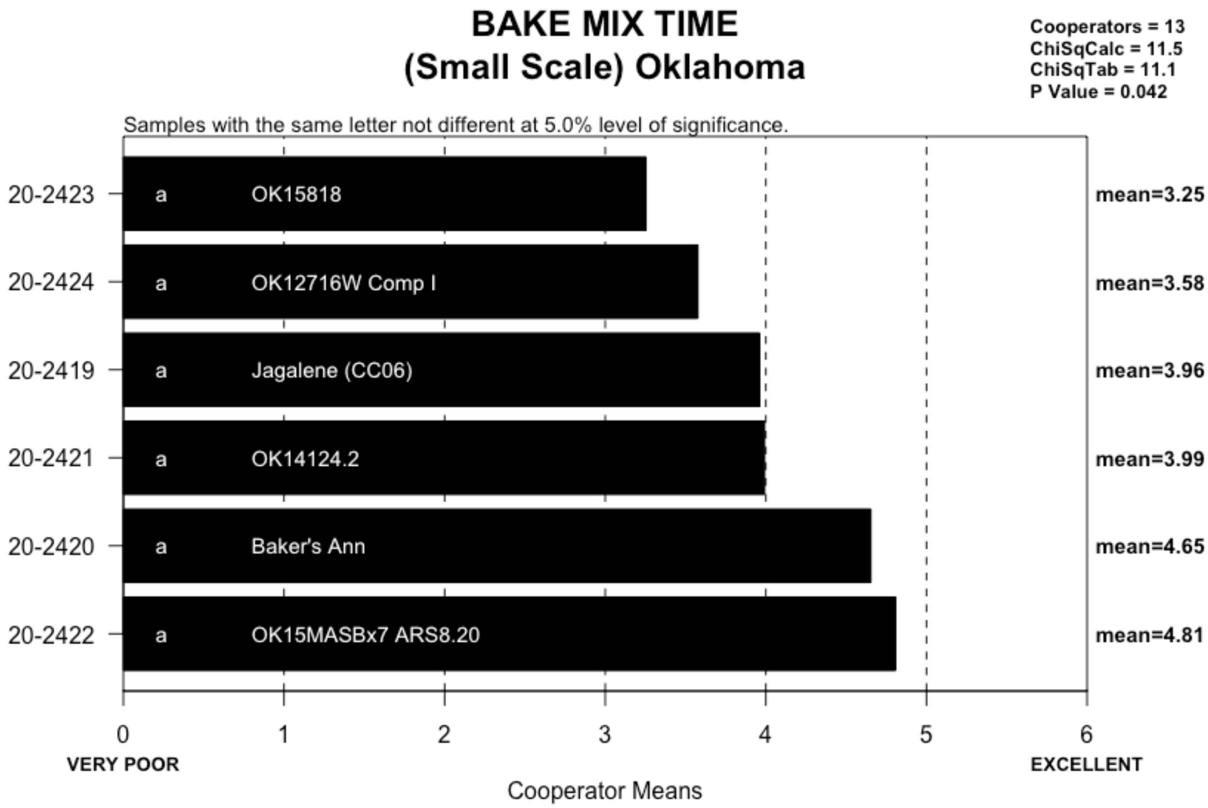


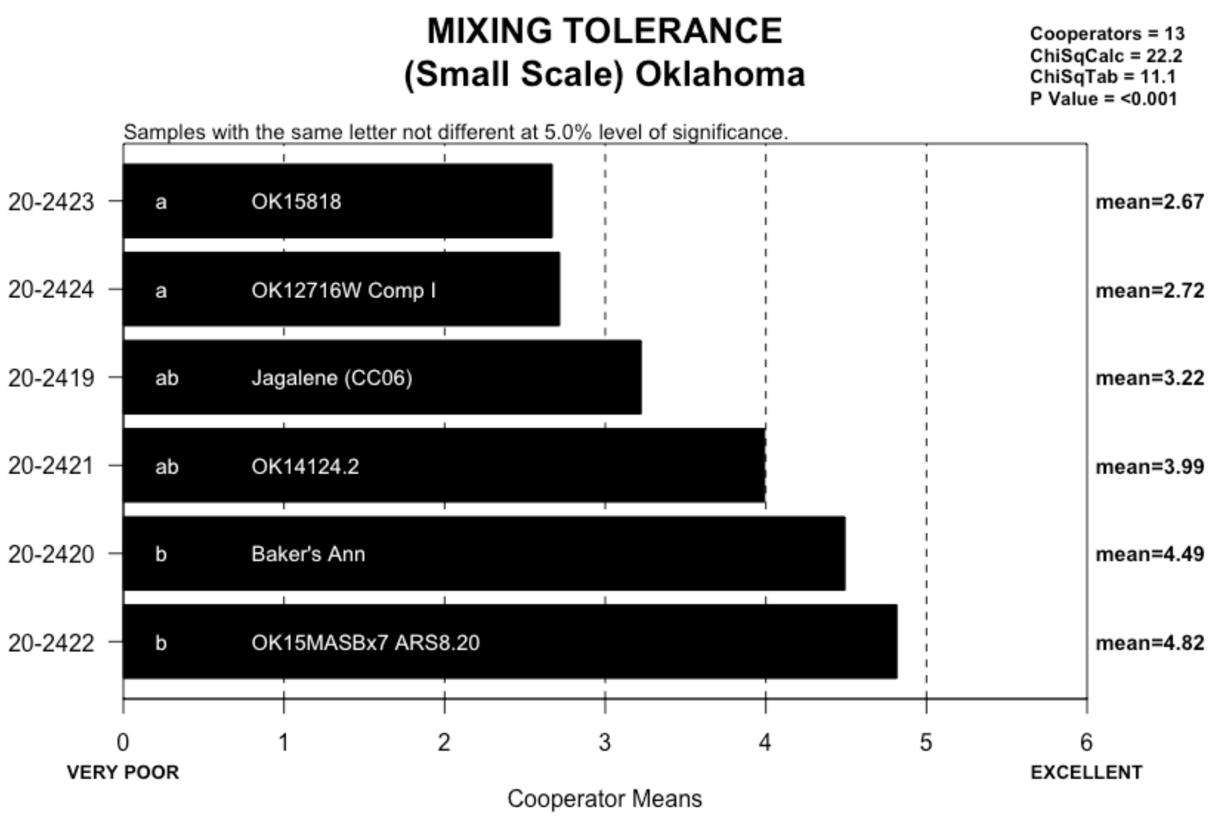
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Oklahoma
Cooperators A – M

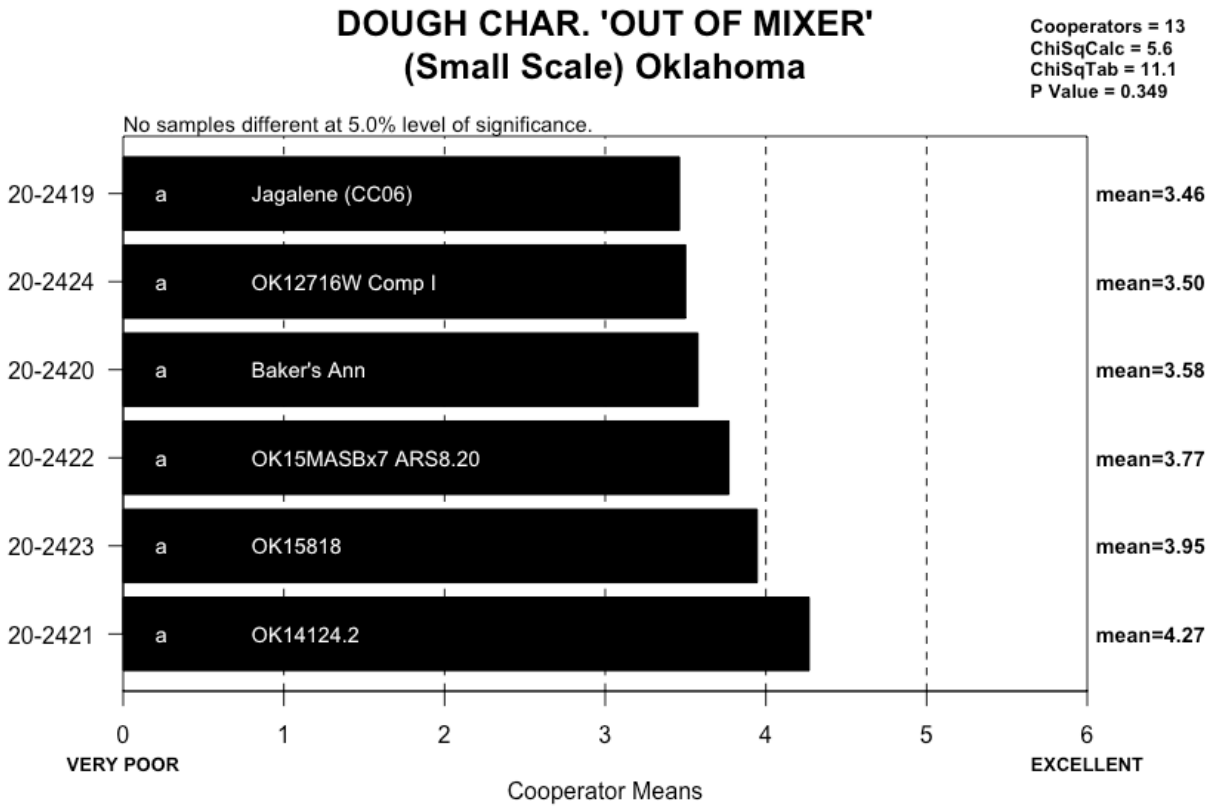
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2419	Jagalene (CC06)	56	77.9	69.5	70.0	61.9	62.1	67.3	67.5	72.0	69.0	61.8	67.2	71.0
20-2420	Baker's Ann	56	76.3	69.9	69.2	64.0	62.8	67.5	67.8	70.1	67.9	62.1	68.0	69.9
20-2421	OK14124-2	58	78.1	72.0	73.3	64.7	63.8	69.1	73.3	71.6	70.6	62.6	70.7	72.6
20-2422	OK15MASBx7 ARS8-20	57	81.9	72.9	72.7	66.0	64.1	71.4	74.8	74.2	73.4	62.1	71.0	75.4
20-2423	OK15818	57	78.3	69.4	69.2	62.6	63.1	66.2	69.7	72.3	71.8	62.0	67.3	73.8
20-2424	OK12716W Comp I	56	74.0	67.5	68.2	60.6	61.0	63.9	66.2	67.4	66.4	62.5	66.0	68.4

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2419	Jagalene (CC06)	9	4.5	5.3	4.5	5.0	7.0	4.5	5.0	4.5	8	4	4.4	10
20-2420	Baker's Ann	15	3.5	7.9	7.8	6.2	14.6	7.3	10.0	9.5	8	7	5.4	20
20-2421	OK14124-2	15	4.3	4.9	4.8	3.5	4.9	4.3	5.0	4.0	8	5	4.0	20
20-2422	OK15MASBx7 ARS8-20	15	3.0	13.0	11.6	7.3	21.8	11.5	15.8	12.5	8	14	10.6	20
20-2423	OK15818	6	4.0	3.8	4.6	4.0	4.3	4.0	4.4	4.3	8	4	3.3	11
20-2424	OK12716W Comp I	6	4.5	4.8	4.5	4.2	6.2	4.5	5.0	4.0	8	4	3.8	10

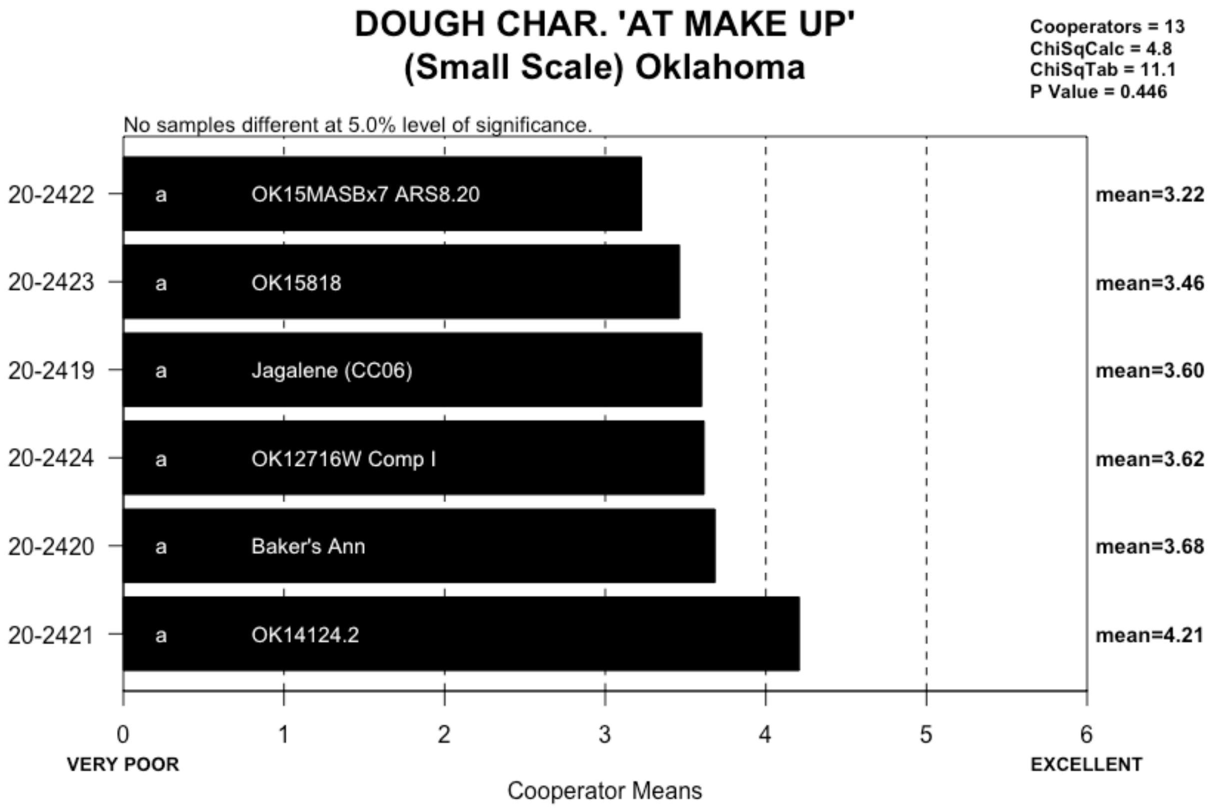

BAKE MIX TIME
(Small Scale) Oklahoma
Cooperators = 13
ChiSqCalc = 11.5
ChiSqTab = 11.1
P Value = 0.042
Samples with the same letter not different at 5.0% level of significance.
20-2423 a OK15818 mean=3.25
20-2424 a OK12716W Comp I mean=3.58
20-2419 a Jagalene (CC06) mean=3.96
20-2421 a OK14124.2 mean=3.99
20-2420 a Baker's Ann mean=4.65
20-2422 a OK15MASBx7 ARS8.20 mean=4.81
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Oklahoma
Cooperators = 13
ChiSqCalc = 22.2
ChiSqTab = 11.1
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2423 a OK15818 mean=2.67
20-2424 a OK12716W Comp I mean=2.72
20-2419 ab Jagalene (CC06) mean=3.22
20-2421 ab OK14124.2 mean=3.99
20-2420 b Baker's Ann mean=4.49
20-2422 b OK15MASBx7 ARS8.20 mean=4.82
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



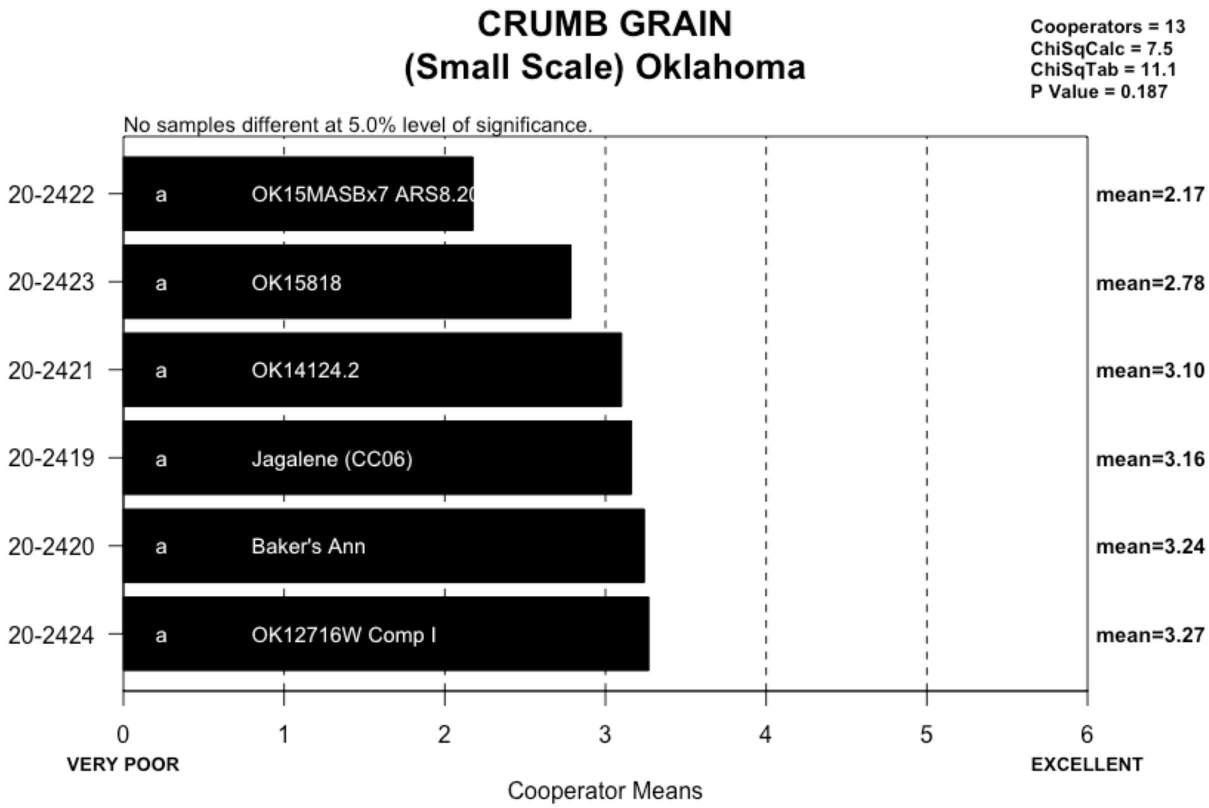
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Oklahoma

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2419	Jagalene (CC06)	1	3	2	7	0
20-2420	Baker's Ann	5	1	2	5	0
20-2421	OK14124-2	0	0	5	8	0
20-2422	OK15MASBx7 ARS8-20	2	2	4	5	0
20-2423	OK15818	2	2	2	7	0
20-2424	OK12716W Comp I	2	2	5	4	0



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2419	Jagalene (CC06)	4	2	2	5	0
20-2420	Baker's Ann	2	1	4	5	0
20-2421	OK14124-2	1	0	5	6	1
20-2422	OK15MASBx7 ARS8-20	1	1	6	4	0
20-2423	OK15818	4	1	0	7	1
20-2424	OK12716W Comp I	3	2	0	8	0

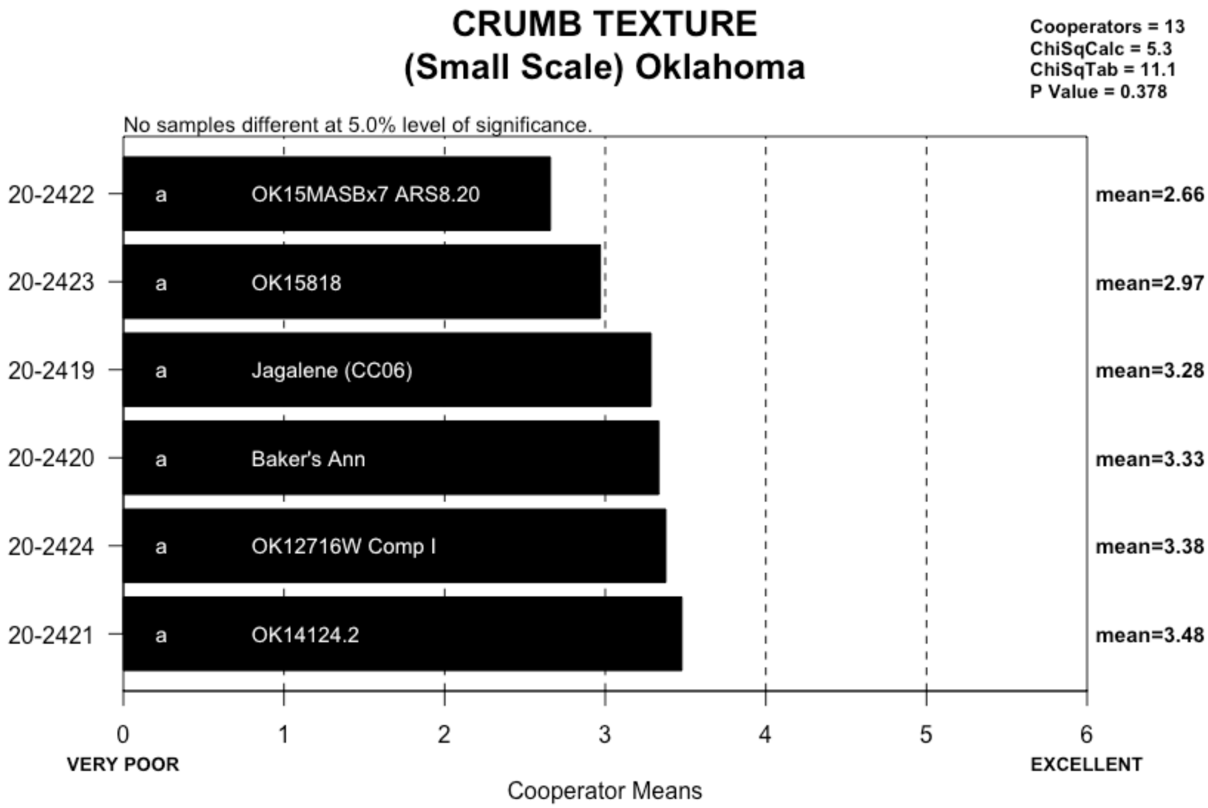


CRUMB GRAIN, DESCRIBED
(Small Scale) Oklahoma

IDCODE	ID	Open	Fine	Dense
20-2419	Jagalene (CC06)	8	5	0
20-2420	Baker's Ann	5	3	4
20-2421	OK14124-2	8	4	1
20-2422	OK15MASBx7 ARS8-20	5	3	4
20-2423	OK15818	9	4	0
20-2424	OK12716W Comp I	6	6	1

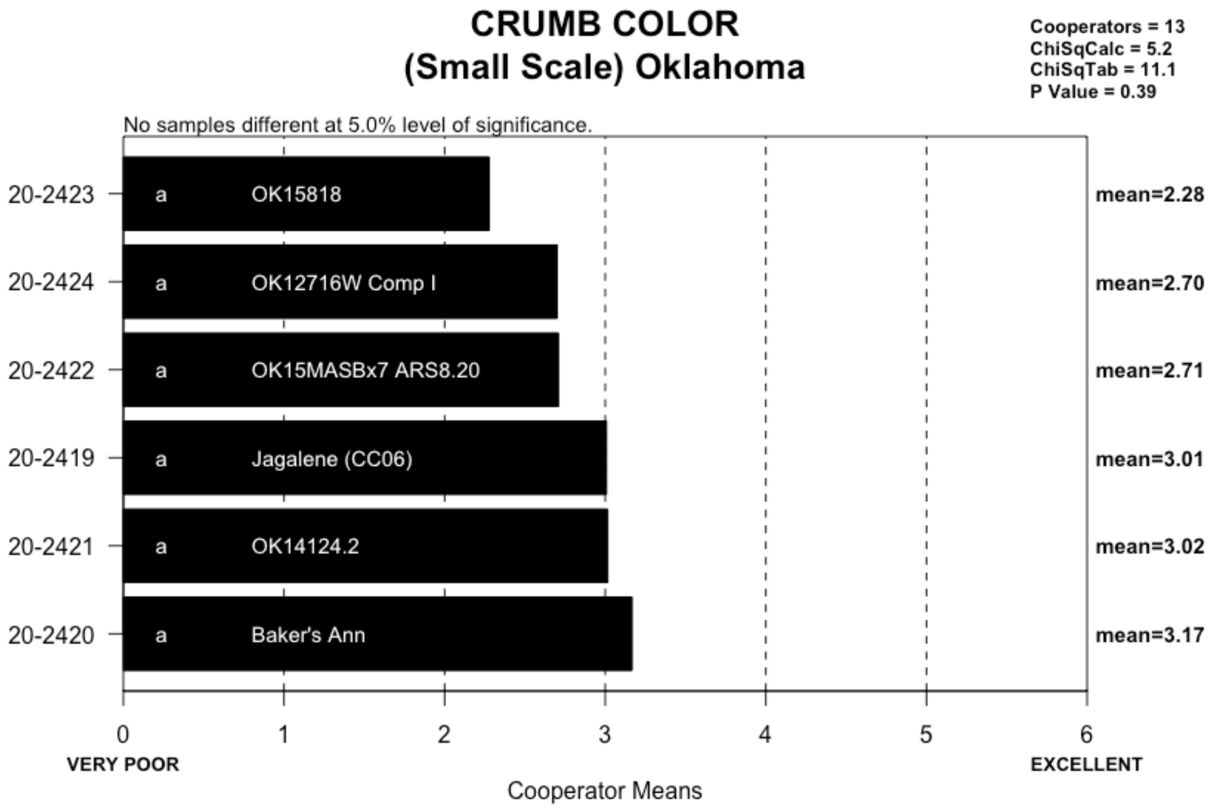
CELL SHAPE, DESCRIBED
(Small Scale) Oklahoma

IDCODE	ID	Round	Irregular	Elongated
20-2419	Jagalene (CC06)	4	6	3
20-2420	Baker's Ann	3	5	4
20-2421	OK14124-2	6	4	3
20-2422	OK15MASBx7 ARS8-20	6	3	3
20-2423	OK15818	4	8	1
20-2424	OK12716W Comp I	6	4	3



CRUMB TEXTURE, DESCRIBED
(Small Scale) Oklahoma

IDCODE	ID	Harsh	Smooth	Silky
20-2419	Jagalene (CC06)	6	6	1
20-2420	Baker's Ann	4	7	1
20-2421	OK14124-2	3	9	1
20-2422	OK15MASBx7 ARS8-20	6	5	1
20-2423	OK15818	6	7	0
20-2424	OK12716W Comp I	4	9	0



CRUMB COLOR, DESCRIBED
(Small Scale) Oklahoma

IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2419	Jagalene (CC06)	0	0	6	2	4	1	0
20-2420	Baker's Ann	0	1	4	2	5	0	0
20-2421	OK14124-2	0	0	5	5	3	0	0
20-2422	OK15MASBx7 ARS8-20	1	1	2	6	2	0	0
20-2423	OK15818	0	3	6	3	1	0	0
20-2424	OK12716W Comp I	0	2	5	2	4	0	0

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2419	Jagalene (CC06)	415	141.9	139.7	153.6	145.0	141.5	142.9	153.6	145	447.4	478.7	146.0	418.1
20-2420	Baker's Ann	410	139.9	138.8	154.3	144.1	140.1	144.5	154.6	145	NA	480.4	144.2	421.8
20-2421	OK14124-2	413	135.9	138.2	153.4	144.7	142.6	145.5	158.1	146	453.6	479.9	148.5	422.2
20-2422	OK15MASBx7 ARS8-20	415	141.7	142.4	155.4	144.8	136.0	144.7	158.4	151	NA	478.9	149.0	422.5
20-2423	OK15818	415	144.8	140.4	156.7	146.5	143.3	146.3	158.0	148	454.0	481.8	150.4	418.1
20-2424	OK12716W Comp I	420	141.7	139.6	149.8	143.8	136.5	145.4	153.3	146	457.0	480.8	147.2	419.6

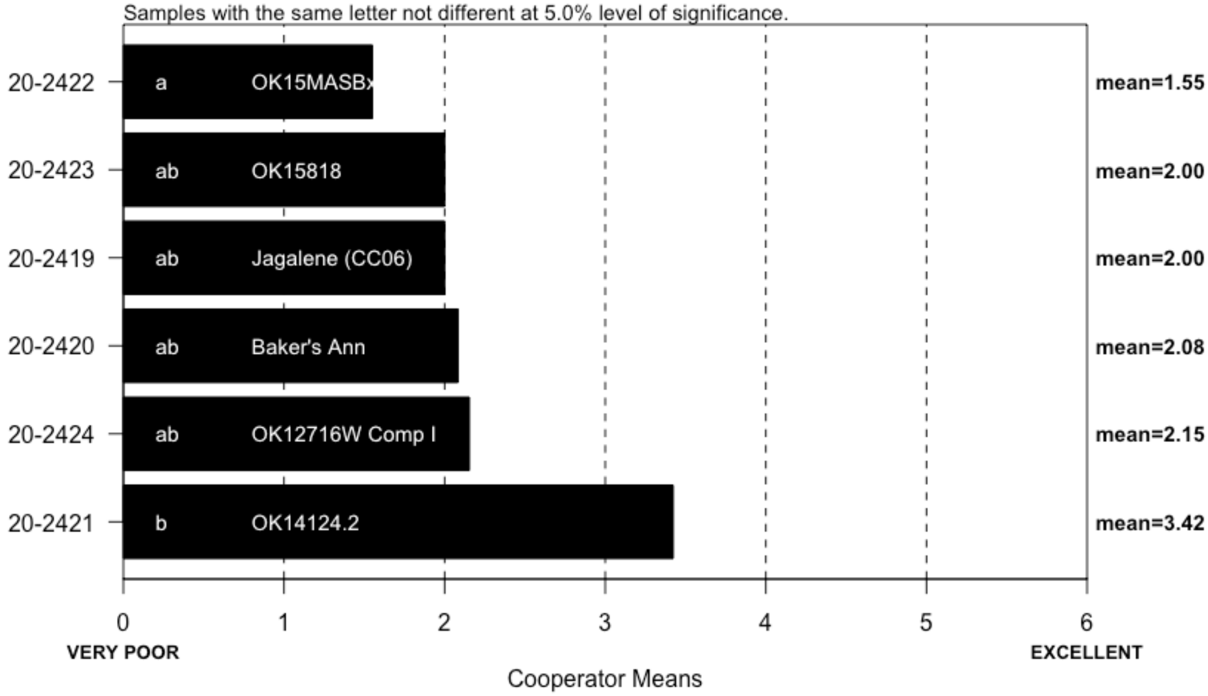
LOAF VOLUME, ACTUAL
(Small Scale) Oklahoma
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2419	Jagalene (CC06)	2675	955	777	795	620	815	840	740	672	2098	2375	775	2300
20-2420	Baker's Ann	2700	725	834	748	685	778	900	720	587	NA	2463	670	2550
20-2421	OK14124-2	2950	820	824	915	785	920	1040	860	799	2307	2513	830	2675
20-2422	OK15MASBx7 ARS8-20	2700	650	706	770	630	731	855	735	535	NA	2438	750	2375
20-2423	OK15818	2550	820	707	735	655	775	835	760	705	2151	2450	730	2325
20-2424	OK12716W Comp I	2500	850	748	795	585	835	800	780	690	2299	2438	790	2525

LOAF VOLUME
(Small Scale) Oklahoma

Cooperators = 13
ChiSqCalc = 13.3
ChiSqTab = 11.1
P Value = 0.021

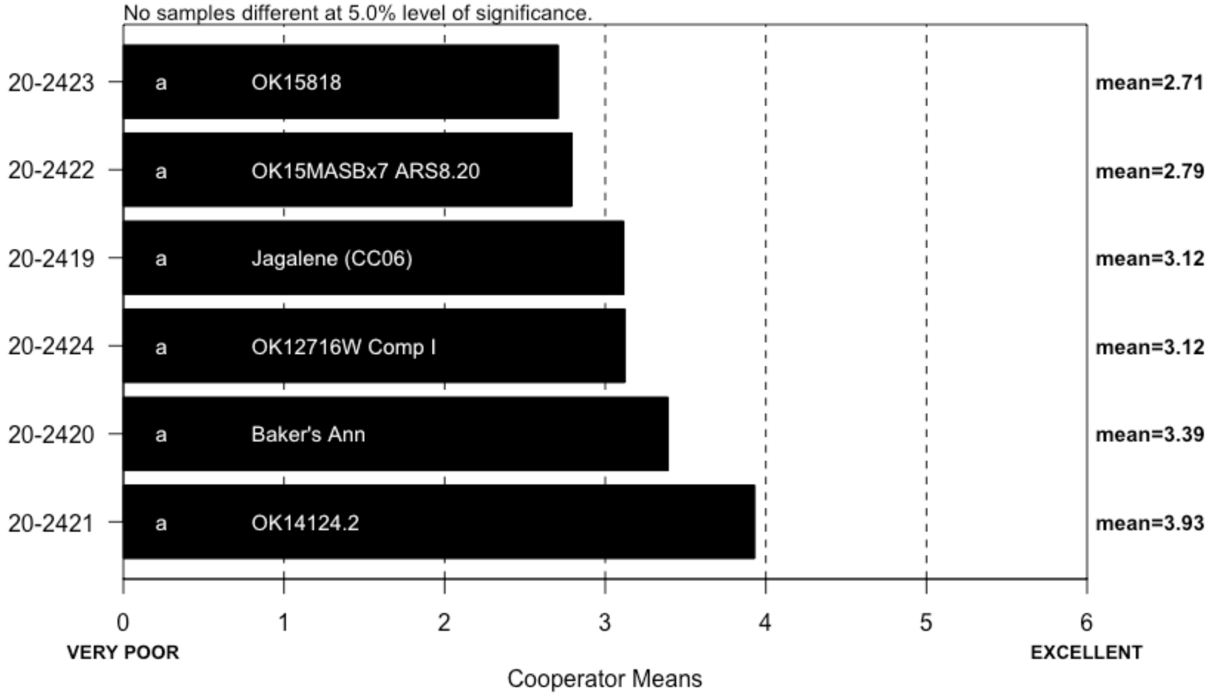
Samples with the same letter not different at 5.0% level of significance.



OVERALL BAKING QUALITY
(Small Scale) Oklahoma

Cooperators = 13
ChiSqCalc = 11
ChiSqTab = 11.1
P Value = 0.05

No samples different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) Oklahoma

COOP. **20-2419 Jagalene (CC06)**

A. No comment.
B. Dark crust color.
C. No comment.
D. Good dough performance for protein level, volume and crumb grain at good level for protein.
E. Protein does not meet target.
F. Normal Protein & Water Abs, Long MT, Slight Sticky & Strong Dough, Fair Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
G. Cap, rough break.
H. Low protein flour, high absorption, poor grain, very low volume.
I. Crumb felt moist and spongy.
J. No comment.
K. Low mixing tolerance, good absorption, avg grain, very low volume.
L. No comment.
M. Low volume and protein, fair mix time, high absorption. Recommend for blending.

COOP. **20-2420 Baker's Ann**

A. No comment.
B. No comment.
C. No comment.
D. Dough performance good for protein level, low bread volume but somewhat on par for protein.
E. Protein does not meet target.
F. Low Protein & Water Abs, Very Long MT, Slight Sticky & Strong Dough, Fair Volume, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Slight cap.
H. Low protein flour, long mix time, high absorption, dense grain, dark yellow crumb, very low volume.
I. Dough toughened up during the baking process, top of the dough split in the pan prior to baking, crumb felt moist and spongy.
J. After 2 minutes in mixer, the dough could not hold together, smeared on sides and bottom, tried twice to make certain it wasn't procedure, could not make it work to continue.
K. Good absorption, avg grain, low volume.
L. No comment.
M. Low protein, high mix time and absorption, good dough notes, fair volume. Recommend for bread application.

COOP. 20-2421 OK14124-2

A. No comment.
B. No comment.
C. No comment.
D. Good dough mixing performance with average bread results.
E. Best in set.
F. High Protein & Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Yellow/brown dough, slight cap.
H. Very high absorption (73%), open grain, avg volume.
I. Poor crumb color.
J. No comment.
K. High absorption, open grain, avg volume.
L. No comment.
M. High mix time and absorption, good protein and volume. Recommend.

COOP. 20-2422 OK15MASBx7 ARS8-20

A. No comment.
B. Very small, dense crumb, dark crust color.
C. No comment.
D. Dough mixing performed well but bread performance very marginal for protein level.
E. Long mix time.
F. High Protein & Water Abs, Too Long MT, Sticky & Strong Dough, Low Volume, Dull Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
G. Long time to pick up, brown dough, tough dough, long mix, rough break, undermixed?
H. Very long mix time, very high absorption (75%), dense grain, sticky tough dough at makeup, very low volume.
I. Undesirable mix time, dough broke apart in the sheeter at panning, poor end-product, crumb had a dull brownish hue and felt moist and spongy.
J. After 2 minutes in mixer, the dough could not hold together, smeared on sides and bottom, could not make it work to continue baking.
K. Long mix time, good absorption, open grain, very tough dough, low volume.
L. No comment.
M. Huge absorption, good protein and dough notes but low volume.

COOP. 20-2423 OK15818

A. No comment.
B. Poor crumb color.
C. No comment.
D. Dough mixing performed well but bread performance very marginal for protein level.
E. Protein does not meet target.
F. Medium Protein & Water Abs, Medium MT, Slight Sticky & Strong Dough, Fair Volume, Yellow Crumb, Open Irregular Cells, Soft Resilient & Slightly Harsh Texture.
G. No comment.
H. High absorption, open grain, dark yellow crumb, very low volume.
I. No comment.
J. No comment.
K. Low mixing tolerance, good absorption, avg grain, dark yellow crumb, low volume.
L. No comment.
M. Huge absorption, low protein, low volume and mix time, flat top, and small loaf. Do not recommend.

COOP. 20-2424 OK12716W Comp I

A. No comment.
B. No comment.
C. No comment.
D. Good dough performance for low protein level, bread performance also at fairly good level for low flour protein.
E. Protein does not meet target.
F. Low Protein & Water Abs, Long MT, Slight Sticky & Strong Dough, Medium Volume, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Rough break.
H. Low protein flour, high absorption, open grain, dark yellow crumb, very low volume.
I. Good dough performance considering the low flour protein content, crumb felt spongy.
J. No comment.
K. Low mixing tolerance, high absorption, open grain, dark yellow crumb, wet doughs at makeup, low volume.
L. No comment.
M. High absorption, very low protein, fair mix time and volume, overall a nice sample. Recommend.

Notes: **A, K, and M** conducted sponge and dough bake tests

MONTANA

20-2425	Jagalene (CC07)
20-2426	Yellowstone
20-2427	MTCL1737
20-2428	MT1745

Description of Test Plots and Breeder Entries

Montana – Phil Bruckner / Jim Berg / Peggy Lamb

Growing Locations & Conditions

In 2020, Montana opted out of the Northern WQC Grow Out, and blended samples, in equal amounts, from both Havre (Northern Ag Research Center) and Bozeman (Post Agronomy Farm.

Data in the table below is from the Havre location:

2020 Havre, MT WQC Growout						
	Yield	Test Wt	Heading	Plant Ht	Sawfly	Protein
Entry Name	bu/a	lb/bu	day	inches	% cut	%
Jagalene	**58.7**	**63.5**	**5-Jun-20**	**25**	**39**	**14.4**
Yellowstone	**63.2**	**61.9**	**8-Jun-20**	**28**	**36**	**14.7**
MT1745	**61.5**	**62.6**	**9-Jun-20**	**25**	**16**	**13.7**
MTCL1737	**63.8**	**61.9**	**11-Jun-20**	**23**	**15**	**14.7**
Seeded: Sept 25, 2019			Seeding to Harvest Rainfall = 9.21"			
Harvested: July 31, 2020						

The Bozeman WQC drill strips were planted on October 8, 2019 and harvested on August 26, 2020. Then Bozeman strips were planted into above average fall soil moisture (and below average temperatures, which further delayed planting for the bulk of our breeding program). There was normal snow cover during winter months and no winterkill was observed (December and January temperatures were well above normal). Temperatures from February to August were average. After a wet fall, the 2020 crop year had below average spring precipitation, in all months, except June.

The Montana Intrastate Winter Wheat Test (varieties and elite lines, planted in another field), which includes Montana lines grown in the WQC drill strips, had yields (average = 89 bu/a, range 62 – 104 bu/a) well below the past 2 years and test weights (average = 62.6 lb/bu, range 59.4 – 64.3 lb/bu) which were comparable to recent years for Bozeman. Proteins at 13.4% (range 11.6 – 15.7%) were well above normal.

MT1745 – a medium to late heading, medium height, hollow stemmed hard red winter wheat line with the pedigree Decade*2 / NI06732. Decade is a 2010 release from MAES and NI06732 is a Nebraska irrigated selection containing Niobrara.

MT1745 has above average yield, above average test weight and average to below average protein. Over 25 location-years, yield of MT1745 was similar to high yielding varieties Northern, Keldin, and LCS Jet and higher yielding than Yellowstone and Decade. MT1745 has above average winter hardiness (similar to Decade) in limited testing in Montana and North Dakota. MT1745 has a medium-late heading date (similar to Yellowstone) and is shorter in height to both Decade and Yellowstone. MT1745 is susceptible to stem rust (Yellowstone is susceptible, while Decade is tolerant) and resistant to stripe rust (Yellowstone is moderately resistant and Decade is highly susceptible). MT745 had low dwarf bunt % infection in Utah tests. MT1745 is Al tolerant.

MT1745 is a medium PPO line with average flour yield and below average flour protein, in MSU tests. Ash is good and lower than Decade and Yellowstone. Mix times are medium-long, similar to most Montana varieties. Mixing tolerance is high. Mix and bake absorption is average. Loaf volume is below average and similar to LCS Jet and SY Monument.

MT1745 will be tested for another season before a decision is made on release.

<u>MTCl1737</u> – a hollow, 2-gene herbicide resistant Clearfield hard red winter wheat line. MTCL1737 is derived from the cross Yellowstone-2CL /3/ Yellowstone*2 / Pelsart // Promontory / 3*Yellowstone. The herbicide resistant trait donor for this cross is Yellowstone-2CL (= Yellowstone*4 /3/ MTCL01158 / CDC Teal 11A // Jagalene).

MTCL1737 is an average yielding line, with below average test weight and average protein. MTCL1737 has above average winter hardiness and above average yield when winterkill occurs (higher than Yellowstone, Brawl Cl Plus, or SY Clearstone 2CL). MTCL1737 has a late heading date (similar to SY Clearstone 2CL and later than Brawl CL Plus). MTCL1737 is a short line, shorter than both SY Clearstone 2CL and Brawl CL Plus. MTCL1737 is resistant to stem rust and moderately resistant to stripe rust. MTCL1737 had very low dwarf bunt % infection in Utah tests.

MTCL1737 is a medium-low PPO line with average flour yield and flour protein in MSU tests. Ash is above average. Mix times are shorter than most Montana varieties. Mixing tolerance is below average (similar to Brawl Cl Plus). Mix and bake absorptions are average to below average, but better than Brawl Cl Plus. Loaf volume is average (similar to SY Clearstone 2Cl and Brawl CL Plus).

MTCL1737 will be removed from release consideration due to herbicide crop injury concerns.

Montana: 2020 (Small-Scale) Samples

Test entry number	20-2425	20-2426	20-2427	20-2428
Sample identification	**Jagalene (CC07)**	**Yellowstone**	**MTCL1737**	**MT1745**
Wheat Data				
GIPSA classification	1 HRW	1 HRW	1 HRW	1 HRW
Test weight (lb/bu) **Hectoliter weight (kg/hl)**	65.4 85.9	64.5 84.8	64.5 84.8	65.1 85.5
1000 kernel weight (gm)	37.4	36.9	32.3	35.8
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 77.2 22.7 0.1	 79.5 20.4 0.1	 75.4 24.6 0.0	 75.1 24.6 0.3
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	 68.3/16.5 37.4/9.5 2.88/0.38 9.8/0.5 02-08-20-70-01 Hard	 69.1/15.3 36.9/9.2 2.73/0.37 10.1/0.5 01-06-20-73-01 Hard	 68.4/13.4 32.3/7.7 2.68/0.35 9.5/0.6 01-05-21-73-01 Hard	 65.1/15.1 35.8/10.9 2.70/0.40 9.8/0.6 02-08-26-64-01 Hard
Wheat protein (12% mb) **Wheat ash (12% mb)**	14.6 1.30	13.9 1.31	13.7 1.41	13.3 1.33
Milling and Flour Quality Data				
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 77.7 70.1	 76.5 69.8	 77.8 70.1	 77.0 70.4
Flour moisture (%) **Flour protein (14% mb)** **Flour ash (14% mb)**	12.1 13.7 0.54	12.6 13.0 0.47	12.6 12.9 0.54	12.6 12.4 0.47
Rapid Visco-Analyser Peak Time (min) Peak Viscosity (RVU) Breakdown (RVU) Final Viscosity at 13 min (RVU)	 6.1 156.5 51.9 193.8	 6.2 191.8 61.1 233.0	 6.3 190.2 57.4 236.3	 6.2 193.0 51.0 255.1
Minolta color meter L* a* b* **PPO**	 90.66 -1.09 8.69 0.440	 90.64 -1.05 8.29 0.378	 90.37 -1.11 8.97 0.370	 90.85 -1.13 8.44 0.470
Falling number (sec)	381	405	413	442
Damaged Starch (AI%) (AACC76-31)	 98.6 8.4	 98.4 8.2	 98.3 8.2	 98.5 8.3

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

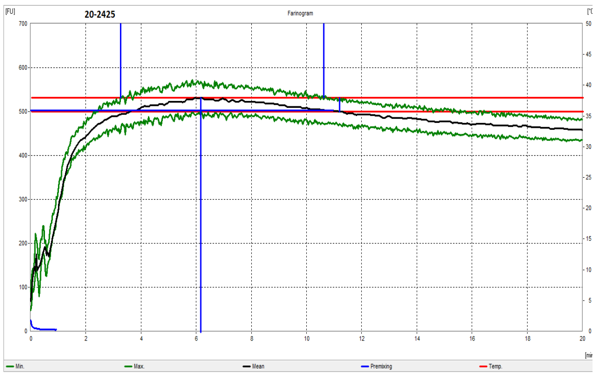
Montana: Physical Dough Tests and Gluten Analysis
2020 (Small-Scale) Samples

Test Entry Number	20-2425	20-2426	20-2427	20-2428
Sample Identification	Jagalene (CC07)	Yellowstone	MTCL1737	MT1745
MIXOGRAPH				
Flour Abs (% as-is)	73.0	72.2	71.0	71.1
Flour Abs (14% mb)	70.8	70.5	69.4	69.5
Mix Time (min)	2.9	7.6	4.6	5.5
Mix tolerance (0-6)	3	6	4	6
FARINOGRAPH				
Flour Abs (% as-is)	73.2	71.2	69.5	68.8
Flour Abs (14% mb)	71.0	69.6	67.9	67.2
Peak time (min)	6.2	5.7	6.2	6.3
Mix stability (min)	7.4	9.3	10.1	11.4
Mix Tolerance Index (FU)	32	32	29	20
Breakdown time (min)	11.0	10.6	11.2	12.1
ALVEOGRAPH				
P(mm): Tenacity	169	161	150	169
L(mm): Extensibility	78	59	61	46
G(mm): Swelling index	19.6	17.1	17.3	15.1
W(10^{-4} J): strength (curve area)	492	410	364	343
P/L: curve configuration ratio	2.17	2.73	2.46	3.67
Ie(P_{200}/P): elasticity index	62.2	68.0	60.4	63.4
EXTENSIGRAPH				
Resist (BU at 45/90/135 min)	237/270/309	610/816/856	361/516/480	515/635/706
Extensibility (mm at 45/90/135 min)	161/154/147	122/102/112	129/126/128	141/134/129
Energy (cm^2 at 45/90/135 min)	70/77/79	117/118/135	75/108/101	131/156/154
Resist $_{max}$ (BU at 45/90/135 min)	316/375/399	782/936/1029	459/685/634	743/970/1001
Ratio (at 45/90/135 min)	1.5/1.8/2.1	5.0/8.0/7.7	2.8/4.1/3.8	3.7/4.8/5.5
PROTEIN ANALYSIS				
HMW-GS Composition	1,2*, 17+18, 5+10	1, 7+8, 5+10	1, 7+9, 5+10	1, 7+9, 5+10
TPP/TMP	0.75	0.79	0.85	0.88
SEDIMENTATION TEST				
Volume (ml)	68.5	70.8	62.0	69.9

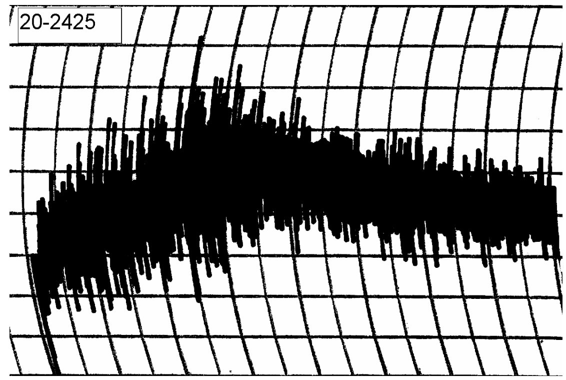
Physical Dough Tests
2020 (Small Scale) Samples – Montana

Farinograms

Mixograms

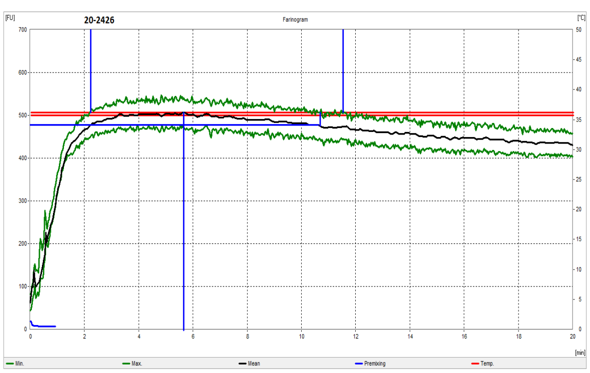


Water abs = 71.0%, Peak time = 6.2 min
Mix stab = 7.4 min, MTI = 32 FU

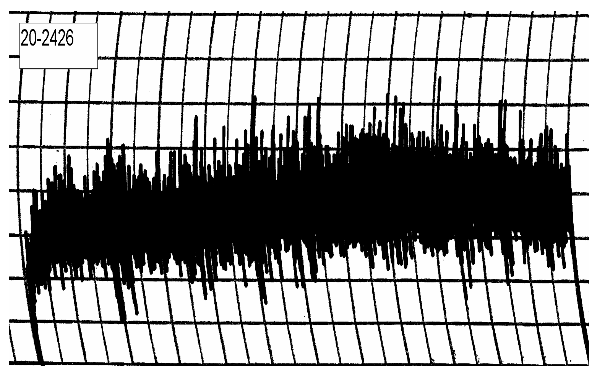


Water abs = 70.8%
Mix time = 2.3 min

20-2425, Jagalene (CC07)



Water abs = 69.6%, Peak time = 5.7 min,
Mix stab = 9.3 min, MTI = 32 FU



Water abs = 70.5%
Mix time = 7.6 min

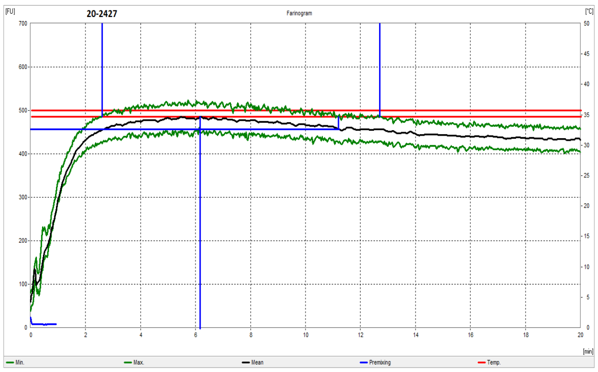
20-2426, Yellowstone

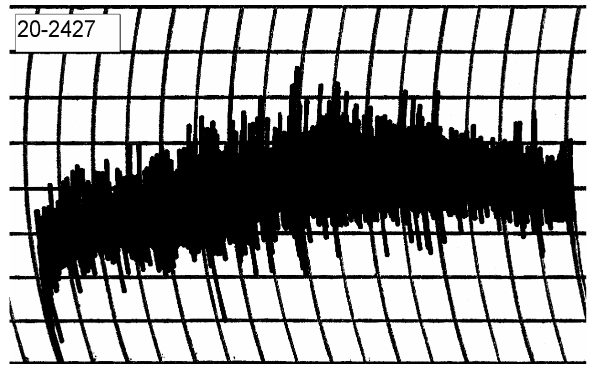
Physical Dough Tests

2020 (Small Scale) Samples – Montana (continued)

Farinograms

Mixograms

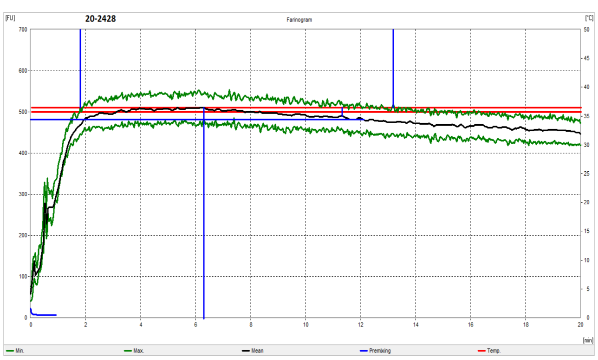


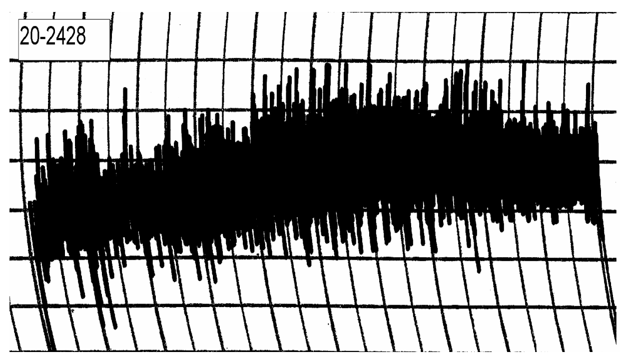


Water abs. = 67.9%, Peak time = 6.2 min,
Mix stab = 10.1 min, MTI = 29 FU

Water abs = 69.4%
Mix time = 4.6 min

20-2427, MTCL1737



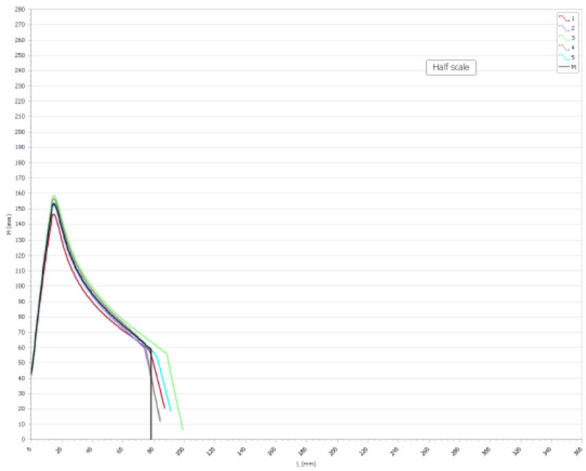


Water abs. = 67.2%, Peak time = 6.3 min,
Mix stab = 11.4 min, MTI = 20 FU

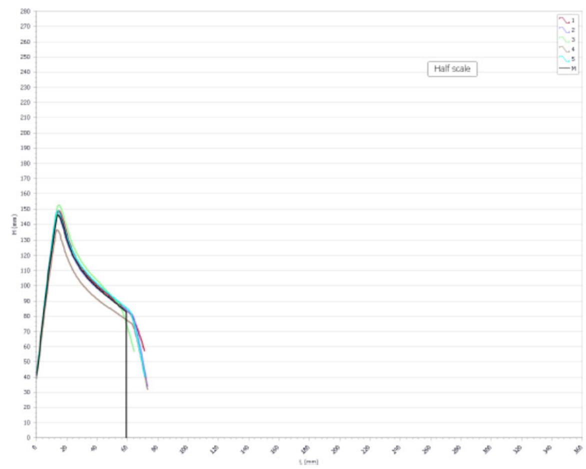
Water abs = 69.5%
Mix time = 5.5 min

20-2428, MT1745

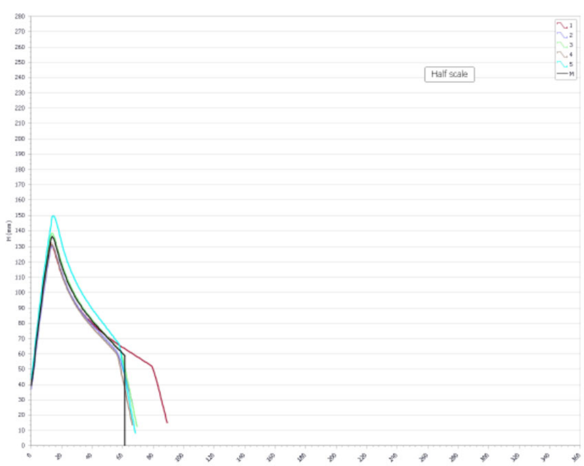
Physical Dough Tests - Alveograph
2020 (Small Scale) Samples – Montana



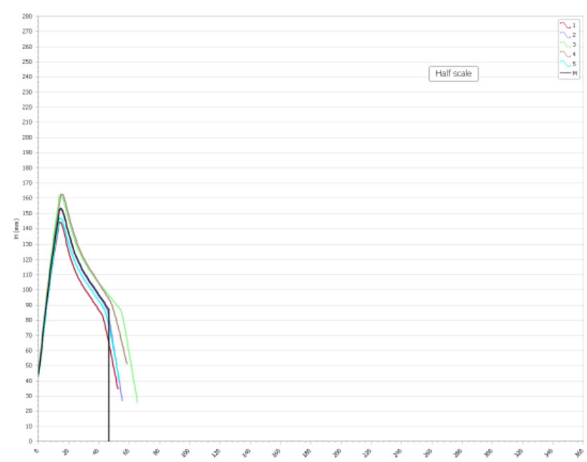
20-2425, Jagalene (CC07)
P (mm H_20) = 169, L (mm) = 78, W ($10E^{-4}J$) = 492



20-2426, Yellowstone
P (mm H_20) = 161, L (mm) = 59, W ($10E^{-4}J$) = 410



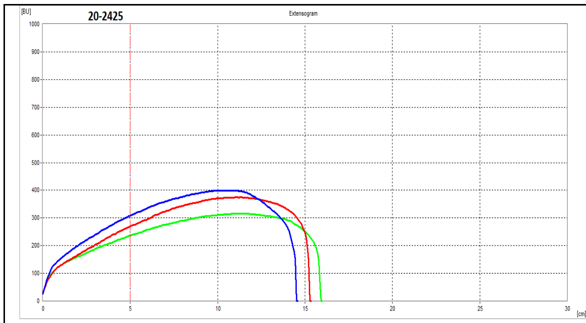
20-2427, MTCL1737
P (mm H_20) = 150, L (mm) = 61, W ($10E^{-4}J$) = 364



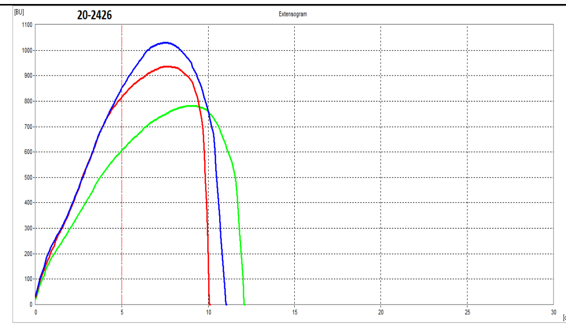
20-2428, MT1745
P (mm H_20) = 169, L (mm) = 46, W ($10E^{-4}J$) = 343

Physical Dough Tests - Extensigraph

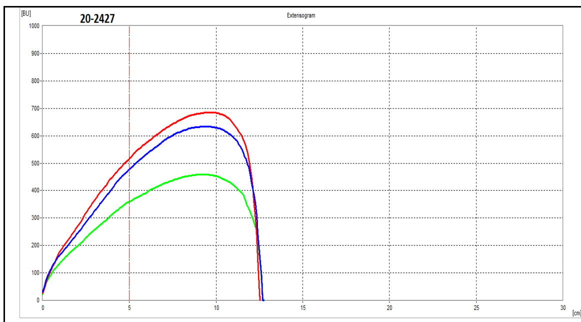
2020 (Small Scale) Samples – Montana



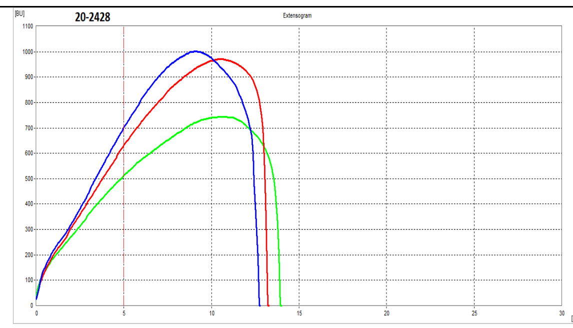
20-2425, Jagalene (CC07)
R (BU) = 270, E (mm) = 154, W (cm^2) = 77
Rmax (BU) = 375, Ratio = 1.8 at 90 min



20-2426, Yellowstone
R (BU) = 816, E (mm) = 102, W (cm^2) = 118
Rmax (BU) = 936, Ratio = 8.0 at 90 min



20-2427, MTCL1737
R (BU) = 516, E (mm) = 126, W (cm^2) = 108
Rmax (BU) = 685, Ratio = 4.1 at 90 min



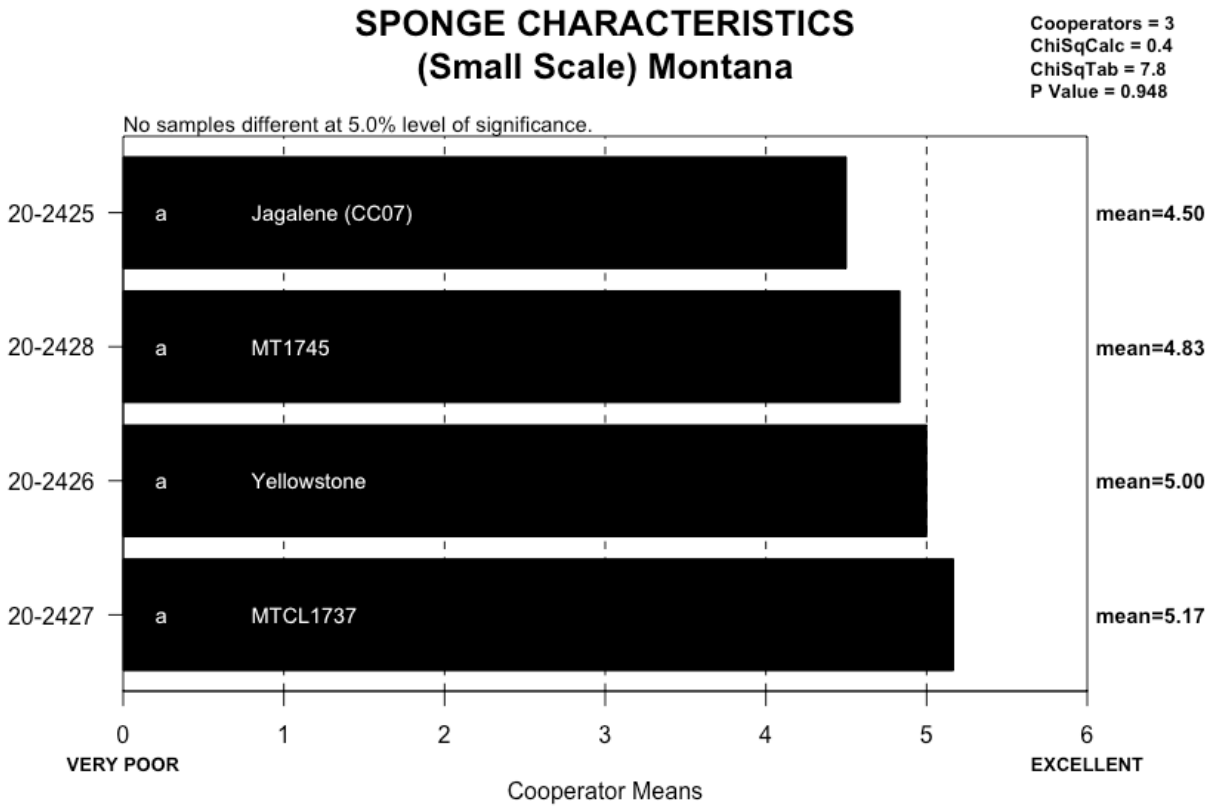
20-2428, MT1745
R (BU) = 635, E (mm) = 134, W (cm^2) = 156
Rmax (BU) = 970, Ratio = 4.8 at 90 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

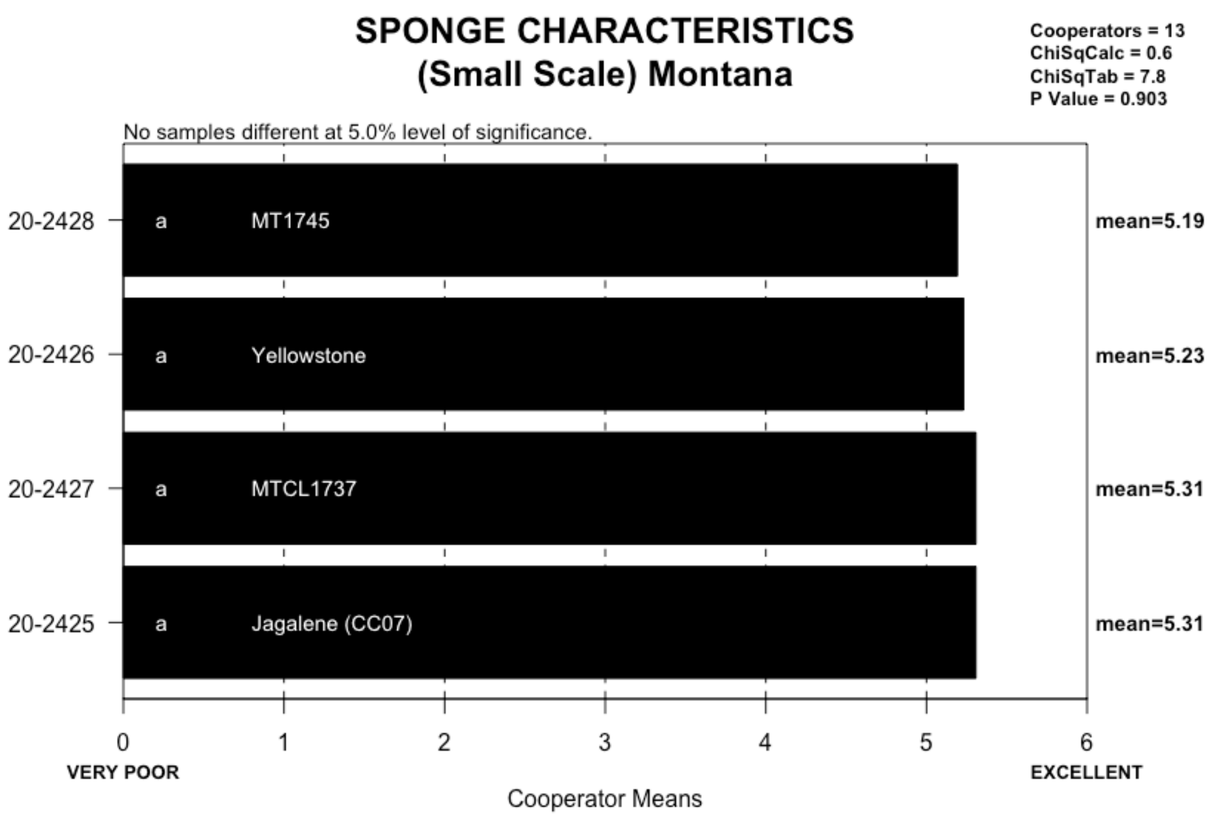
Montana: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples

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})
6295	6295	110	3198	0.450	2.477	1.666	1.754	-0.93
2426	6811	111	3384	0.448	2.447	3.960	1.725	-2.34

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})
2427	6625	111	3421	0.444	2.444	1.326	1.794	-7.25
2428	6278	111	3454	0.430	2.167	5.437	1.792	-7.75



SPONGE CHARACTERISTICS
(Small Scale) Montana
Cooperators = 3
ChiSqCalc = 0.4
ChiSqTab = 7.8
P Value = 0.948
No samples different at 5.0% level of significance.
20-2425
a
Jagalene (CC07)
mean=4.50
20-2428
a
MT1745
mean=4.83
20-2426
a
Yellowstone
mean=5.00
20-2427
a
MTCL1737
mean=5.17
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



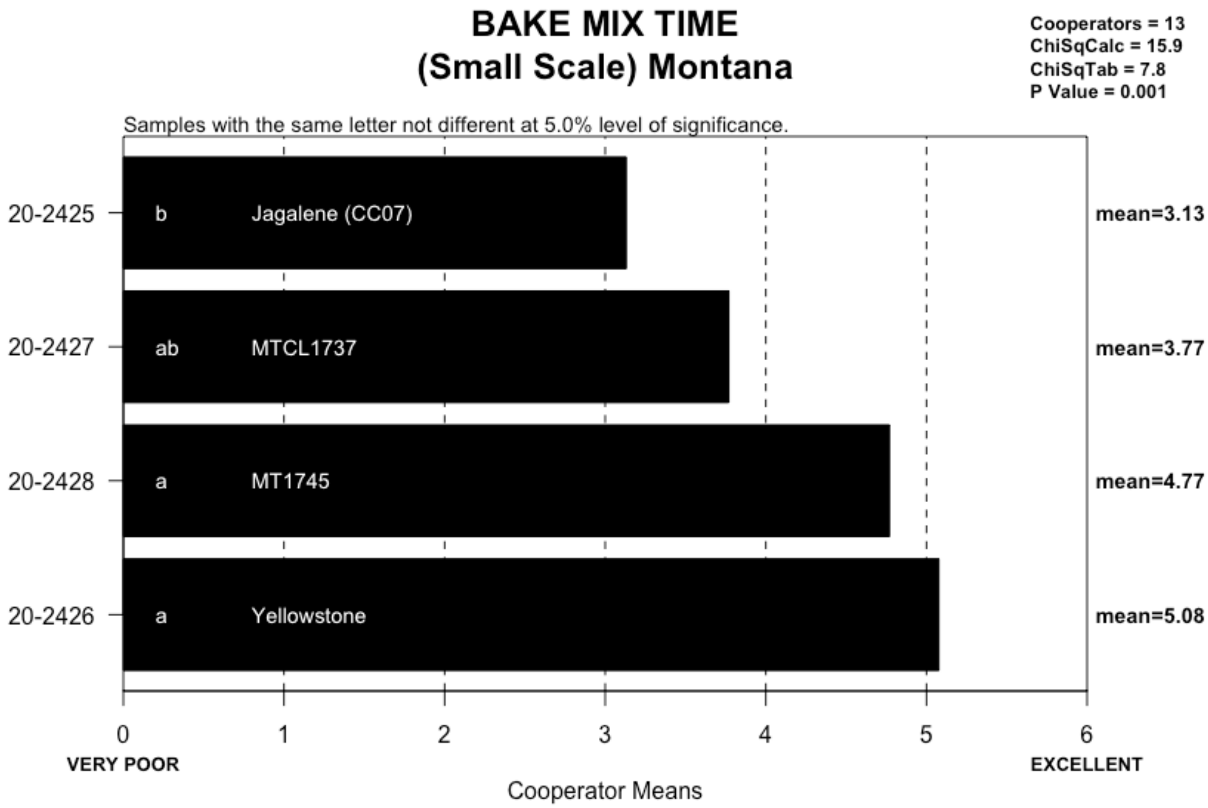
SPONGE CHARACTERISTICS
(Small Scale) Montana
Cooperators = 13
ChiSqCalc = 0.6
ChiSqTab = 7.8
P Value = 0.903
No samples different at 5.0% level of significance.
20-2428
a
MT1745
mean=5.19
20-2426
a
Yellowstone
mean=5.23
20-2427
a
MTCL1737
mean=5.31
20-2425
a
Jagalene (CC07)
mean=5.31
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

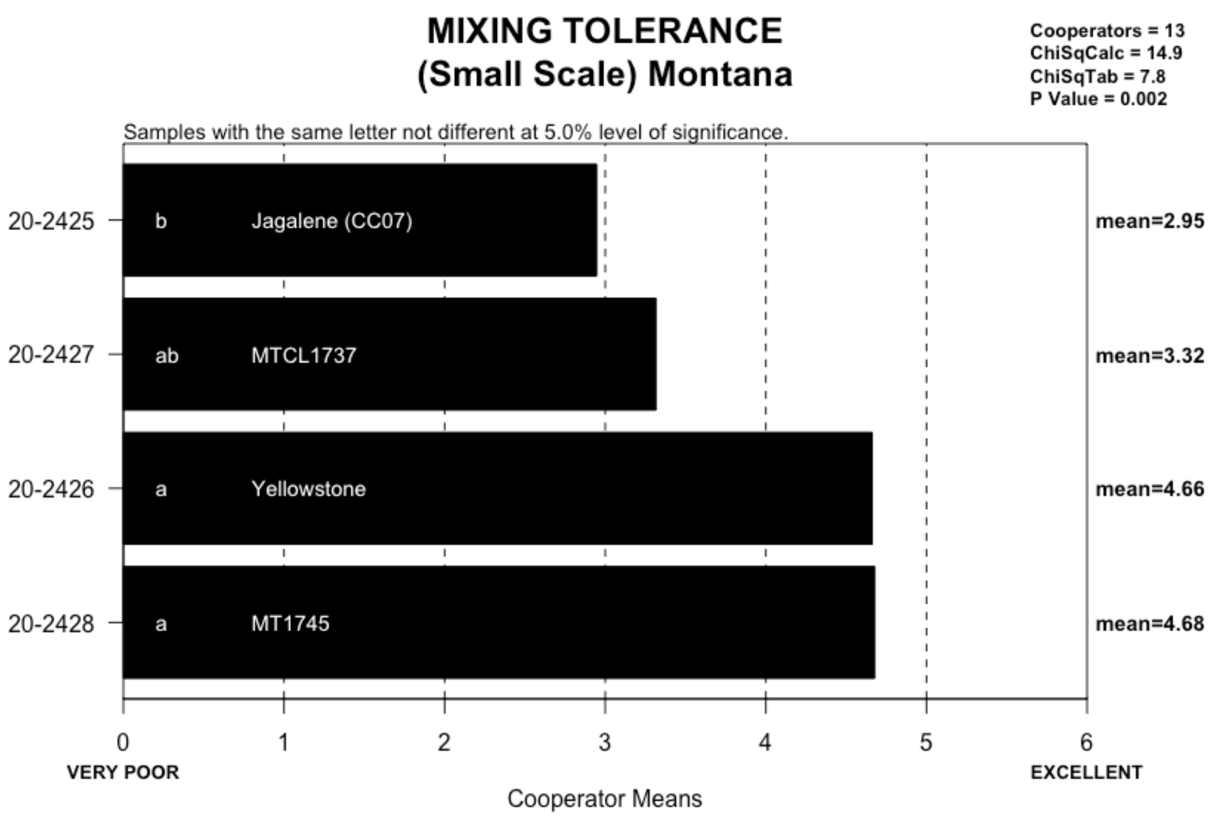
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Montana
Cooperators A – M

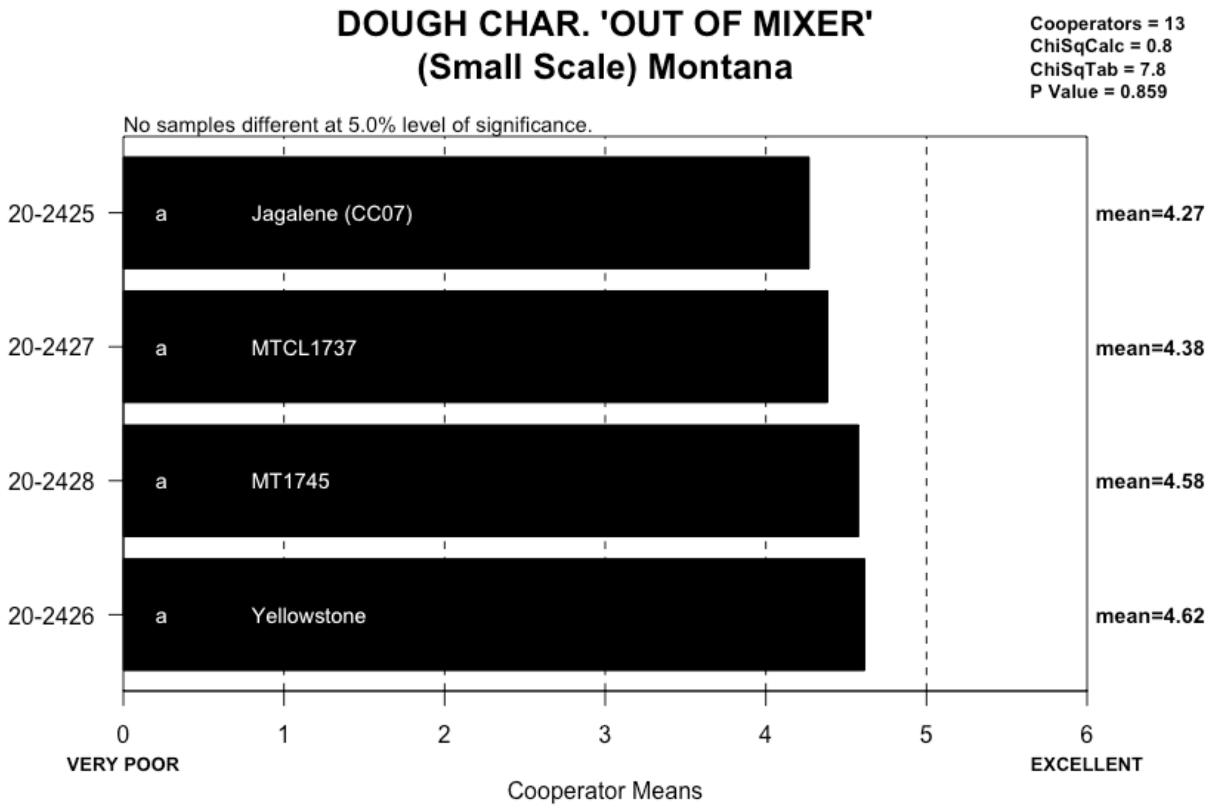
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2425	Jagalene (CC07)	60	74.8	73.1	73.0	67.7	68.0	70.3	72.5	71.5	71.0	61.8	70.8	73.0
20-2426	Yellowstone	59	75.5	72.1	73.6	68.0	66.5	70.6	70.5	70.4	69.6	62.3	70.5	71.6
20-2427	MTCL1737	59	70.6	71.2	71.6	66.2	65.0	68.7	69.1	67.9	67.9	62.4	69.4	69.9
20-2428	MT1745	58	72.9	71.1	72.6	66.0	64.5	67.6	69.1	68.2	67.2	62.4	69.5	69.2

BAKE MIX TIME, ACTUAL
(Small Scale) Montana
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2425	Jagalene (CC07)	7	4	4.0	4.0	3.0	5.2	3.5	4.8	3.8	8	4	2.9	12
20-2426	Yellowstone	15	6	7.0	7.8	6.0	10.3	6.3	9.5	7.5	8	17	7.6	20
20-2427	MTCL1737	7	4	4.5	4.8	4.0	7.0	3.8	5.0	4.5	8	6	4.6	14
20-2428	MT1745	15	5	6.0	7.3	5.5	8.5	6.0	8.0	6.5	8	11	5.5	20

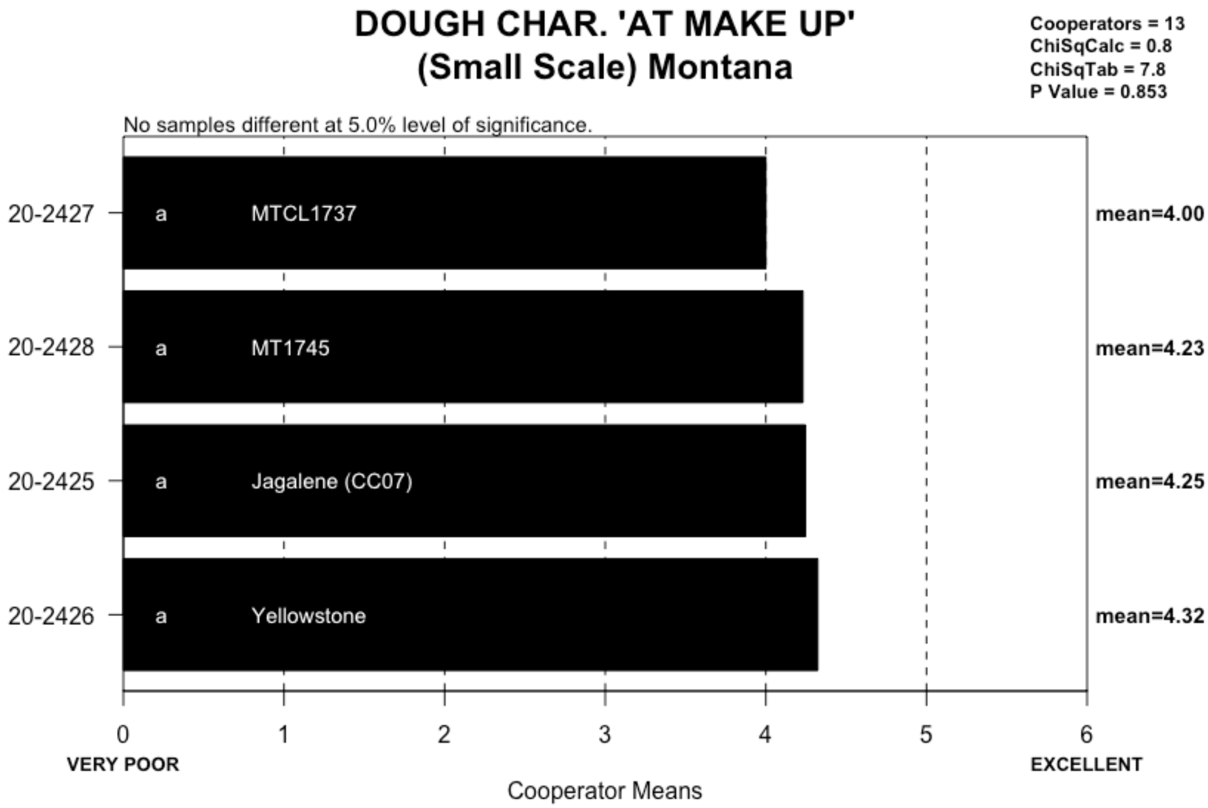

BAKE MIX TIME
(Small Scale) Montana
Cooperators = 13
ChiSqCalc = 15.9
ChiSqTab = 7.8
P Value = 0.001
Samples with the same letter not different at 5.0% level of significance.
20-2425
b
Jagalene (CC07)
mean=3.13
20-2427
ab
MTCL1737
mean=3.77
20-2428
a
MT1745
mean=4.77
20-2426
a
Yellowstone
mean=5.08
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Montana
Cooperators = 13
ChiSqCalc = 14.9
ChiSqTab = 7.8
P Value = 0.002
Samples with the same letter not different at 5.0% level of significance.
20-2425
b
Jagalene (CC07)
mean=2.95
20-2427
ab
MTCL1737
mean=3.32
20-2426
a
Yellowstone
mean=4.66
20-2428
a
MT1745
mean=4.68
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



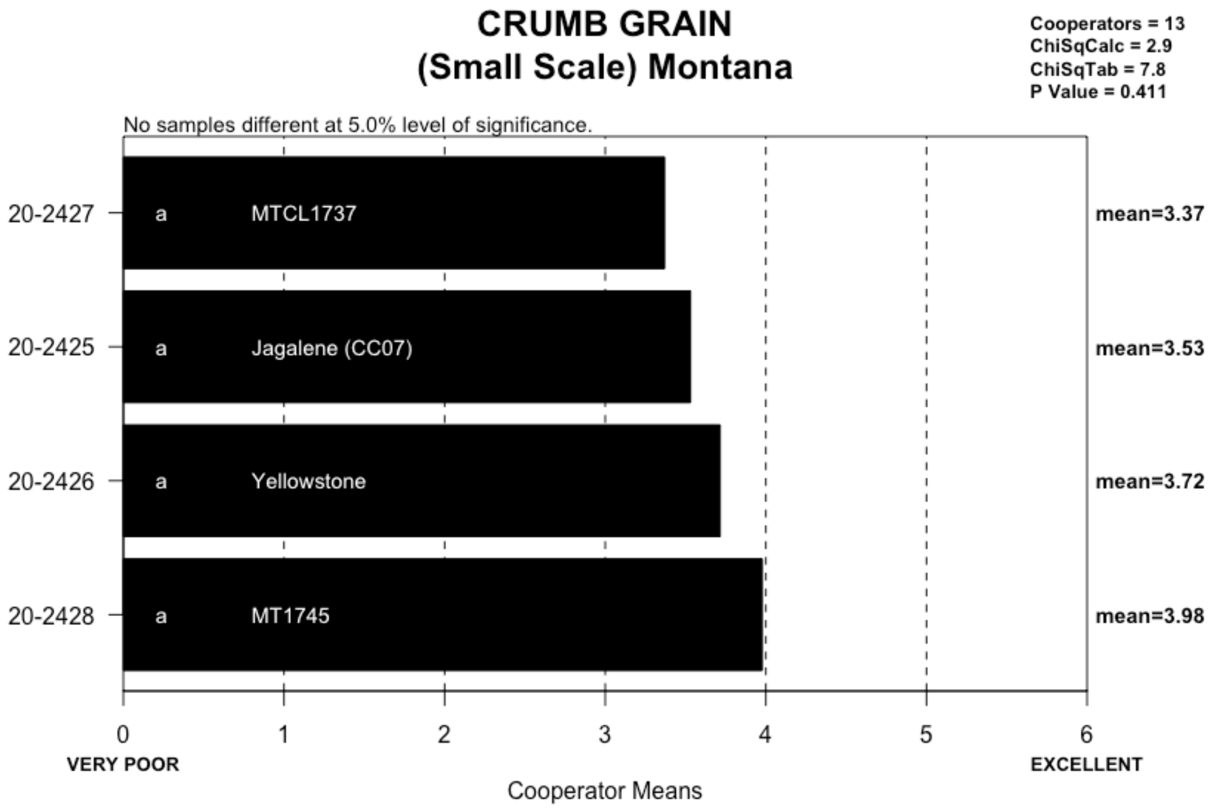
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Montana

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2425	Jagalene (CC07)	0	0	2	10	1
20-2426	Yellowstone	0	0	5	7	1
20-2427	MTCL1737	2	1	2	7	1
20-2428	MT1745	0	0	5	6	2



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2425	Jagalene (CC07)	0	0	2	9	2
20-2426	Yellowstone	0	0	4	7	2
20-2427	MTCL1737	1	1	2	9	0
20-2428	MT1745	1	0	6	4	2

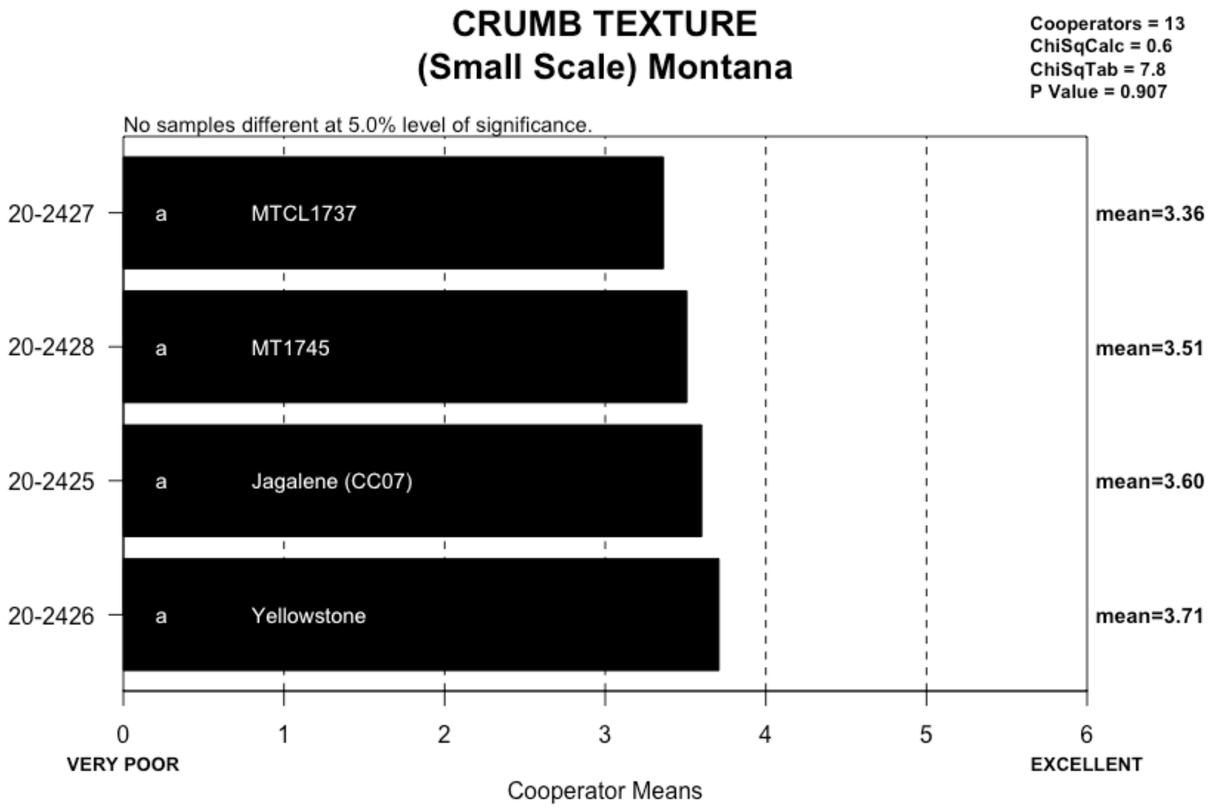


CRUMB GRAIN, DESCRIBED
(Small Scale) Montana

IDCODE	ID	Open	Fine	Dense
20-2425	Jagalene (CC07)	6	6	1
20-2426	Yellowstone	7	6	0
20-2427	MTCL1737	7	6	0
20-2428	MT1745	6	6	1

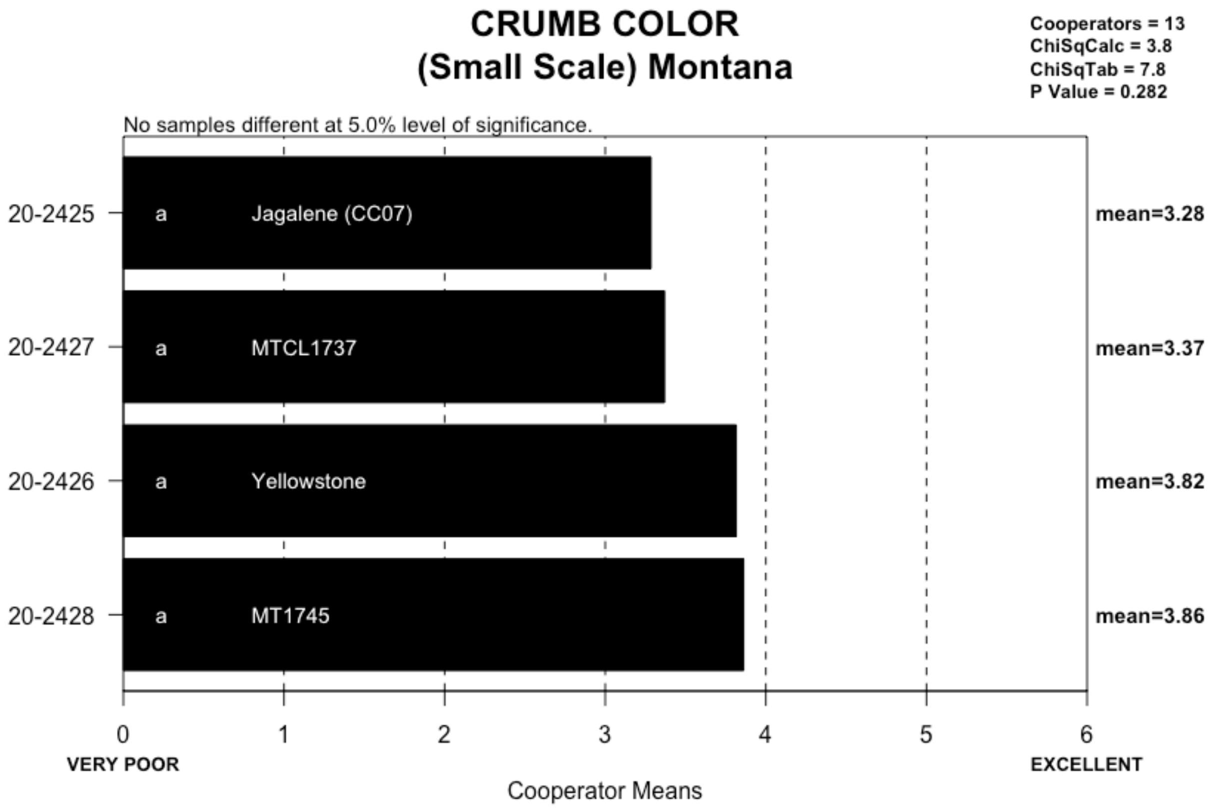
CELL SHAPE, DESCRIBED
(Small Scale) Montana

IDCODE	ID	Round	Irregular	Elongated
20-2425	Jagalene (CC07)	7	3	3
20-2426	Yellowstone	4	5	4
20-2427	MTCL1737	3	6	4
20-2428	MT1745	4	3	6



CRUMB TEXTURE, DESCRIBED
(Small Scale) Montana

IDCODE	ID	Harsh	Smooth	Silky
20-2425	Jagalene (CC07)	3	6	4
20-2426	Yellowstone	3	7	3
20-2427	MTCL1737	2	10	1
20-2428	MT1745	2	10	1



CRUMB COLOR, DESCRIBED
(Small Scale) Montana

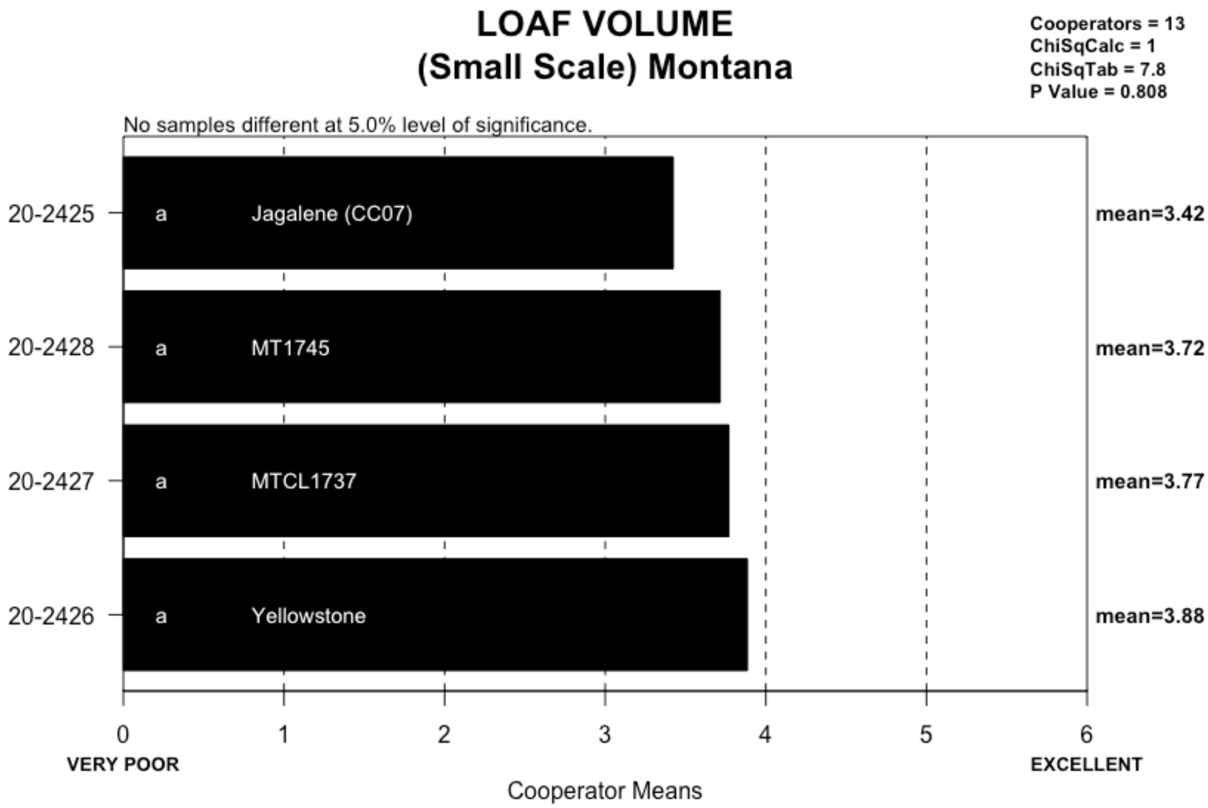
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2425	Jagalene (CC07)	0	1	2	4	5	1	0
20-2426	Yellowstone	0	0	0	5	8	0	0
20-2427	MTCL1737	0	1	2	5	4	1	0
20-2428	MT1745	0	0	1	4	7	1	0

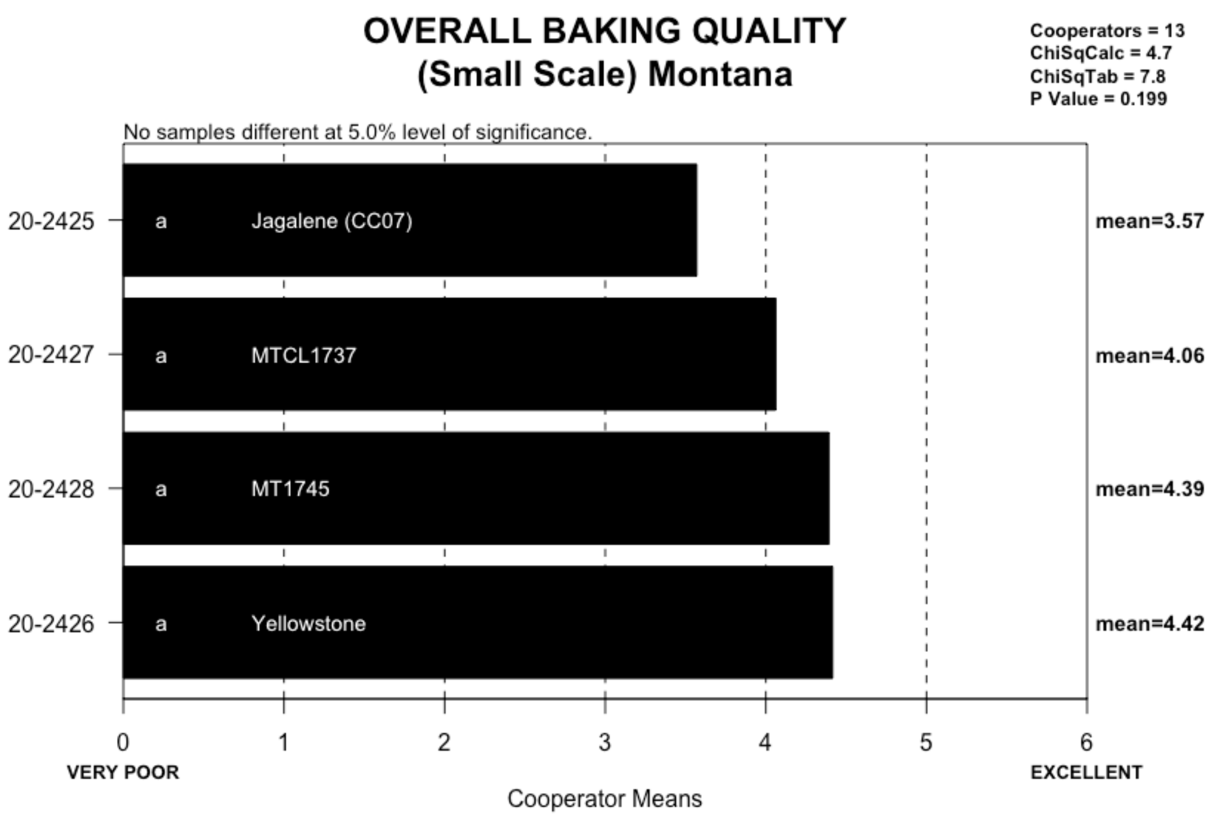
LOAF WEIGHT, ACTUAL
(Small Scale) Montana
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2425	Jagalene (CC07)	417	137.6	137.4	161.6	146.1	141.7	149.6	158.3	147	452.5	478.9	150.0	419.3
20-2426	Yellowstone	414	136.5	137.8	160.8	145.2	137.6	149.5	154.2	146	458.3	479.6	147.0	425.8
20-2427	MTCL1737	415	134.9	137.7	153.8	144.9	138.4	149.3	154.0	143	454.0	479.5	143.5	423.3
20-2428	MT1745	416	136.6	139.2	151.5	144.2	139.7	144.7	153.2	144	457.8	477.7	145.6	422.8

LOAF VOLUME, ACTUAL
(Small Scale) Montana
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2425	Jagalene (CC07)	2750	920	850	820	855	1050	885	930	877	2491	2513	770	2475
20-2426	Yellowstone	2875	940	812	1005	890	928	915	930	836	2246	2563	810	2625
20-2427	MTCL1737	2800	905	859	903	885	950	835	915	841	2426	2538	850	2550
20-2428	MT1745	2750	820	854	905	930	865	970	850	768	2492	2613	710	2775


LOAF VOLUME
(Small Scale) Montana
Cooperators = 13
ChiSqCalc = 1
ChiSqTab = 7.8
P Value = 0.808
No samples different at 5.0% level of significance.
20-2425
a
Jagalene (CC07)
mean=3.42
20-2428
a
MT1745
mean=3.72
20-2427
a
MTCL1737
mean=3.77
20-2426
a
Yellowstone
mean=3.88
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Small Scale) Montana
Cooperators = 13
ChiSqCalc = 4.7
ChiSqTab = 7.8
P Value = 0.199
No samples different at 5.0% level of significance.
20-2425
a
Jagalene (CC07)
mean=3.57
20-2427
a
MTCL1737
mean=4.06
20-2428
a
MT1745
mean=4.39
20-2426
a
Yellowstone
mean=4.42
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Montana

COOP. 20-2425 Jagalene (CC07)

A. No comment.
B. No comment.
C. No comment.
D. Exceptionally poor performance for protein level.
E. Given protein level should have had higher loaf volume.
F. Very High Protein & Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Dark Yellow Crumb, Slightly Open Elongated Cells, Resilient & Very Smooth Texture.
G. Good loaf externals.
H. Very high absorption (73%), open grain, good volume.
I. No comment.
J. No comment.
K. Low mixing tolerance, good absorption, avg grain and volume.
L. No comment.
M. High absorption and protein, lower stability and mix time, volume has room for improvement.

COOP. 20-2426 Yellowstone

A. No comment.
B. No comment.
C. No comment.
D. Dough mix time somewhat long but loaf volume and crumb grain at good levels.
E. Good.
F. Very High Protein & Water Abs, Very Long MT, Slight Sticky & Strong Dough, High Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. Long time to pick up, white dough, good loaf externals.
H. Long mix time, very high absorption (71%), avg grain, tough doughs, good volume.
I. No comment.
J. No comment.
K. Long mix time, good absorption, good grain, creamy crumb, avg volume.
L. No comment.
M. High absorption and protein, lower stability but high mix time, good loaf volume and dough notes. Recommend.

COOP. 20-2427 MTCL1737

A. No comment.
B. No comment.
C. No comment.
D. Dough mixing properties good, loaf volume low with crumb grain generally weaker looking.
E. Good.
F. Very High Protein & Water Abs, Long MT, Sticky & Slightly Strong Dough, High Volume, Dark Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
G. No comment.
H. High absorption, avg grain, good volume.
I. No comment.
J. No comment.
K. Good absorption, avg grain and volume.
L. No comment.
M. High protein and absorption, fair volume and mix time. Recommend.

COOP. 20-2428 MT1745

A. No comment.
B. No comment.
C. No comment.
D. Good dough properties and water absorption, loaf volume and crumb grain at average levels for protein.
E. Best is set.
F. High Protein & Water Abs, Long MT, Sticky & Slightly Strong Dough, High Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
G. Long time to pick up, white dough, excellent loaf externals.
H. Long mix time, high absorption, avg grain and volume.
I. No comment.
J. No comment.
K. Long mix time, very tolerant to mixing, good absorption, avg grain, creamy crumb, good volume.
L. No comment.
M. Good protein and high absorption, great volume, overall a nice sample. Recommend.

Notes: **A, K, and M** conducted sponge and dough bake tests

KANSAS-MANHATTAN

20-2429	**Everest**
20-2430	**Jagalene (CC08)**
20-2431	**KS12DH0156-88**
20-2432	**KS090616K-1**

Description of Test Plots and Breeder Entries

Kansas-Manhattan – Allan Fritz

Everest and Jagalene were used as the local and common check.

KS090049K-8 was released in 2020 as KS Hatchett. The pedigree is Duster//Overley*3/Amadina. It is an early maturing, medium short hard red winter wheat variety with resistance to soil-borne mosaic virus and Hessian fly, tolerance to acid soils and very good leaf rust resistance that appears to is derived from sources of race non-specific resistance. It is moderately susceptible to the newer races of stripe rust and Fusarium head blight. It has yielded 108% of SY Monument over more than thirty site years in central Kansas. Breeding program data would suggest is has good quality, falling between Zenda and SY Monument.

KS12DH0156-88 is an experimental line under consideration for release. It is derived from the cross KS040477K-12/Gallagher. It is a late maturing hard red winter wheat with resistance to soil-borne mosaic virus, moderate resistance to leaf and stripe rust and is susceptible to Fusarium head blight. It has yielded 106% of SY Monument over more than thirty site years in central Kansas. It has demonstrated to the ability to yield extremely well but is less table for yield than KS Hatchett. It's quality profile has been similar to Zenda.

All four samples were grown at Ashland Research Farm near Manhattan, KS in 2020. They were planted no-till after soybeans on October 22, 2019. Twenty-five pounds of actual N was applied at planting in the form of diammonium phosphate. An additional 80 pounds of actual N was applied as a split application in the spring.

Kansas-Manhattan: 2020 (Small-Scale) Samples

Test entry number	20-2429	20-2430	20-2431	20-2432
Sample identification	**Everest**	**Jagalene (CC08)**	**KS12DH0156-88**	**KS090616K-1**
Wheat Data				
GIPSA classification	2 HRW	1 HRW	2 HRW	3 HDWH
Test weight (lb/bu) **Hectoliter weight (kg/hl)**	59.5 78.3	60.8 80.0	59.3 78.0	59.5 78.3
1000 kernel weight (gm)	32.0	34.7	34.7	38.3
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 72.1 27.8 0.1	 79.1 20.5 0.4	 80.7 19.1 0.2	 88.7 11.1 0.2
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	 68.2/17.6 32.0/8.2 2.72/0.32 11.4/0.4 02-09-22-67-01 Hard	 66.9/18.1 34.7/9.8 2.84/0.37 11.7/0.4 02-12-20-66-01 Hard	 65.2/18.4 34.7/9.8 2.79/0.39 11.9/0.4 05-09-27-59-01 Hard	 60.5/16.8 38.3/10.0 2.93/0.34 11.6/0.5 04-16-29-51-01 Hard
Wheat protein (12% mb) **Wheat ash (12% mb)**	14.3 1.91	13.4 1.74	12.4 1.68	13.4 1.78
Milling and Flour Quality Data				
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 75.2 65.6	 77.8 69.2	 76.7 68.6	 75.8 66.3
Flour moisture (%) **Flour protein (14% mb)** **Flour ash (14% mb)**	12.0 12.8 0.75	12.2 12.2 0.71	12.2 11.3 0.66	12.8 12.1 0.66
Rapid Visco-Analyser Peak Time (min) Peak Viscosity (RVU) Breakdown (RVU) Final Viscosity at 13 min (RVU)	 6.5 219.6 62.6 259.1	 6.1 198.4 73.6 231.1	 6.2 200.8 72.9 233.8	 6.0 170.8 84.8 165.9
Minolta color meter L* a* b* **PPO**	 89.42 -0.80 8.12 0.677	 89.48 -0.80 8.27 0.566	 90.13 -1.08 8.37 0.246	 90.75 -1.22 8.44 0.713
Falling number (sec)	412	429	407	327
Damaged Starch (AI%) (AACC76-31)	 97.2 7.2	 98.1 8.0	 97.6 7.6	 96.9 7.0

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Kansas-Manhattan: Physical Dough Tests and Gluten Analysis
2020 (Small-Scale) Samples

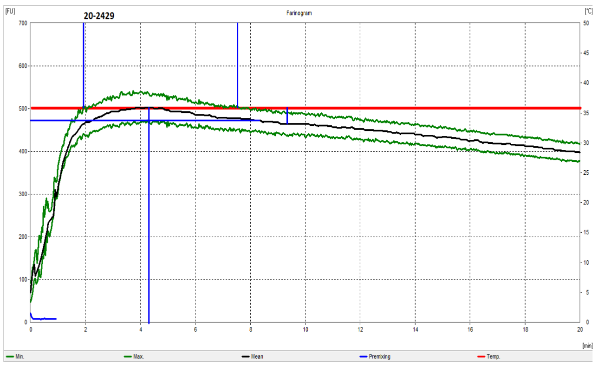
Test Entry Number	20-2429	20-2430	20-2431	20-2432
Sample Identification	Everest	Jagalene (CC08)	KS12DH0156-88	KS090616K-1
MIXOGRAPH				
Flour Abs (% as-is)	68.3	68.3	63.0	66.0
Flour Abs (14% mb)	66.0	66.3	61.0	64.7
Mix Time (min)	2.4	4.5	3.9	5.1
Mix tolerance (0-6)	1	4	3	3
FARINOGRAPH				
Flour Abs (% as-is)	70.1	69.4	65.7	65.8
Flour Abs (14% mb)	67.8	67.3	63.6	64.4
Peak time (min)	4.3	4.3	4.0	3.7
Mix stability (min)	5.6	6.8	8.7	6.1
Mix Tolerance Index (FU)	38	39	25	39
Breakdown time (min)	8.3	8.0	10.5	7.5
ALVEOGRAPH				
P(mm): Tenacity	139	163	130	131
L(mm): Extensibility	39	37	37	57
G(mm): Swelling index	13.9	13.5	13.5	16.8
W(10^{-4} J): strength (curve area)	209	262	198	293
P/L: curve configuration ratio	3.56	4.41	3.51	2.30
Ie(P_{200}/P): elasticity index	0.0	0.0	0.0	56.3
EXTENSIGRAPH				
Resist (BU at 45/90/135 min)	232/275/292	441/490/603	313/354/369	442/576/603
Extensibility (mm at 45/90/135 min)	111/107/106	123/115/117	116/111/111	129/126/121
Energy (cm^2 at 45/90/135 min)	38/43/44	84/88/105	57/61/61	93/116/114
Resist $_{max}$ (BU at 45/90/135 min)	241/290/306	522/610/718	351/410/412	558/757/759
Ratio (at 45/90/135 min)	2.1/2.6/2.8	3.6/4.3/5.1	2.7/3.2/3.3	3.4/4.6/5.0
PROTEIN ANALYSIS				
HMW-GS Composition	1, 7+8, 2+12	1,2* 17+18, 5+10	2*, 7+9, 5+10	2*, 7+8, 5+10
TPP/TMP	0.64	0.79	0.72	0.79
SEDIMENTATION TEST				
Volume (ml)	30.3	42.1	34.8	49.3

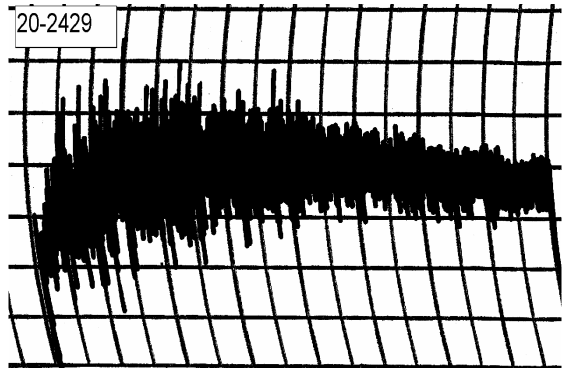
Physical Dough Tests

2020 (Small Scale) Samples – Kansas-Manhattan

Farinograms

Mixograms

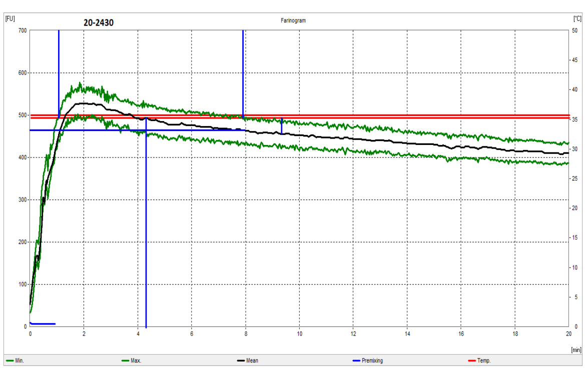


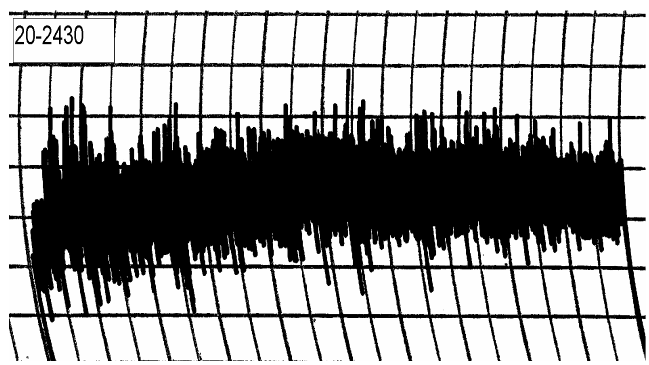


Water abs = 67.8%, Peak time = 4.3 min
Mix stab = 5.6 min, MTI = 38 FU

Water abs = 66.0%
Mix time = 2.4 min

20-2429, Everest





Water abs = 67.3%, Peak time = 4.3 min,
Mix stab = 6.8 min, MTI = 39 FU

Water abs = 66.3%
Mix time = 4.5 min

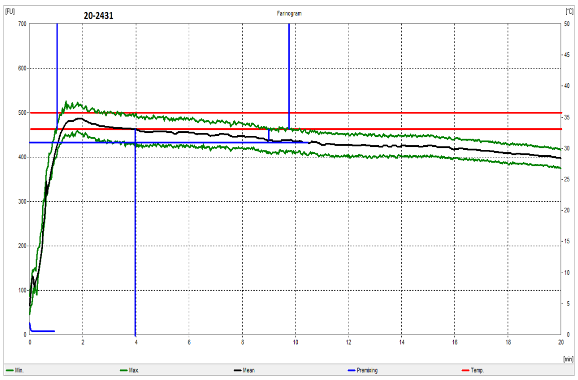
20-2430, Jagalene (CC08)

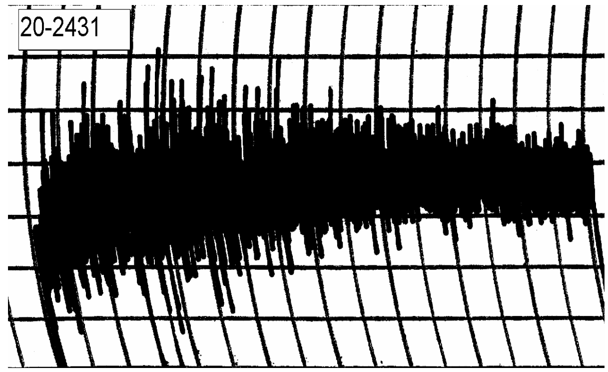
Physical Dough Tests

2020 (Small Scale) Samples – Kansas-Manhattan (continued)

Farinograms

Mixograms

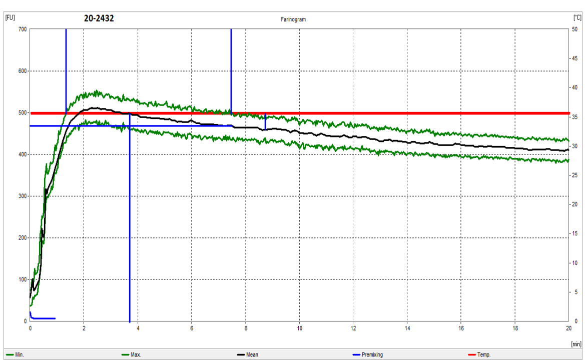


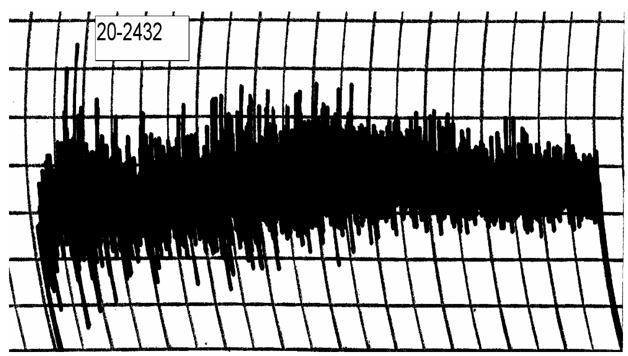


Water abs. = 63.6%, Peak time = 4.0 min,
Mix stab = 8.7 min, MTI = 25 FU

Water abs = 61.0%
Mix time = 3.9 min

20-2431, KS12DH0156-88



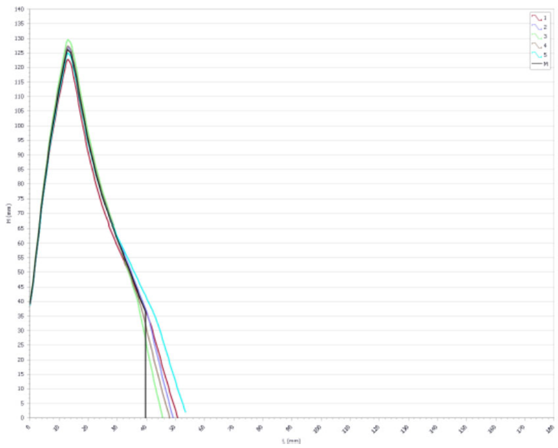


Water abs. = 64.4%, Peak time = 3.7 min,
Mix stab = 6.1 min, MTI = 39 FU

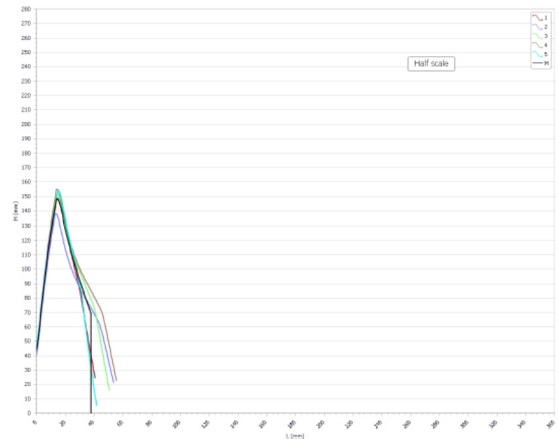
Water abs = 64.7%
Mix time = 5.1 min

20-2432, KS090616K-1

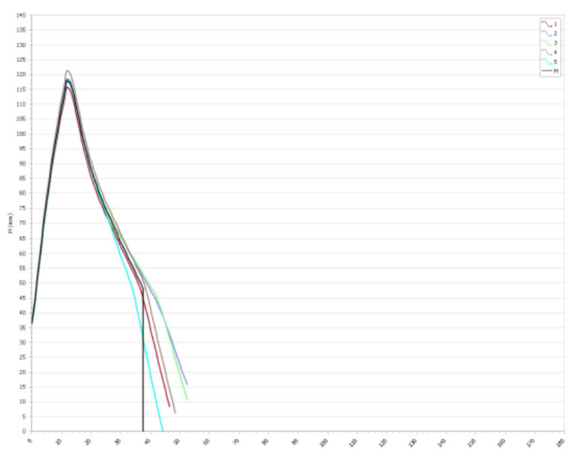
Physical Dough Tests - Alveograph
2020 (Small Scale) Samples – Kansas-Manhattan



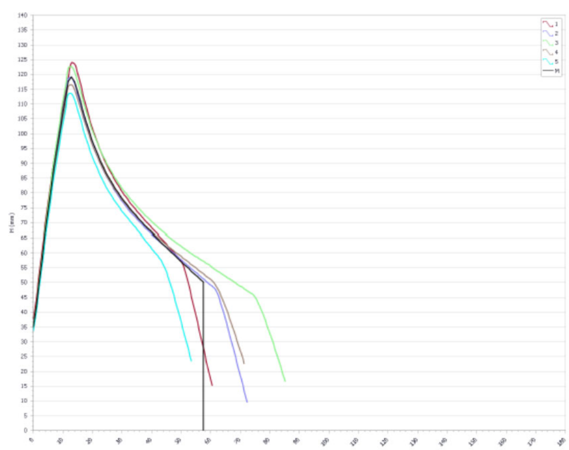
20-2429, Everest
P (mm H_20) = 139, L (mm) = 39, W ($10E^{-4}$J) = 209



20-2430, Jagalene (CC08)
P (mm H_20) = 163, L (mm) = 37, W ($10E^{-4}$J) = 262



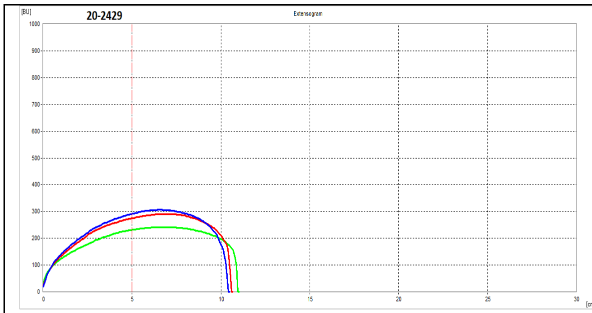
20-2431, KS12DH0156-88
P (mm H_20) = 130, L (mm) = 37, W ($10E^{-4}$J) = 198



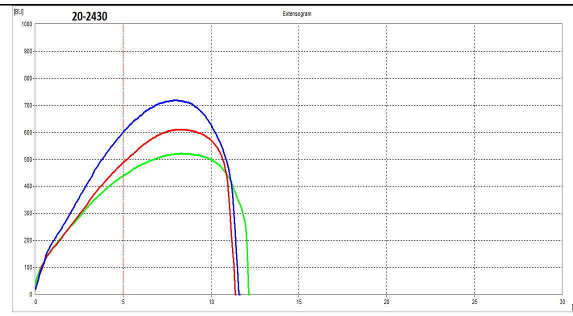
20-2432, KS090616K-1
P (mm H_20) = 131, L (mm) = 57, W ($10E^{-4}$J) = 293

Physical Dough Tests - Extensigraph

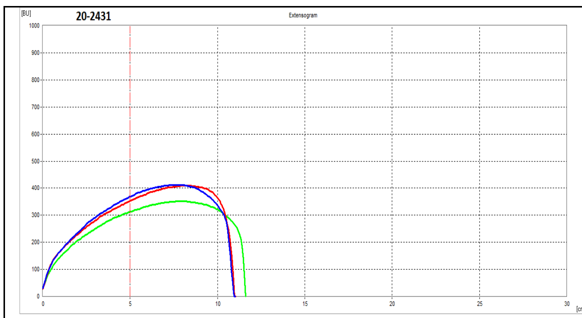
2020 (Small Scale) Samples – Kansas-Manhattan



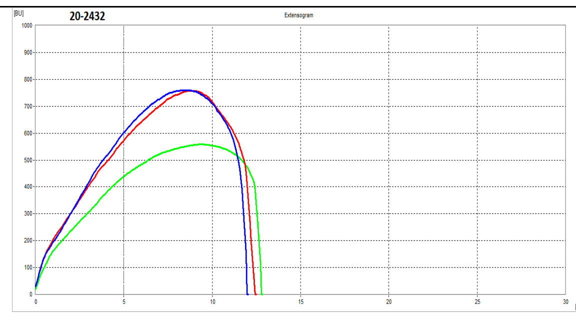
20-2429, Everest
R (BU) = 275, E (mm) = 107, W (cm^2) = 43
Rmax (BU) = 290, Ratio = 2.6 at 90 min



20-2430, Jagalene (CC08)
R (BU) = 490, E (mm) = 115, W (cm^2) = 88
Rmax (BU) = 610, Ratio = 4.3 at 90 min



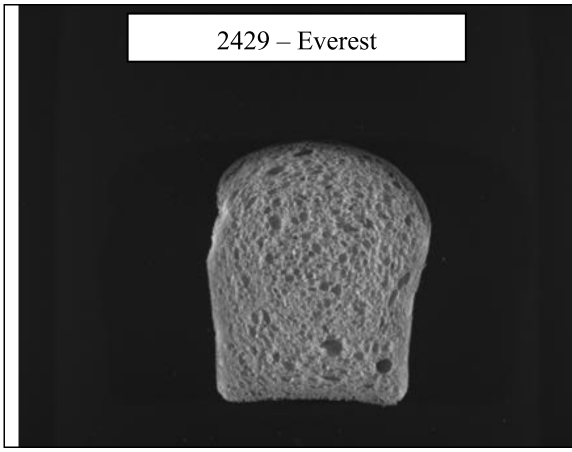
20-2431, KS12DH0156-88
R (BU) = 354, E (mm) = 111, W (cm^2) = 61
Rmax (BU) = 410, Ratio = 3.2 at 90 min

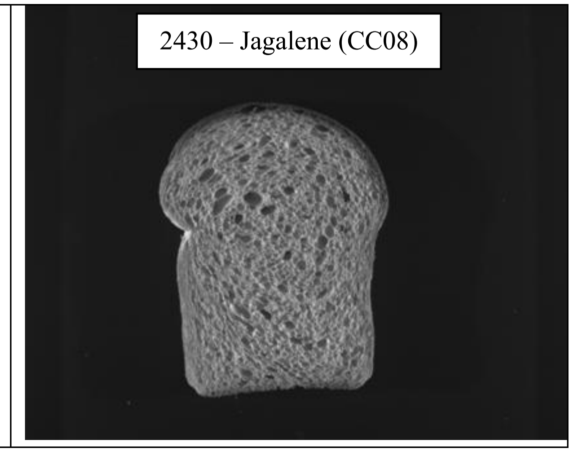


20-2432, KS090616K-1
R (BU) = 576, E (mm) = 126, W (cm^2) = 116
Rmax (BU) = 757, Ratio = 4.6 at 90 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Kansas-Manhattan: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples



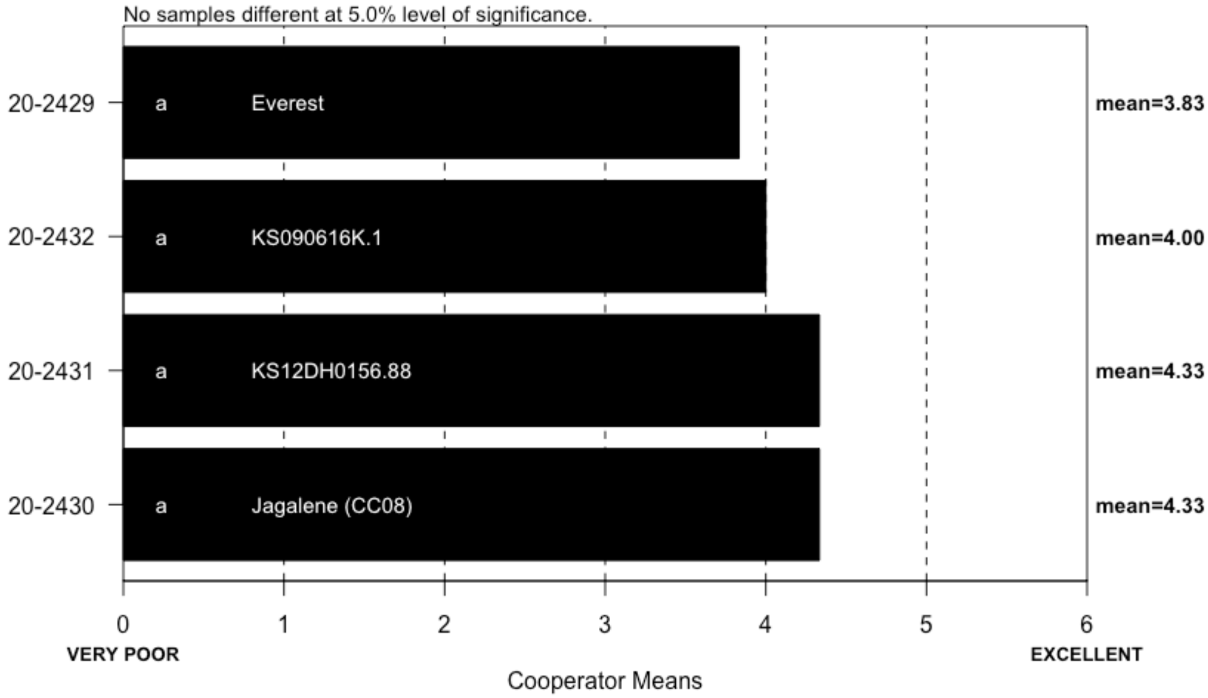


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2429	5412	113	3106	0.442	2.187	1.271	1.661	-2.79
2430	5896	111	3275	0.437	2.098	1.848	1.759	-2.96

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})
2431	5844	114	3274	0.438	2.142	1.098	1.712	-1.38
2432	6559	120	3586	0.440	2.242	3.031	1.781	0.04

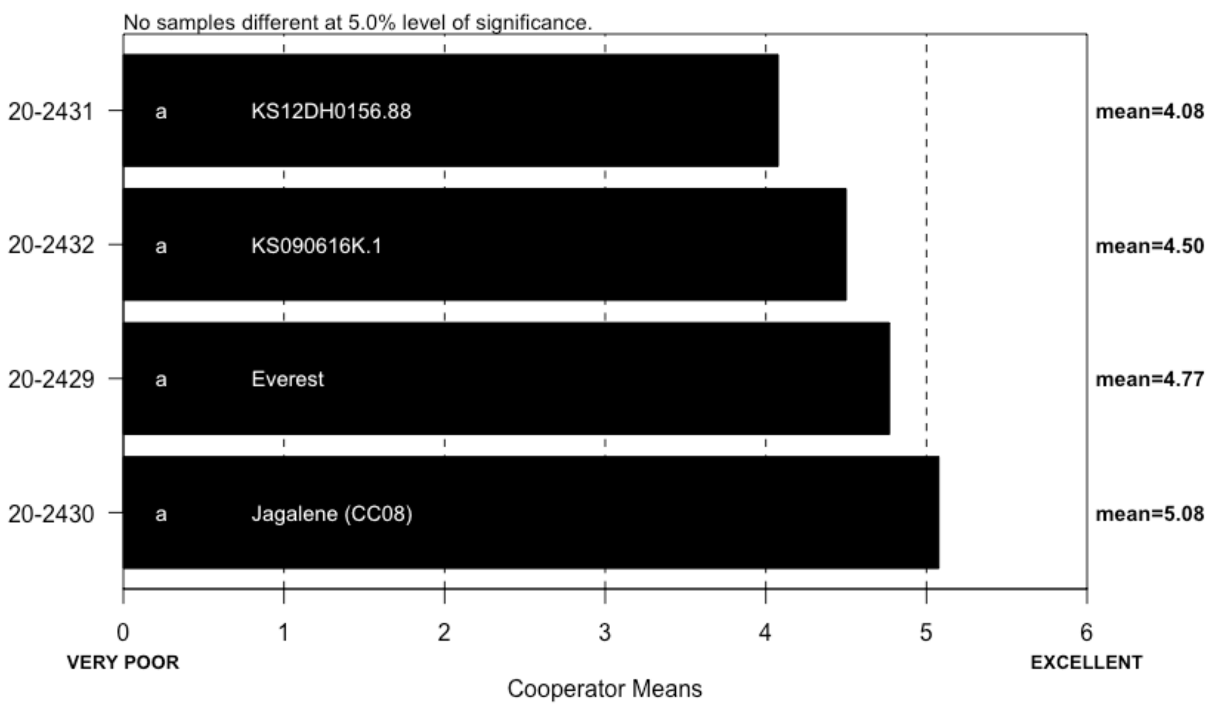
SPONGE CHARACTERISTICS
(Small Scale) Kansas-Manhattan

Cooperators = 3
ChiSqCalc = 0.4
ChiSqTab = 7.8
P Value = 0.939



BAKE ABSORPTION
(Small Scale) Kansas-Manhattan

Cooperators = 13
ChiSqCalc = 3.7
ChiSqTab = 7.8
P Value = 0.3

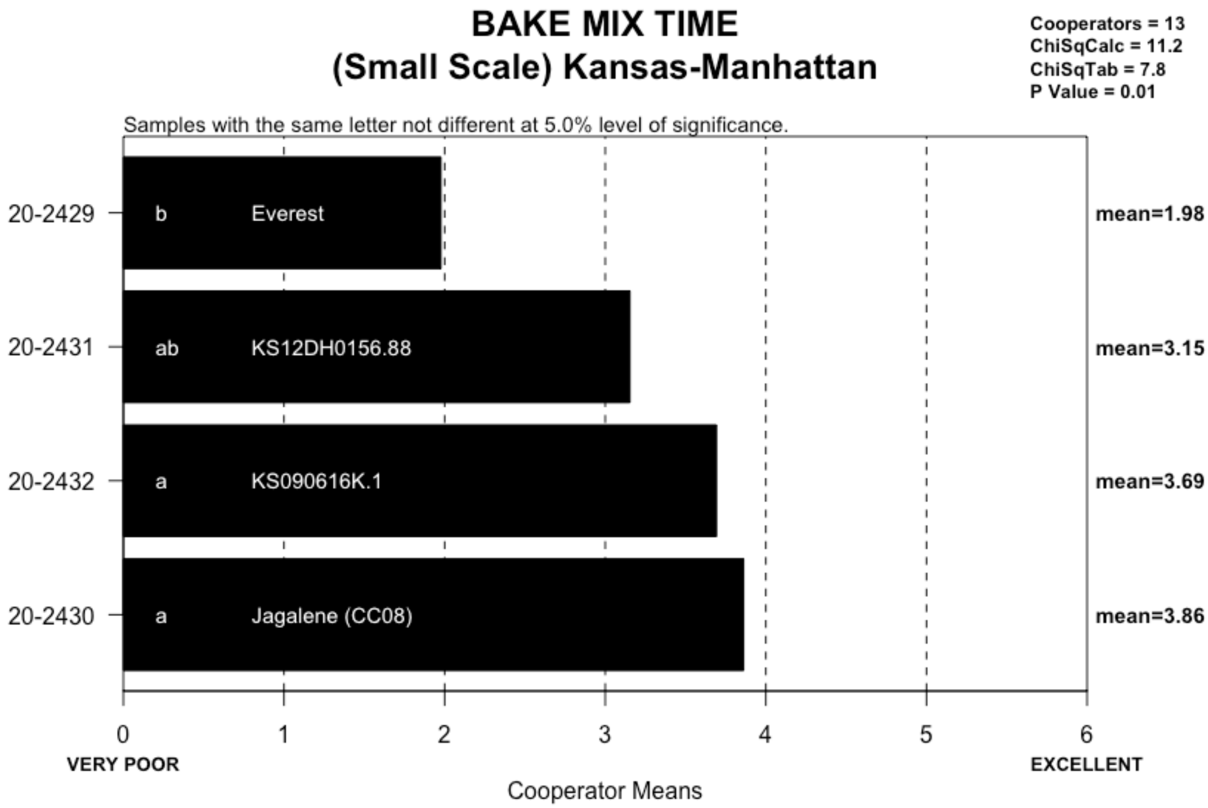


BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Kansas-Manhattan
Cooperators A – M

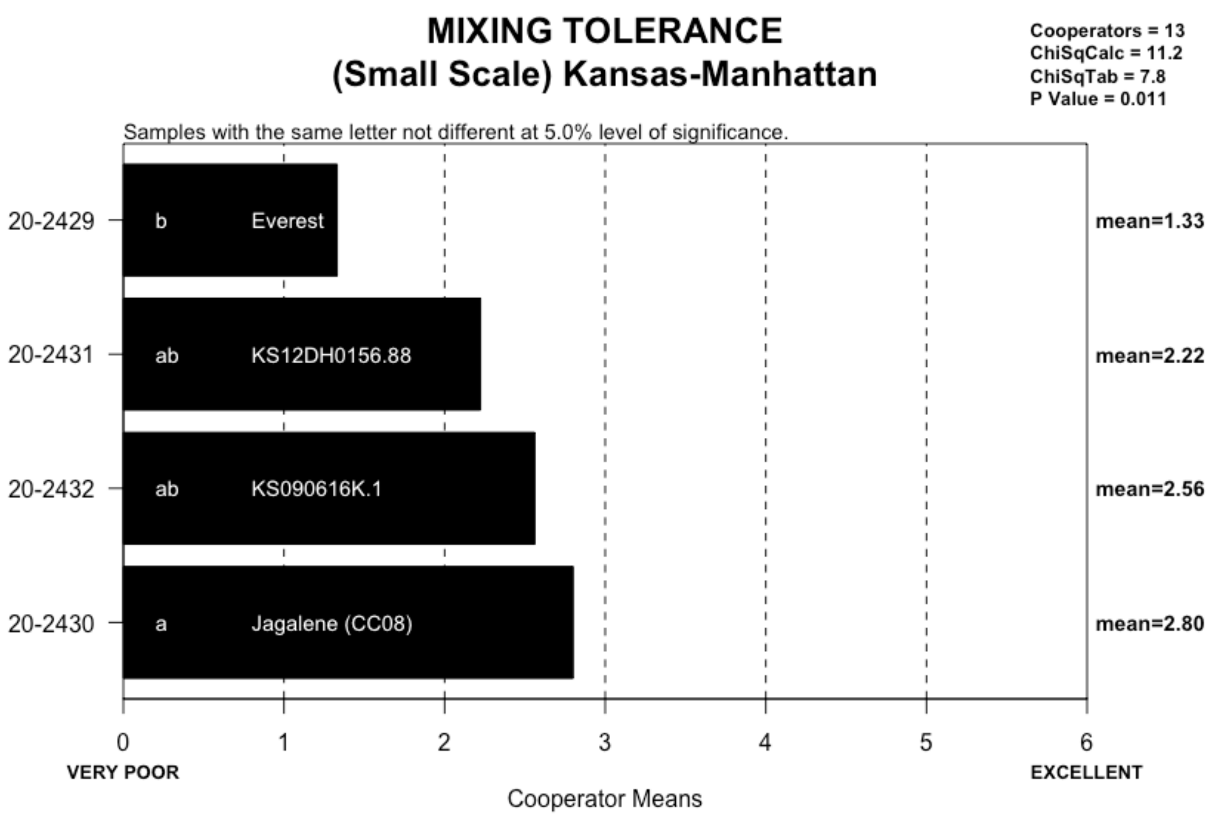
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2429	Everest	59	74.8	68.2	66.9	65.8	67.5	64.5	66.4	68.8	67.8	59.7	66.0	69.8
20-2430	Jagalene (CC08)	58	73.9	68.2	69.1	64.8	66.0	68.4	68.7	68.1	67.3	62.0	66.3	69.3
20-2431	KS12DH0156-88	57	70.1	63.2	64.6	63.2	64.0	65.2	60.7	64.6	63.6	62.0	61.0	65.6
20-2432	KS090616K-1	58	69.7	65.8	67.8	64.0	64.0	69.0	64.4	65.9	64.4	60.7	64.7	66.4

BAKE MIX TIME, ACTUAL
(Small Scale) Kansas-Manhattan
Cooperators A – M

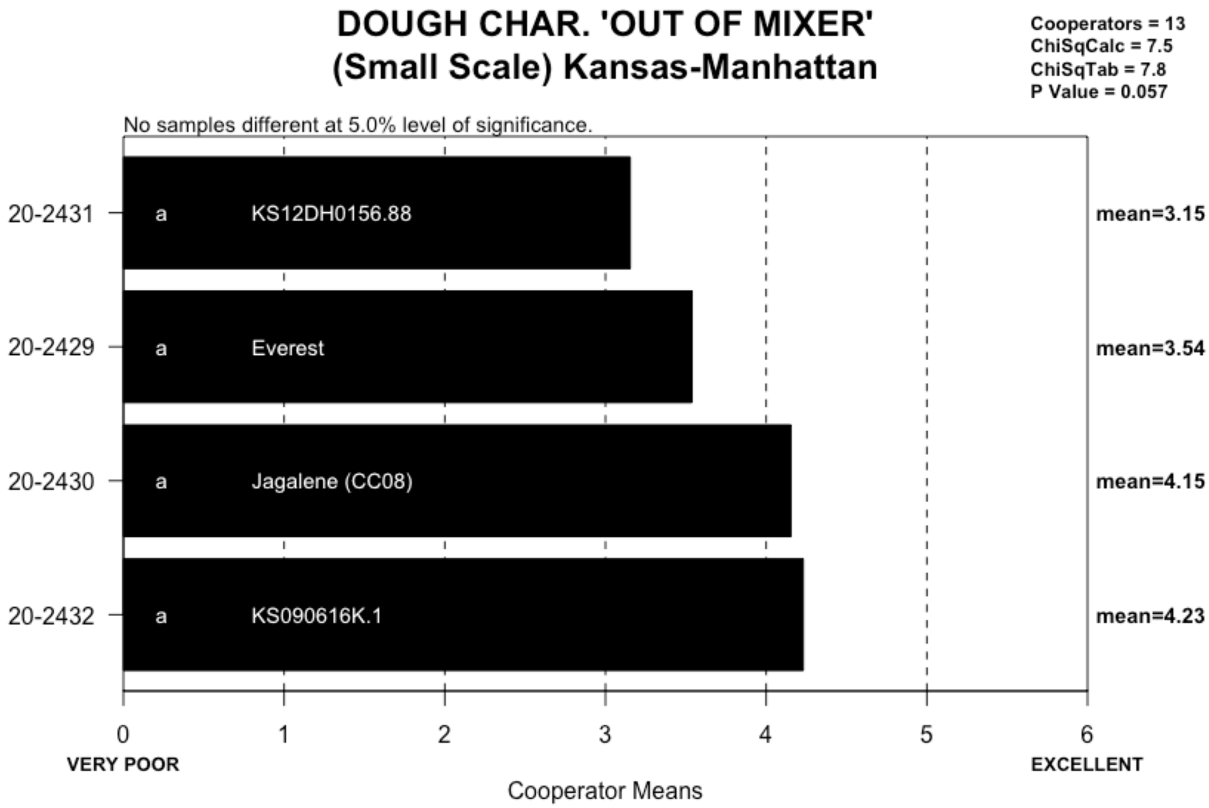
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2429	Everest	4	3.5	2.5	2.7	2.5	3.7	3.0	3.0	2.5	8	4	2.4	6
20-2430	Jagalene (CC08)	5	5.5	4.7	5.3	4.0	4.7	4.8	6.0	5.3	8	4	4.5	11
20-2431	KS12DH0156-88	4	4.5	3.6	4.0	3.0	7.4	3.8	5.0	4.8	8	4	3.9	8
20-2432	KS090616K-1	5	4.5	4.3	4.9	4.5	6.1	4.3	5.3	5.3	8	4	5.1	13



BAKE MIX TIME
(Small Scale) Kansas-Manhattan
Cooperators = 13
ChiSqCalc = 11.2
ChiSqTab = 7.8
P Value = 0.01
Samples with the same letter not different at 5.0% level of significance.
20-2429
b
Everest
mean=1.98
20-2431
ab
KS12DH0156.88
mean=3.15
20-2432
a
KS090616K.1
mean=3.69
20-2430
a
Jagalene (CC08)
mean=3.86
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

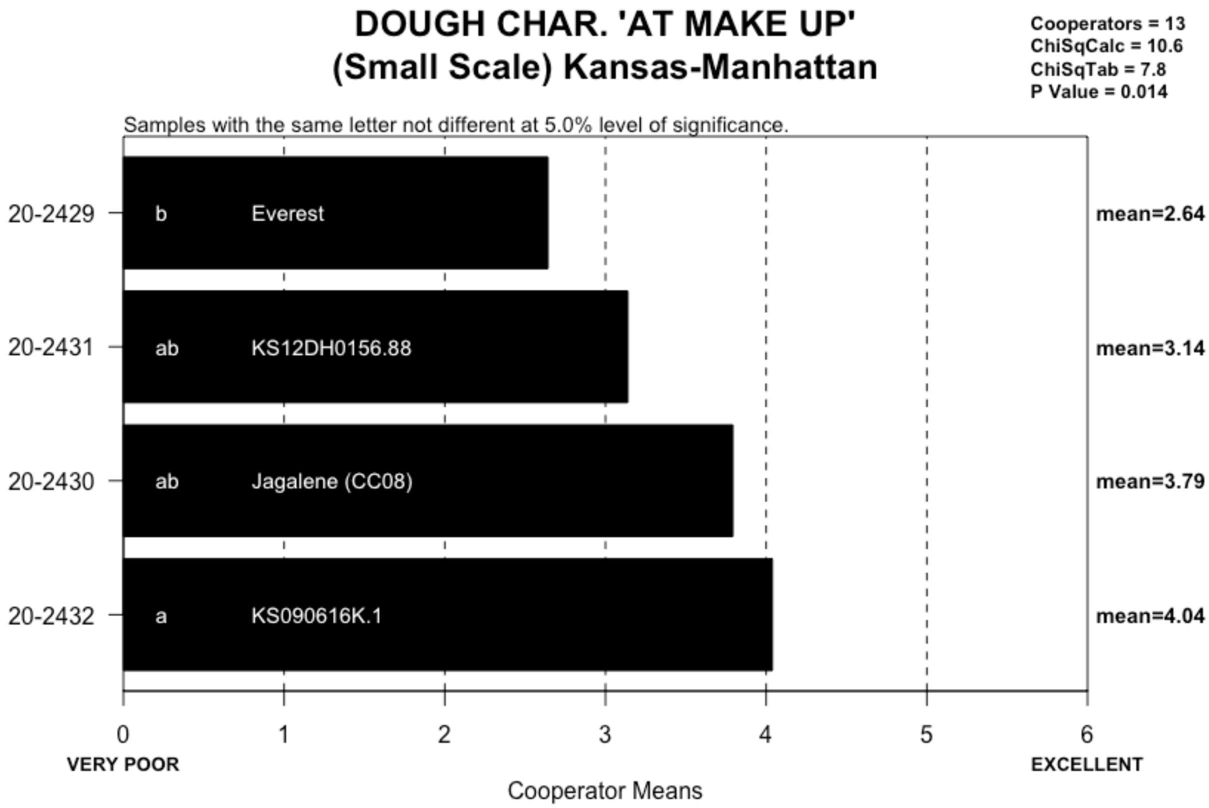


MIXING TOLERANCE
(Small Scale) Kansas-Manhattan
Cooperators = 13
ChiSqCalc = 11.2
ChiSqTab = 7.8
P Value = 0.011
Samples with the same letter not different at 5.0% level of significance.
20-2429
b
Everest
mean=1.33
20-2431
ab
KS12DH0156.88
mean=2.22
20-2432
ab
KS090616K.1
mean=2.56
20-2430
a
Jagalene (CC08)
mean=2.80
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



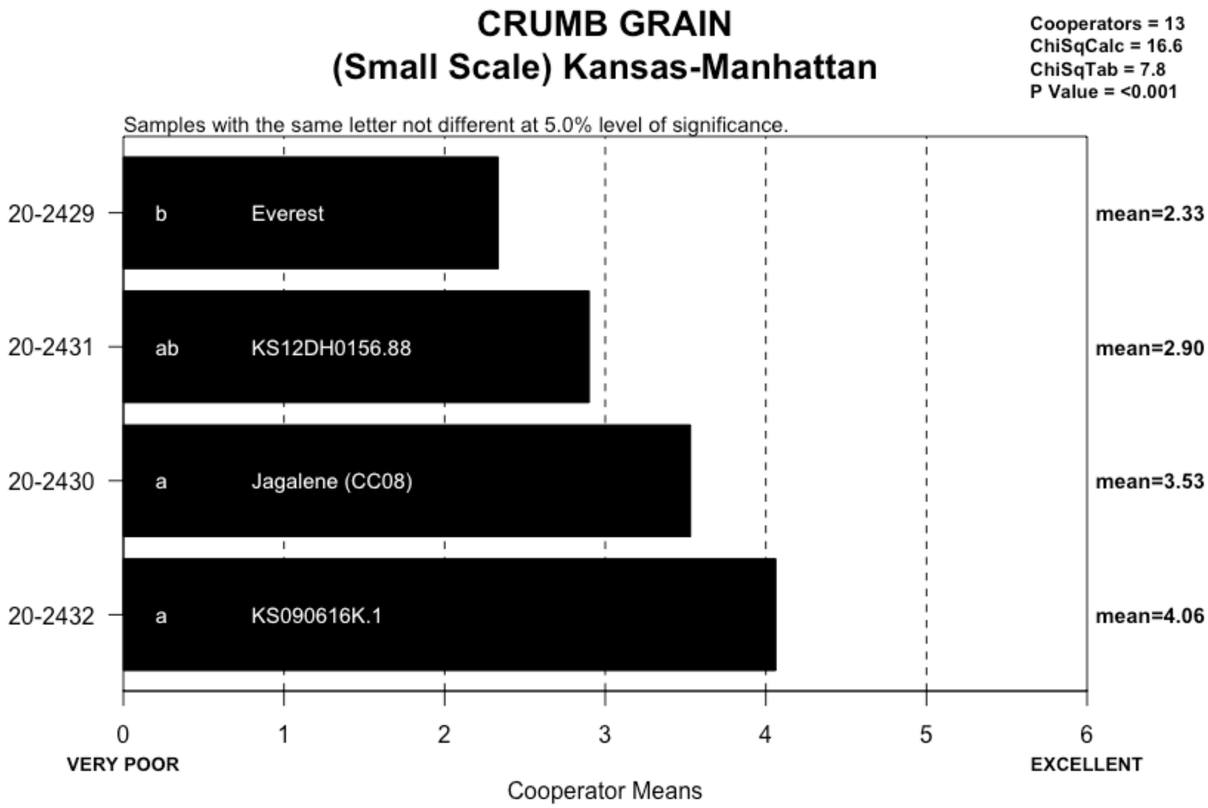
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Kansas-Manhattan

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2429	Everest	4	2	2	4	1
20-2430	Jagalene (CC08)	0	0	2	9	2
20-2431	KS12DH0156-88	4	1	3	4	1
20-2432	KS090616K-1	2	0	4	6	1



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2429	Everest	4	3	0	5	0
20-2430	Jagalene (CC08)	1	0	2	10	0
20-2431	KS12DH0156-88	3	2	1	7	0
20-2432	KS090616K-1	1	1	3	8	0

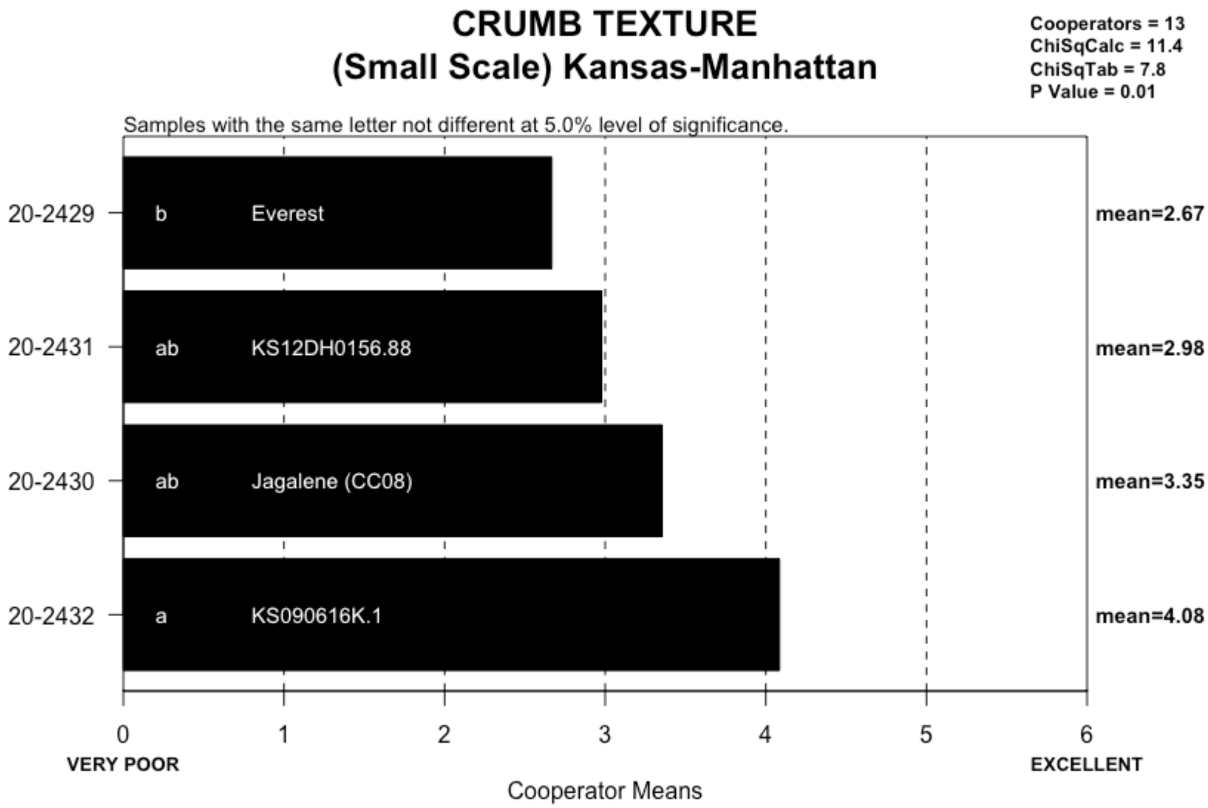


CRUMB GRAIN, DESCRIBED
(Small Scale) Kansas-Manhattan

IDCODE	ID	Open	Fine	Dense
20-2429	Everest	5	2	5
20-2430	Jagalene (CC08)	3	9	1
20-2431	KS12DH0156-88	6	5	2
20-2432	KS090616K-1	6	6	1

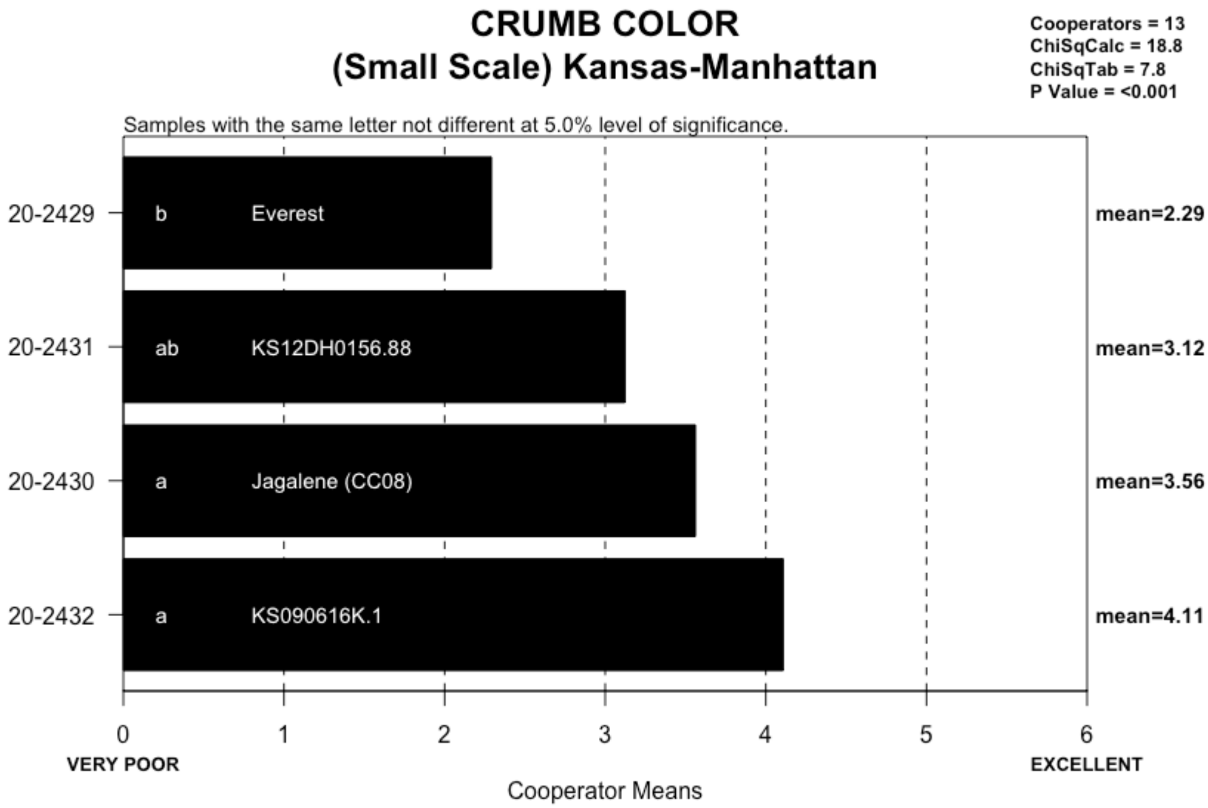
CELL SHAPE, DESCRIBED
(Small Scale) Kansas-Manhattan

IDCODE	ID	Round	Irregular	Elongated
20-2429	Everest	6	4	2
20-2430	Jagalene (CC08)	6	3	4
20-2431	KS12DH0156-88	6	5	2
20-2432	KS090616K-1	2	6	5



CRUMB TEXTURE, DESCRIBED
(Small Scale) Kansas-Manhattan

IDCODE	ID	Harsh	Smooth	Silky
20-2429	Everest	7	5	0
20-2430	Jagalene (CC08)	4	7	2
20-2431	KS12DH0156-88	7	5	1
20-2432	KS090616K-1	1	7	5



CRUMB COLOR, DESCRIBED
(Small Scale) Kansas-Manhattan

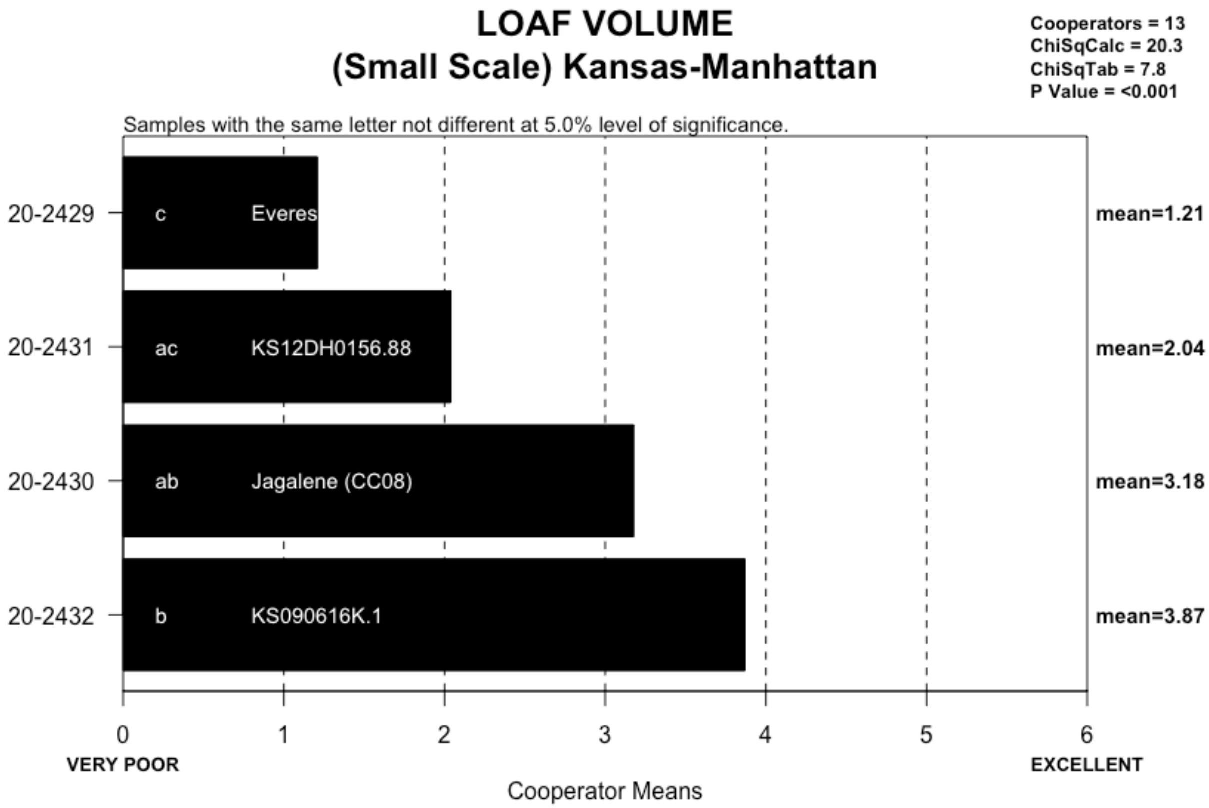
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2429	Everest	0	2	3	7	0	0	0
20-2430	Jagalene (CC08)	0	0	1	6	5	1	0
20-2431	KS12DH0156-88	0	0	2	8	3	0	0
20-2432	KS090616K-1	0	0	2	2	5	4	0

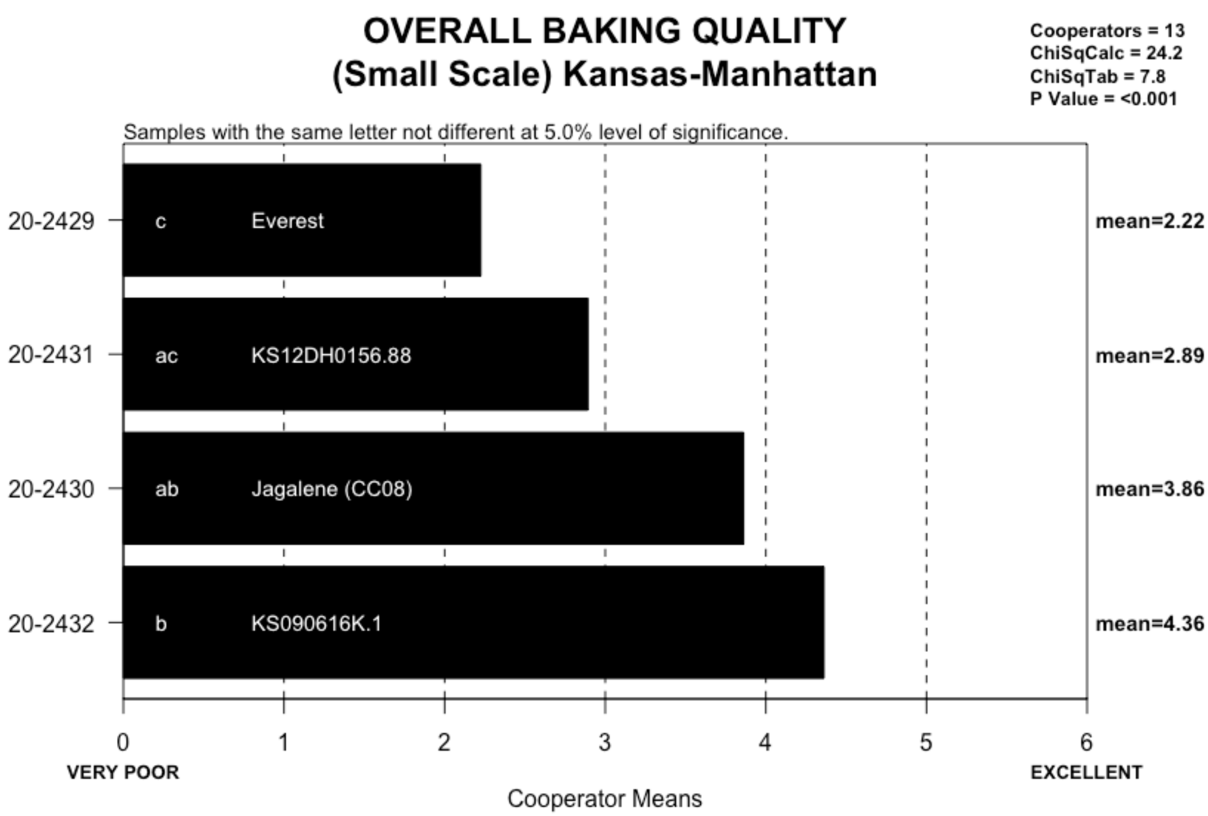
LOAF WEIGHT, ACTUAL
(Small Scale) Kansas-Manhattan
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2429	Everest	415	142.6	139.0	160.2	144.8	141.7	144.9	157.8	150	NA	483.1	146.3	424.5
20-2430	Jagalene (CC08)	414	139.2	138.5	153.1	144.0	139.7	145.0	153.7	146	462.5	474.9	143.8	421.9
20-2431	KS12DH0156-88	411	135.8	140.1	149.4	143.5	138.0	143.7	149.3	141	466.6	476.0	141.1	425.1
20-2432	KS090616K-1	411	133.8	138.9	153.4	142.0	138.2	147.0	150.4	142	462.5	479.6	143.1	426.1

LOAF VOLUME, ACTUAL
(Small Scale) Kansas-Manhattan
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2429	Everest	2250	600	692	735	700	813	685	685	587	NA	2225	710	2275
20-2430	Jagalene (CC08)	2900	815	881	843	855	870	965	790	652	2406	2575	810	2625
20-2431	KS12DH0156-88	2700	780	748	743	755	848	740	760	642	2227	2338	740	2325
20-2432	KS090616K-1	2925	995	854	890	935	923	965	860	783	2576	2575	860	2700


LOAF VOLUME
(Small Scale) Kansas-Manhattan
Cooperators = 13
ChiSqCalc = 20.3
ChiSqTab = 7.8
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2429
c
Everes
mean=1.21
20-2431
ac
KS12DH0156.88
mean=2.04
20-2430
ab
Jagalene (CC08)
mean=3.18
20-2432
b
KS090616K.1
mean=3.87
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Small Scale) Kansas-Manhattan
Cooperators = 13
ChiSqCalc = 24.2
ChiSqTab = 7.8
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2429
c
Everest
mean=2.22
20-2431
ac
KS12DH0156.88
mean=2.89
20-2430
ab
Jagalene (CC08)
mean=3.86
20-2432
b
KS090616K.1
mean=4.36
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Kansas-Manhattan

COOP. 20-2429 Everest

A. No comment.
B. Very small, dense crumb, light crust color.
C. No comment.
D. Very weak dough, very low volume for protein level with crumb grain very poor.
E. Given protein should have had higher loaf volume.
F. High Protein & Water Abs, Short MT, Slight Sticky & Strong Dough, Fair Volume, Dark Yellow Crumb, Open Irregular Cells, Resilient & Harsh Texture.
G. Brown dough.
H. Low mixing tolerance, high absorption, dense grain, wet dough at makeup, very low volume.
I. Short mix time, weak dough characteristics, poor crumb color.
J. After 5 minutes in mixer, the dough could not hold together, smeared on sides and bottom, couldn't make it work to continue baking.
K. Low mixing tolerance, avg absorption, open grain, sticky wet doughs, loaf volume too low.
L. No comment.
M. High absorption and protein, low mix time and volume.

COOP. 20-2430 Jagalene (CC08)

A. No comment.
B. No comment.
C. No comment.
D. Good mix time but generally weaker dough type, loaf volume low for protein with weaker looking crumb grain.
E. Good.
F. Very High Protein & Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. Excellent loaf externals.
H. High absorption, open grain, very low volume.
I. Poor crumb color.
J. No comment.
K. Low mixing tolerance, good absorption, fine grain, avg volume.
L. No comment.
M. Good protein and volume, fair mix time and dough notes. Recommend.

COOP. 20-2431 KS12DH0156-88

A. No comment.
B. No comment.
C. No comment.
D. Very weak dough, very low volume for protein level with crumb grain very poor.
E. Protein does not meet target.
F. Normal Protein & Water Abs, Long MT, Slight Sticky & Strong Dough, Medium Volume, Dull Crumb, Open Elongated Cells, Resilient & Slightly Harsh Texture.
G. Left and right break, weak dough?
H. Low absorption, open grain, tough doughs, very low volume.
I. Poor crumb color.
J. No comment.
K. Low mixing tolerance, good absorption, dense grain, very low volume.
L. No comment.
M. Good protein and absorption, lower mix time and volume.

COOP. 20-2432 KS090616K-1

A. No comment.
B. No comment.
C. No comment.
D. Weak dough type for protein level, volume and crumb grain performed as expected for protein.
E. Loaf volume matched predicted loaf volume, best in set.
F. High Protein & Water Abs, Long MT, Sticky & Slightly Strong Dough, High Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. White dough, good loaf externals.
H. Open grain, avg volume.
I. Nice dough characteristics, low loaf volume.
J. No comment.
K. Low mixing tolerance, avg absorption, fine grain, tough doughs at makeup, avg volume.
L. No comment.
M. Good protein, volume, and absorption. Recommend.

Notes: **A, K, and M** conducted sponge and dough bake tests

NORTHERN STATES

20-2433	Jagalene (CC09)
20-2434	17NORD-94
20-2435	17NORD-96
20-2436	NE14434
20-2437	NE14696
20-2438	PSB13NEDH-14-83W
20-2439	09BC308-14-16
20-2440	SD12DHA03282

Description of Test Plots and Breeder Entries

Northern States (NE, SD, ND, and Syngenta)

NEBRASKA by Stephen Baenziger

Growing Conditions:

In 2019-20, 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 9 lines (up to 3 per state and the check Jagalene). Before submission, one line per state was dropped. For Nebraska, we were able to retain all three experimental line entries (NE14434, NE14696, and PSB13NEDH-14-83W). 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 moisture. The plots were not sprayed with fungicides but were generally only mildly infected with diseases were infected with leaf rust and Fusarium head blight (FHB, syn. scab).

Yield of some lines at the grow-out site in Lincoln, NE (Lancaster Country) from the State Variety Trial in 2020 are (note NE14696 and PSB13NEDH-14-83W were not grown in Lincoln as they are more adapted to western Nebraska).

Name	Source	Yield	Rank	Test Weight	Height	Protein	
		(bu/a)		(lbs/bu)	(in)	(%)	
Ruth		99.2	1	58.7	39.8	13.1	*
WB4699	WestBred	98.9	2	57.5	32.5	12.0	
NE14434		91.3	3	57.3	39.0	12.7	
Siege		88.8	4	59.8	37.8	14.1	*
NE13493		87.2	9	59.5	38.8	13.2	*
LCS Valiant	Limagrain	82.6	16	58.6	37.3	15.0	*
Scout 66		43.0	23	56.4	43.7	15.3	*
Mean (all lines)		82.8		57.6	36.9	13.6	
LSD (0.05)		6.7		1.0	1.1	0.5	
* Previously evaulated by the Wheat Quality Council							

Data from the 2020 Nebraska Elite Yield Trial (planted later) having two reps sprayed with fungicide and two reps not sprayed with fungicide are:

Name	Lincoln Yield With Fungicides	Lincoln Yield No Fungicides	**NE** Yield **AVERAGE**	State RANK
NI13706	68.5	61.5	**56.19**	1
PSB13NEDH-14-83W	65.5	62.4	**52.50**	4
NW13493	65.4	61.3	**51.74**	8
Ruth	69.0	60.1	**51.60**	10
LCS Valiant	53.5	61	**49.66**	21
NE14434	63.2	58.9	**47.73**	39
NE14696	59.3	54	**46.10**	52
SCOUT66	46.9	41.3	**39.38**	59
CHEYENNE	40.2	46.3	**39.14**	60
Average (all lines)	**60.3**	**56.7**	**48.5**	
Benefit of fungicides	**6%**			

NE14434: NE14434 is a hard red winter wheat that was derived from the cross: SD98W175-1/NW03666//Freeman. The pedigree of SD98175-1 is KS84273BB-10/KSSB110-9//KS831374-141B/YE1110/3/KS82W418/SPN. The pedigree of NW03666 is N94S097KS/NE93459. It has done well in Nebraska but is a more locally adapted wheat to eastern Nebraska. It is a semi-dwarf, hard red winter wheat with good winterhardiness. It has high grain yield where it is adapted but tends to have genetically lower test weight. It is resistant to wheat soilborne mosaic virus and moderately resistant to stem rust. It is moderate resistant to moderately susceptible to strip (yellow) rust and moderately susceptible to leaf rust and acid soils. It is susceptible to Hessian fly, wheat streak mosaic virus, and wheat stem sawfly. It has acceptable end-use quality.

NE14434 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 6.9 on a scale of 1 to 9 where 1 = resistant and 9 = susceptible, and from 2015 to 2019, severity in the greenhouse and field nurseries averaged 38% and 42%, respectively, indicating it is moderately susceptible.

NE14696: NE14696 is a hard red winter wheat that was derived from the cross: NE05537/Overland. The pedigree of NE05537 is NI97435 (=TAM202/NE86606 (=WRR/SUT//MOW6811/3/AGATE..))/NE94632 (=ABILENE/NORKAN//RAWHIDE). It has done well in northwest Nebraska and in the Northern Regional Performance Nursery (2018 and 2019), it was the highest yielding line averaged across South Dakota. NE14696 is resistant to moderately resistant to stem rust, stripe rust, and soil borne mosaic virus. It is moderately resistant to moderate susceptible to leaf rust and susceptible to Hessian fly and by molecular markers to wheat streak mosaic virus and wheat stem sawfly. It has acceptable end-use quality. **NE14696** is superior to very susceptible FHB lines such as Overley, but inferior to moderately resistant FHB lines such as Overland. From 2015 to 2019, its FHB severity averaged 24% and 44% in the greenhouse and field nurseries, respectively, indicating it is moderately susceptible.

PSB13NEDH-14-83W: PSB13NEDH-14-83W is a doubled haploid line jointly created by the University of Nebraska and Limagrain Cereal Seeds. It was derived from the cross: NW03681/SD07W084 where the pedigree of NW03681 is WI88-052/WI81-162-610W//N94L189 and the pedigree of SD07W084 is SD92107-5/Falcon//Jagalene which was made in 2009. However the pedigree is likely wrong as the line has red kernels and by parentage it should have white kernels. PSB13NEDH-14-83W is a hard red winter wheat that is a winterhardy semi-dwarf experimental line that seems to be broadly adapted across Nebraska. It is resistant to Wheat soilborne mosaic virus and Hessian fly; moderately resistant to stem, leaf, and stripe rust, and most likely susceptible to wheat streak mosaic virus and wheat stem sawfly. It has acceptable end-use quality
PSB13NEDH-14-83W: is superior to very susceptible FHB lines such as Overley, but inferior to moderately resistant FHB lines such as Overland. From 2015 to 2019, its FHB severity averaged 56% and 47% in the greenhouse and field nurseries, respectively, indicating it is moderately susceptible.

Jagalene was the quality control line.

SOUTH DAKOTA by Sunish Sehgal

Growing Location and Conditions: A total of 9 entries were evaluated under the 2020 Northern Wheat Quality Council (WQC) grow-outs. At Brookings (SD), all entries and Jagalene (check) were timely planted on October 2, 2019, as 200' long and 5' wide strips (7-rows) in oat stubble (no-till). A starter fertilizer 10-34-0 (10 gallons/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 (45 gallons/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 4-5 days due to a late spring freeze. The grow-outs were harvested on August 8th, 2020. The grain protein content ranged from 13.1% to 14.3% and the test weight ranged from 60 lb/bu -63 lb/bu among the 9 entries.

SD12DHA03282

SD12DHA03282 is a doubled haploid lined developed from the cross Striker/SD03184-4 and has medium height and late maturity, similar to Ideal. It has good to excellent winter hardiness and straw strength. SD12DHA03282 has demonstrated a good yield potential (ranked 9th and 6th) in the 2019 and 2020 USDA Northern Regional Performance Nursery, respectively. In South Dakota Crop Performance Trials across 41 environments over 3 years, SD12DHA03282 ranked 2nd in eastern, 6th in central, and 2nd in western SD locations. It has above-average test weight and moderate protein concentration. SD12DHA03282 is moderately resistant to resistant to stripe rust and shows an intermediate response to FHB, leaf, and stem rust.

SD12DHA03282 showed overall acceptable milling and baking qualities. Across multiple trial locations (2019-2020), its milling quality parameters (average flour yield 69.4 %) and baking quality parameters (average loaf volume 930 cm^3 and specific volume 6.3 cc/g) were comparable to Winner (average flour yield 66.0%, average loaf volume 947 cm^3, and specific volume 6.3 cc/g) and better than Overland (average flour yield 68.9%, average loaf volume 886 cm^3, and specific volume 5.9 cc/g).

Table 1. Yield, test weight, and grain protein content of some of the lines tested in South Dakota winter wheat variety performance trial (eastern South Dakota, 2018-2020).

Variety	2020 Yield (bu/ac)	2020 Test Wt (lbs)	2020 Protein (%)	2-year Yield (bu/ac)	2-year Test Wt (lbs)	2-year Protein (%)	3-year Yield (bu/ac)	3-year Test Wt (lbs)	3-year Protein (%)
Winner	**81.2**	59.7	12.5	**75.9**	57.5	12.2	**71.3**	57.5	13.6
SD12DHA03282	**81.0**	60.2	12.5	**76.6**	58.2	12.1	**70.9**	57.7	13.1
Oahe	74.0	60.0	12.9	**70.1**	57.9	12.4	**70.2**	58.5	13.6
WB4462	79.3	59.5	13.2	**72.1**	57.4	12.7	**69.6**	58.0	13.7
Ideal	78.3	58.8	12.4	**76.0**	56.8	12.0	**69.4**	56.9	13.3
Redfield	78.0	59.4	13.1	**74.8**	57.2	12.6	**68.3**	57.1	13.7
Draper	79.5	58.4	12.8	**72.9**	56.6	12.5	**68.2**	56.9	13.7
SD12DHA01373	77.4	59.1	12.8	**72.2**	57.1	12.3	**67.9**	56.6	13.2
Keldin	**82.2**	59.9	12.2	**68.6**	57.5	12.1	**67.6**	56.9	13.5
Cowboy	79.5	58.8	12.0	**73.7**	56.4	11.7	**67.5**	56.5	12.8
SY Monument	73.7	58.3	12.5	**71.4**	55.7	12.1	**66.4**	55.4	13.3
Trial Average	**76.0**	**59.5**	**12.8**	**73.1**	**58.6**	**12.9**	**68.2**	**57.9**	**13.6**
LSD	2.2	0.5	0.4	11.0	1.4	0.8	7.3	1.7	0.6
CV	4.6	1.4	4.6	5.7	1.4	4.3	6.8	2.0	3.8

varieties ranking in the top 1/3 of each trial category are shaded.

NORTH DAKOTA by Francois Marais and Bradley Bisek

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 160') were seeded on Sept. 27th, 2019. Moisture was adequate prior to planting, however there was high competition of volunteer oats from the previous crop. The fall season in general was cool and wet again, with relatively consistent freezing temperatures arriving by early November. The winter brought significant snow amounts, as well as very cold temperatures at times, similarly to 2018. We did not see any significant winter kill in the WQC strips, as adequate crop residue and good snow amounts likely aided winter survival. The 2020 growing season was relatively warm, but ample rainfall at favorable times helped avoid drought conditions. Urea was applied at a rate of 260 lbs/A (120 lbs N) by the ASF on May 2nd, 2020. A pesticide tank-mix of Huskie & Axial XL was sprayed on May 30th at the wheat jointing stage, to control weed growth. The WQC strips were harvested on July 30th, 2020. Seed quality appeared to fluctuate between strips, probably due to maturity differences in genotypes. Rainfall became scarce in early August, making harvest relatively simple, however some heavy rainfalls in mid to late July may have adversely affected the ripening wheat in the field just prior to harvest. Below are the yields for the harvested strips at Casselton.

Entry Name	Yield (bu/A)
Jagalene	48.6
17NORD-94	61
17NORD-96	64.7
NE14434	58.3
NE14696	57
PSB13NEDH-14-83W	52.9
09BC308-14-16	52.2
SD12DHA03282	60.8
SD12DHA01373 - excluded	61.6

SYNGENTA by Josh Coltrain

Increase strips were planted on 10/15/19 at our location in Junction City, KS. The strips had very good fall stand establishment. All increases had 80lbs of 11-52-0 applied with the planter with 70lbs of N applied prior to planting. An additional 70lbs of N and 20lbs of Sulfur was top dressed in the spring prior to jointing. All strips were sprayed with a 13.7oz rate of Trivapro at flag leaf to ensure good quality seed. All samples harvested on 7/6/20.

AP EverRock was developed from the cross SY Wolf/Everest//Postrock made in the fall of 2008 in Junction City, KS. It was tested and evaluated under the experimental designation 09BC308-14-16. SY Wolf is a PVP variety developed by Syngenta Crop Protection AG from the cross of W99-331/97x0906-8 and released in 2007. Everest, released in 2009, was developed by Kansas State University and is a cross between Pioneer experimentals and Betty. Postrock is a PVP variety developed by Syngenta Seeds, Inc. in 2006 from the cross Ogallala/KSU94U261//Jagger.

AP EverRock is a hard red winter wheat broadly adapted to the Central Plains and the Irrigated High Plains. The line is short with moderately early maturity and very good test weight. AP EverRock has shown very good straw strength and aluminum tolerance. It's fungal disease package is similar to SY Wolf. AP EverRock is quite tolerant to leaf rust, and moderately tolerant of stripe rust. It is tolerant of Soil Borne Mosaic virus, has exemplary Barley Yellow Dwarf Virus tolerance, and intermediate tolerance of Wheat Streak Mosaic Virus. Milling and baking data compiled over multiple locations in multiple years indicates good milling and baking properties with excellent flour yield and very good loaf volume.

Northern States: 2020 (Small-Scale) Samples

Test entry number	20-2433	20-2434	20-2435	20-2436
Sample identification	Jagalene (CC09)	17NORD-94	17NORD-96	NE14434
Wheat Data				
GIPSA classification	1 HRW	2 HRW	1 HRW	2 HRW
Test weight (lb/bu)	60.0	58.9	60.4	58.9
Hectoliter weight (kg/hl)	78.9	77.5	79.5	77.5
1000 kernel weight (gm)	31.2	28.9	28.2	30.2
Wheat kernel size (Rotap)				
Over 7 wire (%)	63.4	57.2	55.1	59.2
Over 9 wire (%)	36.3	42.1	44.4	40.4
Through 9 wire (%)	0.3	0.7	0.5	0.4
Single kernel (skcs)[a]				
Hardness (avg /s.d)	65.9/19.8	59.2/18.7	65.5/17.4	57.5/17.5
Weight (mg) (avg/s.d)	31.2/11.3	28.9/9.3	28.2/9.3	30.2/9.6
Diameter (mm)(avg/s.d)	2.70/0.40	2.56/0.36	2.58/0.36	2.62/0.34
Moisture (%) (avg/s.d)	11.7/0.6	11.6/0.7	12.1/0.6	12.0/0.9
SKCS distribution	06-11-20-63-01	08-15-30-47-01	03-10-24-63-01	08-21-26-45-01
Classification	Hard	Hard	Hard	Hard
Wheat protein (12% mb)	14.2	13.4	13.5	13.8
Wheat ash (12% mb)	1.61	1.58	1.58	1.66
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	77.4	76.8	76.2	76.0
Quadrumat Sr. Mill	68.7	68.9	68.1	67.4
Flour moisture (%)	12.7	13.0	12.9	12.7
Flour protein (14% mb)	13.1	13.1	12.3	12.6
Flour ash (14% mb)	0.61	0.58	0.61	0.65
Rapid Visco-Analyser				
Peak time (min)	6.1	6.0	6.2	6.1
Peak viscosity (RVU)	182.4	180.2	207.7	221.1
Breakdown (RVU)	75.1	76.8	76.9	83.9
Final viscosity at 13 min (RVU)	206.4	201.1	234.8	250.1
Minolta color meter				
L*	89.82	89.99	90.04	89.56
a*	-1.02	-0.85	-0.91	-0.92
b*	8.58	7.57	7.68	8.28
PPO	0.615	0.692	0.608	0.569
Falling number (sec)	371	376	394	420
Damaged Starch				
(AI%)	97.4	96.6	96.3	96.1
(AACC76-31)	7.4	6.7	6.5	6.4

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Northern States: 2020 (Small-Scale) Samples (continued)

Test entry number	20-2437	20-2438	20-2439	20-2440
Sample identification	NE14696	PSB13NEDH-14-83W	09BC308-14-16	SD12DHA03282
Wheat Data				
GIPSA classification	1 HRW	2 HRW	2 HRW	1 HRW
Test weight (lb/bu) Hectoliter weight (kg/hl)	60.0 78.9	59.7 78.6	59.9 78.8	60.1 79.1
1000 kernel weight (gm)	29.9	33.1	28.5	29.1
Wheat kernel size (Rotap) Over 7 wire (%) Over 9 wire (%) Through 9 wire (%)	 62.3 37.4 0.3	 74.8 25.0 0.2	 67.5 32.3 0.2	 59.4 40.2 0.4
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	 68.5/19.7 29.9/10.9 2.60/0.34 12.1/0.7 03-10-21-66-01 Hard	 61.0/18.5 33.1/11.3 2.73/0.42 12.1/0.6 06-16-23-55-01 Hard	 68.6/16.8 28.5/9.6 2.65/0.37 12.0/0.6 02-07-22-69-01 Hard	 61.6/19.2 29.1/9.0 2.62/0.33 12.0/0.5 08-15-23-54-01 Hard
Wheat protein (12% mb) Wheat ash (12% mb)	14.2 1.74	13.9 1.74	13.9 1.65	13.3 1.60
Milling and Flour Quality Data				
Flour yield (%, str. grade) Miag Multomat Mill Quadrumat Sr. Mill	 75.1 68.2	 75.9 69.9	 74.8 69.1	 75.9 69.7
Flour moisture (%) Flour protein (14% mb) Flour ash (14% mb)	13.0 13.2 0.66	14.0 12.7 0.63	13.7 12.7 0.56	13.5 12.1 0.56
Rapid Visco-Analyser Peak time (min) Peak viscosity (RVU) Breakdown (RVU) Final viscosity at 13 min (RVU)	 6.1 183.4 68.8 214.7	 6.1 177.5 64.1 215.0	 6.1 200.9 78.8 222.6	 6.2 214.3 73.2 251.9
Minolta color meter L* a* b* PPO	 89.92 -0.82 7.92 0.580	 90.47 -0.93 7.69 0.627	 90.48 -1.18 8.29 0.574	 90.45 -1.31 8.76 0.631
Falling number (sec)	408	368	372	411
Damaged Starch (AI%) (AACC76-31)	 97.2 7.2	 96.4 6.6	 96.3 6.5	 95.8 6.1

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Northern States: Physical Dough Tests and Gluten Analysis
2020 (Small-Scale) Samples

Test Entry Number	20-2433	20-2434	20-2435	20-2436
Sample Identification	Jagalene (CC09)	17NORD-94	17NORD-96	NE14434
	MIXOGRAPH			
Flour Abs (% as-is)	69.8	68.2	67.6	68.4
Flour Abs (14% mb)	68.3	67.0	66.4	66.9
Mix Time (min)	4.6	5.1	5.0	4.5
Mix tolerance (0-6)	4	4	4	4
	FARINOGRAPH			
Flour Abs (% as-is)	64.8	62.4	62.4	63.6
Flour Abs (14% mb)	63.3	61.2	61.1	62.1
Peak time (min)	5.5	4.5	5.7	3.8
Mix stability (min)	12.4	10.3	10.1	8.6
Mix Tolerance Index (FU)	14	17	30	27
Breakdown time (min)	13.7	11.3	11.3	9.4
	ALVEOGRAPH			
P(mm): Tenacity	129	108	108	112
L(mm): Extensibility	75	76	70	88
G(mm): Swelling index	19.2	19.4	18.6	20.8
W(10^{-4} J): strength (curve area)	366	295	273	323
P/L: curve configuration ratio	1.72	1.42	1.54	1.27
Ie(P_{200}/P): elasticity index	61.3	56.6	55.2	53.8
	EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	471/568/661	442/528/660	420/559/565	367/434/437
Extensibility (mm at 45/90/135 min)	137/140/142	139/134/143	141/138/139	154/153/151
Energy (cm^2 at 45/90/135 min)	108/142/166	104/115/161	101/137/137	106/124/127
Resist $_{max}$ (BU at 45/90/135min)	612/819/953	582/677/912	564/780/790	518/624/655
Ratio (at 45/90/135 min)	3.4/4.1/4.7	3.2/4.0/4.6	3.0/4.1/4.1	2.4/2.8/2.9
	PROTEIN ANALYSIS			
HMW-GS Composition	1,2*, 17+18, 5+10	1, 7+9, 5+10	2*, 7+9, 5+10	1, 7+8, 5+10
TPP/TMP	0.98	0.87	0.76	0.84
	SEDIMENTATION TEST			
Volume (ml)	61.6	57.8	53.3	54.2

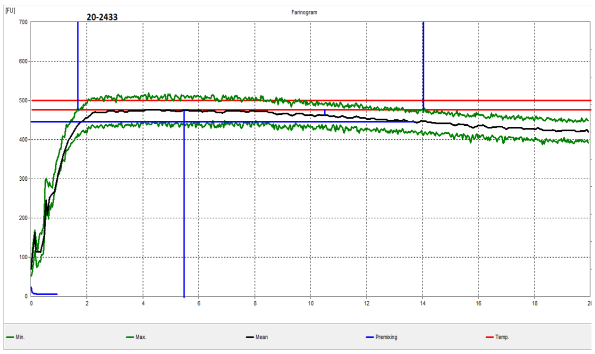
Northern States: Physical Dough Tests and Gluten Analysis 2020 (Small-Scale) Samples (continued)

Test Entry Number	20-2437	20-2438	20-2439	20-2440
Sample Identification	NE14696	PSB13NEDH-14-83W	09BC308-14-16	SD12DHA03282
MIXOGRAPH				
Flour Abs (% as-is)	69.1	65.0	65.4	65.2
Flour Abs (14% mb)	67.9	65.0	65.1	64.7
Mix Time (min)	4.1	3.4	4.6	3.5
Mix tolerance (0-6)	3	3	4	4
FARINOGRAPH				
Flour Abs (% as-is)	64.1	60.1	61.9	60.7
Flour Abs (14% mb)	62.9	60.1	61.8	60.1
Peak time (min)	4.5	5.7	6.7	6.6
Mix stability (min)	8.9	9.9	10.2	9.3
Mix Tolerance Index (FU)	27	29	32	32
Breakdown time (min)	10.7	11.1	11.3	10.9
ALVEOGRAPH				
P(mm): Tenacity	112	87	102	88
L(mm): Extensibility	86	90	87	81
G(mm): Swelling index	20.6	21.1	20.7	20.0
W(10^{-4} J): strength (curve area)	326	251	317	238
P/L: curve configuration ratio	1.3	0.97	1.17	1.09
Ie(P_{200}/P): elasticity index	56.1	56.3	60.5	53.2
EXTENSIGRAPH				
Resist (BU at 45/90/135 min)	421/551/615	302/405/435	380/539/589	316/369/388
Extensibility (mm at 45/90/135 min)	147/130/132	157/156/162	155/149/141	173/186/168
Energy (cm^2 at 45/90/135 min)	108/119/136	89/114/134	108/149/146	106/136/126
Resist $_{max}$ (BU at 45/90/135min)	575/729/829	424/560/645	538/809/862	456/551/589
Ratio (at 45/90/135 min)	2.9/4.2/4.7	1.9/2.6/2.7	2.5/3.6/4.2	1.8/2.0/2.3
PROTEIN ANALYSIS				
HMW-GS Composition	2*, 7+9, 5+10	2*, 7+8, 5+10	2, 7+8, 5+10	2*, 7+9, 5+10
TPP/TMP	0.90	0.86	0.83	0.80
SEDIMENTATION TEST				
Volume (ml)	51.4	45.0	54.3	58.2

Physical Dough Tests

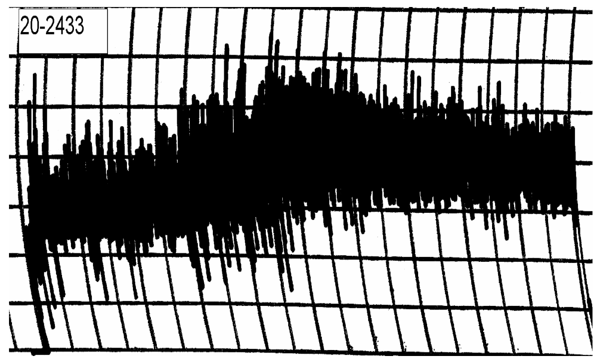
2020 (Small Scale) Samples – Northern States

Farinograms



Water abs = 63.3%, Peak time = 5.5 min,
Mix stab = 12.4 min, MTI = 14 FU

Mixograms

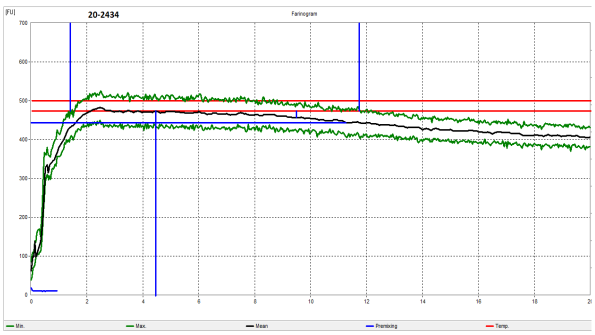


Water abs = 68.3%
Mix time = 4.6 min

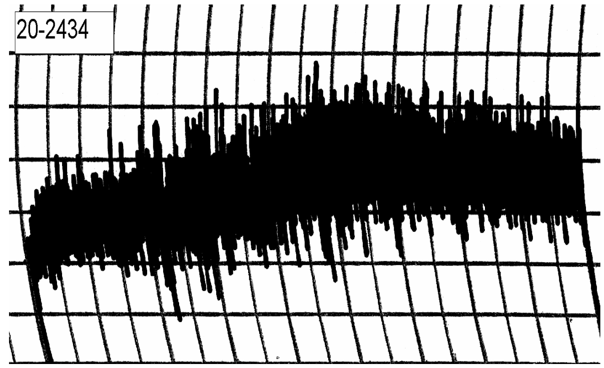
20-2433, Jagalene (CC09)

Physical Dough Tests

2020 (Small Scale) Samples – Northern States



Water abs = 61.2%, Peak time = 4.5 min,
Mix stab = 10.3 min, MTI = 17 FU

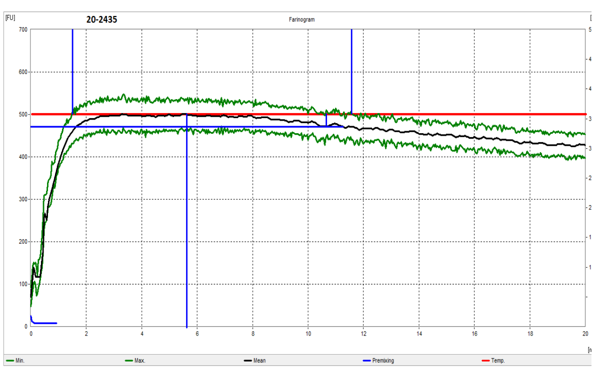


Water abs = 67.0%
Mix time = 5.1 min

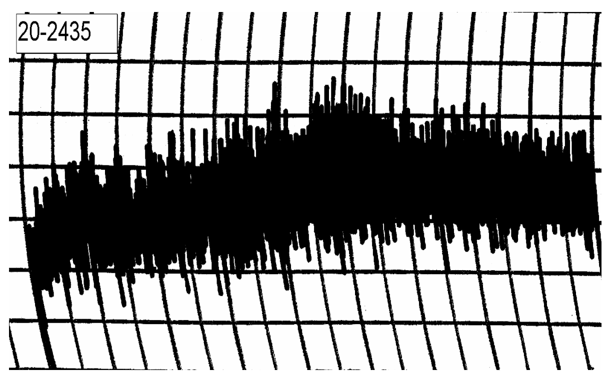
20-2434, 17NORD-94

Farinograms

Mixograms



Water abs = 61.1%, Peak time = 5.7 min,
Mix stab = 10.1 min, MTI = 30 FU

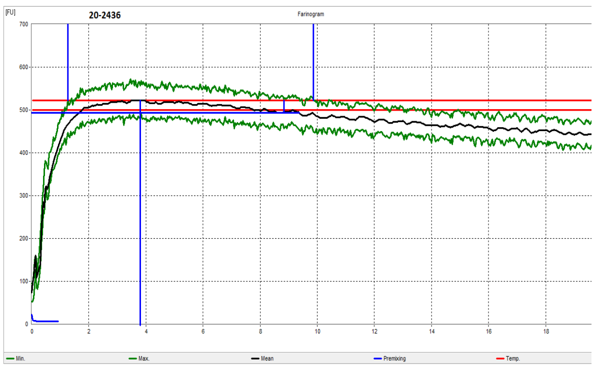


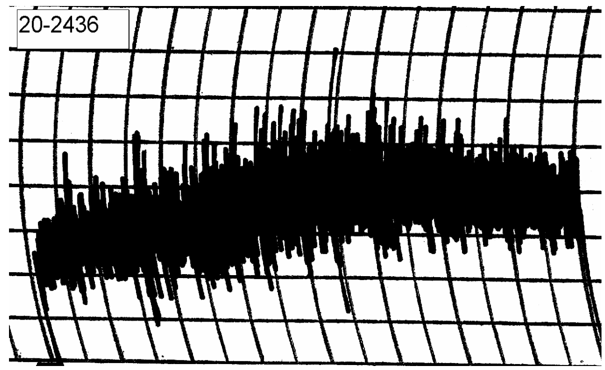
Water abs = 66.4%
Mix time = 5.0 min

20-2435, 17NORD-96

Physical Dough Tests

2020 (Small Scale) Samples – Northern States





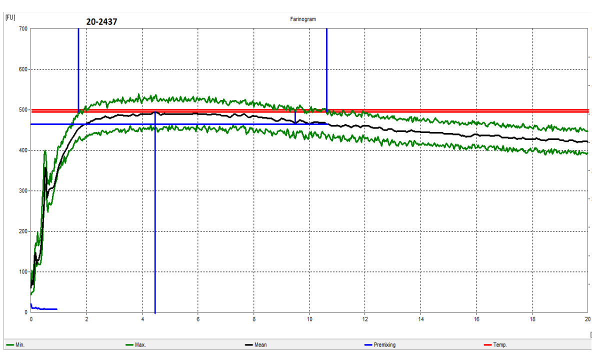
Water abs = 62.1%, Peak time = 3.8 min,
Mix stab = 8.6 min, MTI = 27 FU

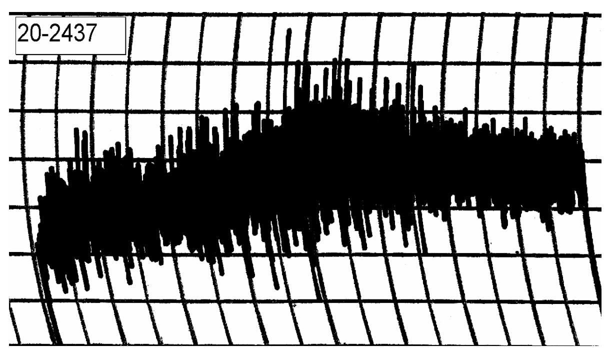
Water abs = 66.9%
Mix time = 4.5 min

20-2436, NE14434

Farinograms

Mixograms



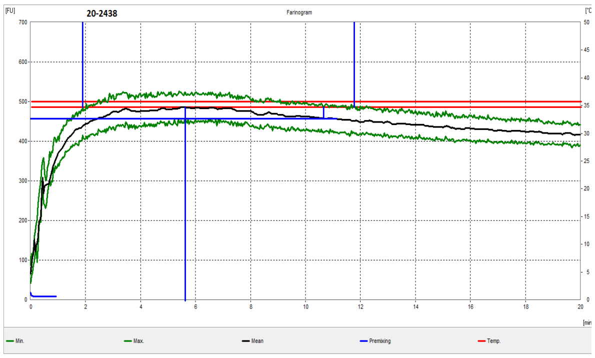


Water abs = 62.9%, Peak time = 4.5 min,
Mix stab = 8.9 min, MTI = 27 FU

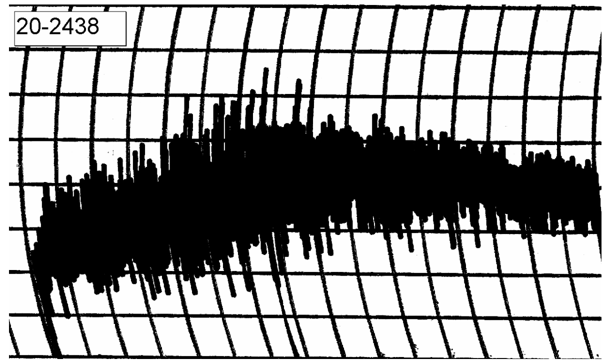
Water abs = 67.9%
Mix time = 4.1min

20-2437, NE14696

Physical Dough Tests
2020 (Small Scale) Samples – Northern States



Water abs = 60.1%, Peak time = 5.7 min,
Mix stab = 9.9 min, MTI = 29 FU

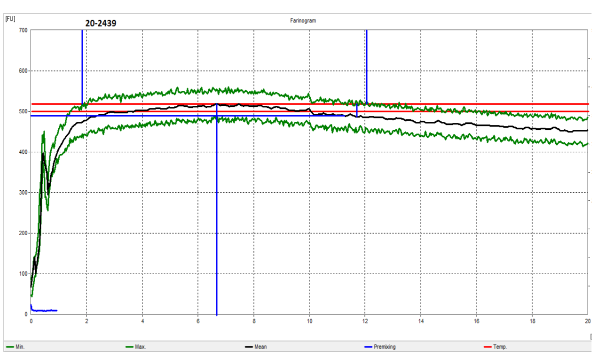


Water abs = 65.0%
Mix time = 3.4 min

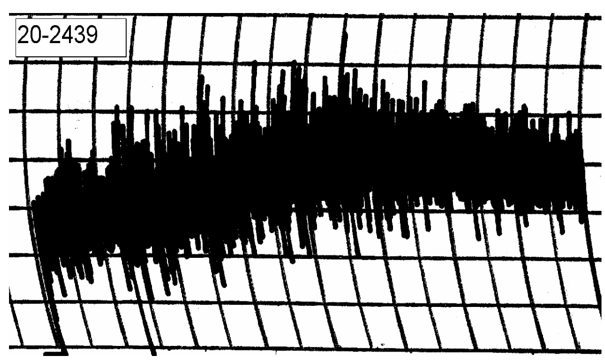
20-2438, PSB13NEDH-14-83W

Farinograms

Mixograms



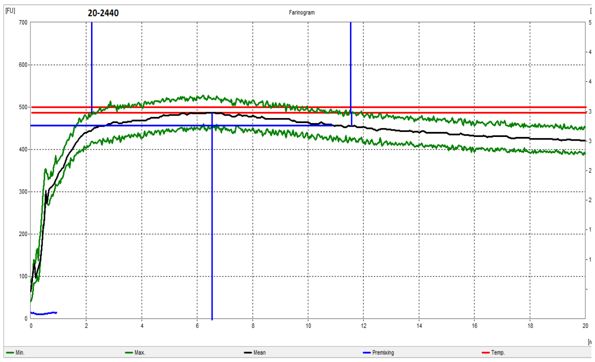
Water abs = 61.8%, Peak time = 6.7 min,
Mix stab = 10.2 min, MTI = 32 FU



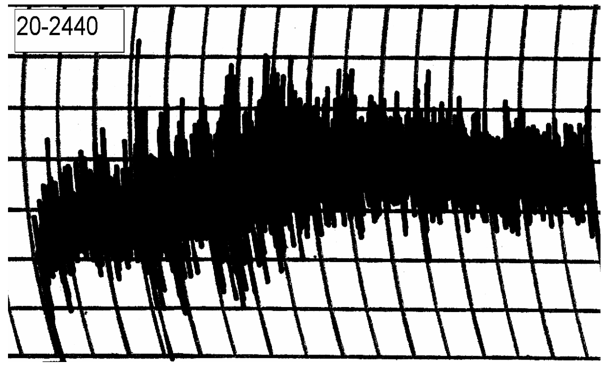
Water abs = 65.1%
Mix time = 4.6 min

20-2439, 09BC308-14-16

Physical Dough Tests
2020 (Small Scale) Samples – Northern States



Water abs = 60.1%, Peak time = 6.6 min,
Mix stab = 9.3 min, MTI = 32 FU

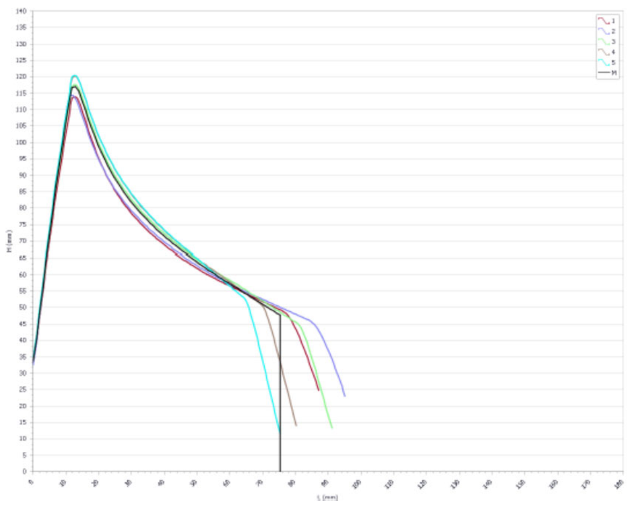


Water abs = 64.7%
Mix time = 3.5 min

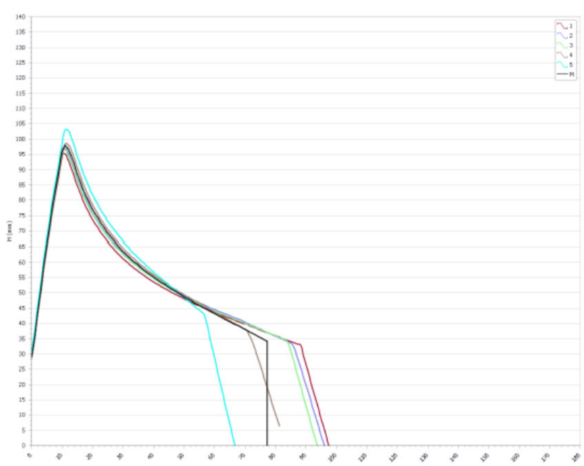
20-2440, SD12DHA03282

Physical Dough Tests - Alveograph

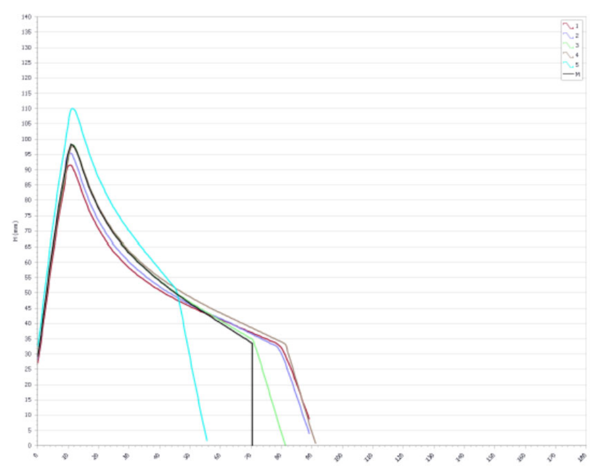
2020 (Small Scale) Samples – Northern States



20-2433, Jagalene (CC09)
P(mm $H_2$0) =129, L(mm) = 75, W(10E^{-4} J) = 366



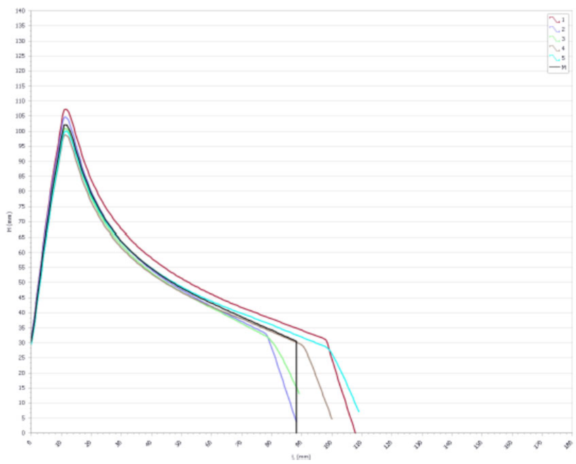
20-2434, 17NORD-94
P(mm $H_2$0) =108, L(mm) = 76, W(10E^{-4} J) = 295



20-2435, 17NORD-96
P(mm $H_2$0) =185, L(mm) = 70, W(10E^{-4} J) = 273

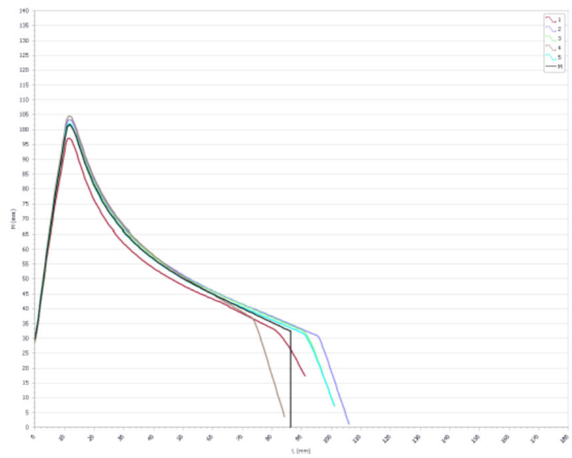
Physical Dough Tests - Alveograph

2020 (Small Scale) Samples – Northern States



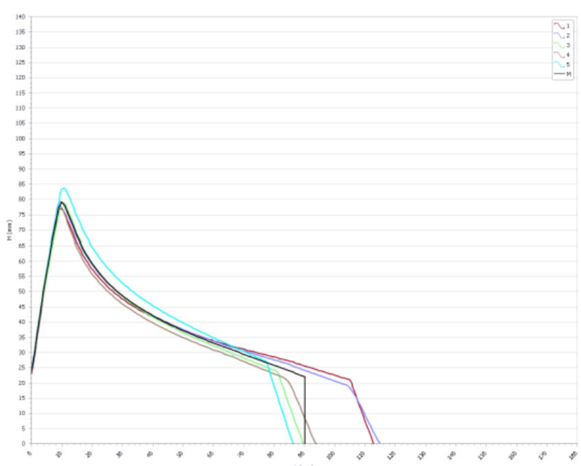
20-2436, NE14434

P(mm H_20) = 112, L(mm) = 88, W($10E^{-4}$ J) = 323



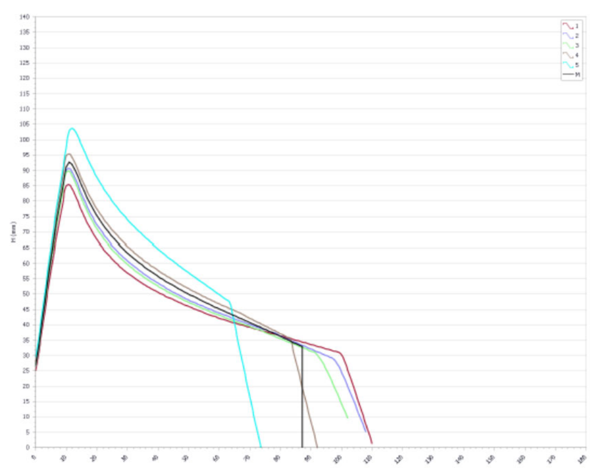
20-2437, NE14696

P(mm H_20) = 112, L(mm) = 86, W($10E^{-4}$ J) = 326



20-2438, PSB13NEDH-14-83W

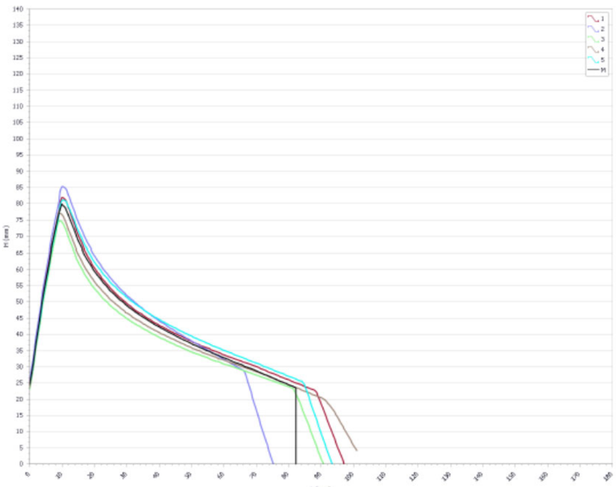
P(mm H_20) = 87, L(mm) = 90, W($10E^{-4}$ J) = 251



20-2439, 09BC308-14-16

P(mm H_20) = 102, L(mm) = 87, W($10E^{-4}$ J) = 317

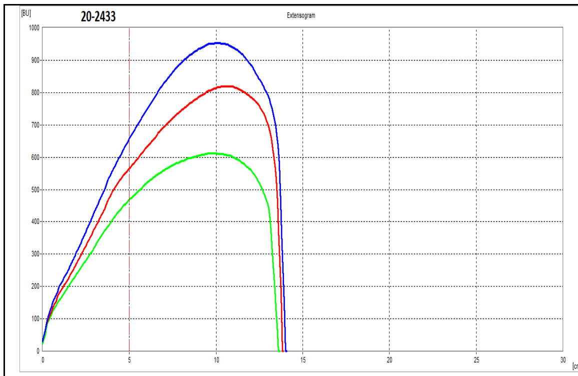
Physical Dough Tests - Alveograph
2020 (Small Scale) Samples – Northern States



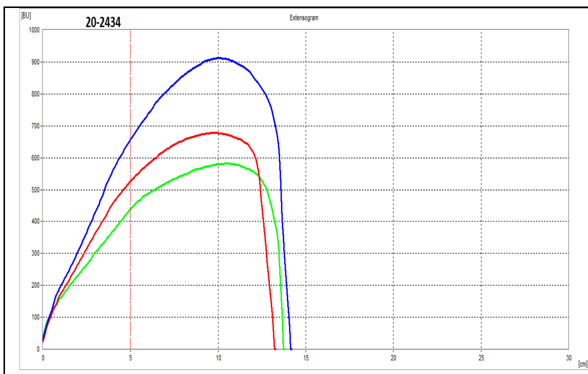
20-2440, SD12DHA03282
P(mm $H_2$0) =88, L(mm) = 81, W(10E^{-4} J) = 238

Physical Dough Tests - Extensigraph

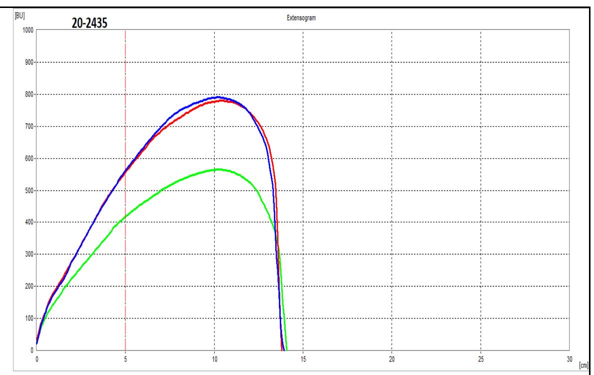
2020 (Small Scale) Samples – Northern States



20-2433, Jagalene (CC09)
R (BU) =568, E (mm) = 140, W (cm^2) = 142
Rmax (BU) = 819, Ratio = 4.1 at 90 min



20-2434, 17NORD-94
R (BU) =528, E (mm) = 134, W (cm^2) = 115
Rmax (BU) = 677, Ratio = 4.0 at 90 min

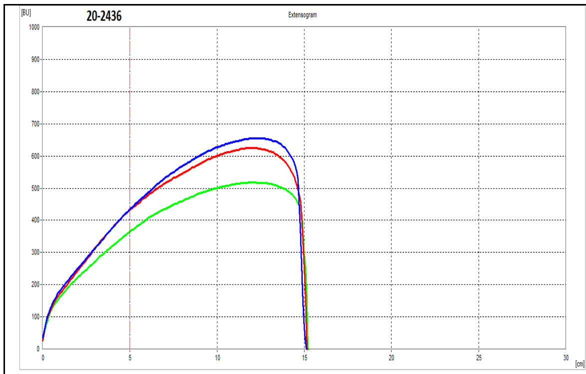


20-2435, 17NORD-96
R (BU) = 559, E (mm) = 138, W (cm^2) = 137
Rmax (BU) = 780, Ratio = 4.1 at 90 min

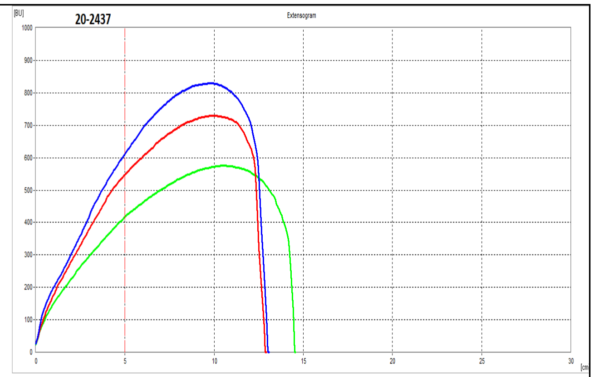
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigraph

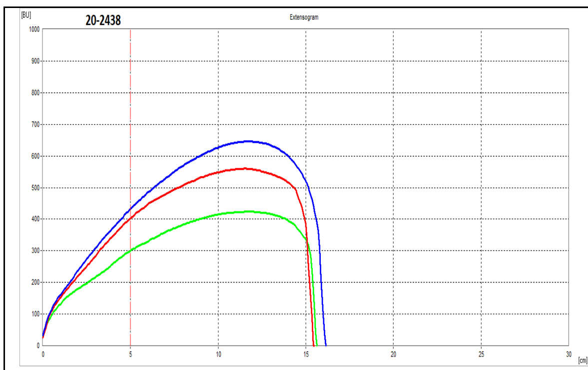
2020 (Small Scale) Samples – Northern States



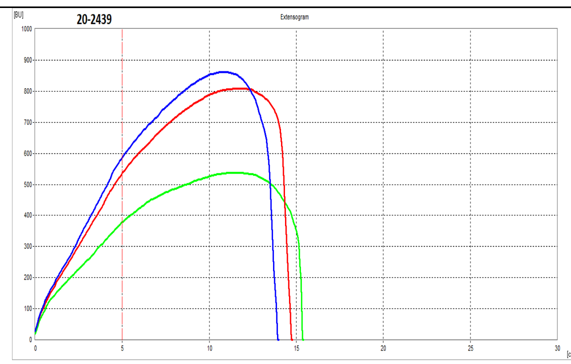
20-2436, NE14434
R (BU) = 434, E (mm) = 153, W (cm^2) = 124
Rmax (BU) = 624, Ratio = 2.8 at 90 min



20-2437, NE14696
R (BU) = 551, E (mm) = 130, W (cm^2) = 119
Rmax (BU) = 729, Ratio = 4.2 at 90 min



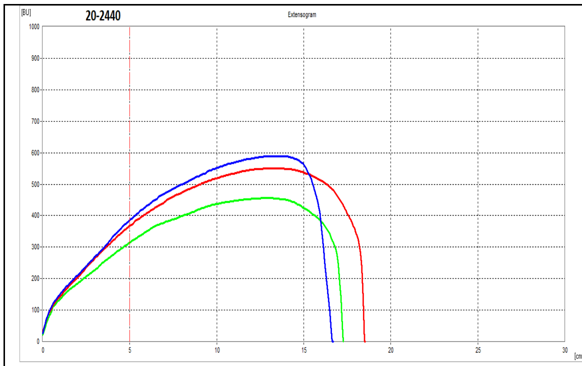
20-2438, PSB13NEDH-14-83W
R (BU) = 405, E (mm) = 156, W (cm^2) = 114
Rmax (BU) = 560, Ratio = 2.6 at 90 min



20-2439, 09BC308-14-16
R (BU) = 539, E (mm) = 149, W (cm^2) = 149
Rmax (BU) = 809, Ratio = 3.6 at 90 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigraph
2020 (Small Scale) Samples – Northern States



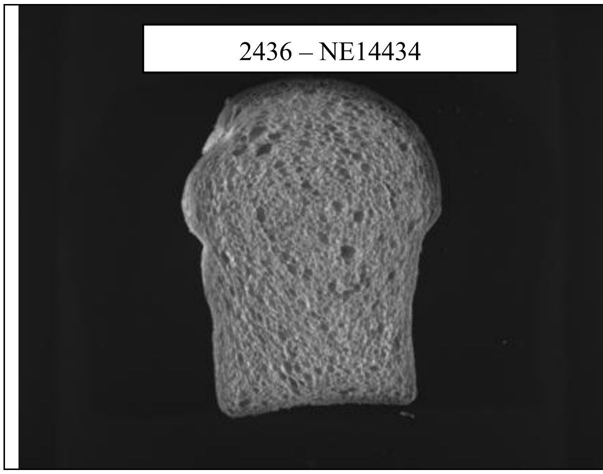
20-2440, SD12DHA03282
R (BU) =369, E (mm) = 186, W (cm^2) = 136
Rmax (BU) = 551, Ratio = 2.0 at 90 min

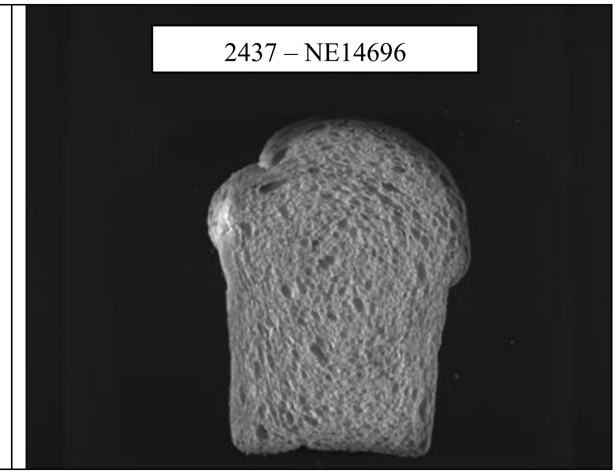
Northern States: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples

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})
2433	6862	111	3497	0.443	2.392	8.136	1.836	-5.70

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})
2434	6786	112	3787	0.429	2.184	5.037	1,839	-5.55
2435	6479	115	3408	0.442	2.365	4.224	1.851	-7.71

Northern States: C-Cell Bread Images and Analysis
2020 (Small-Scale) Samples



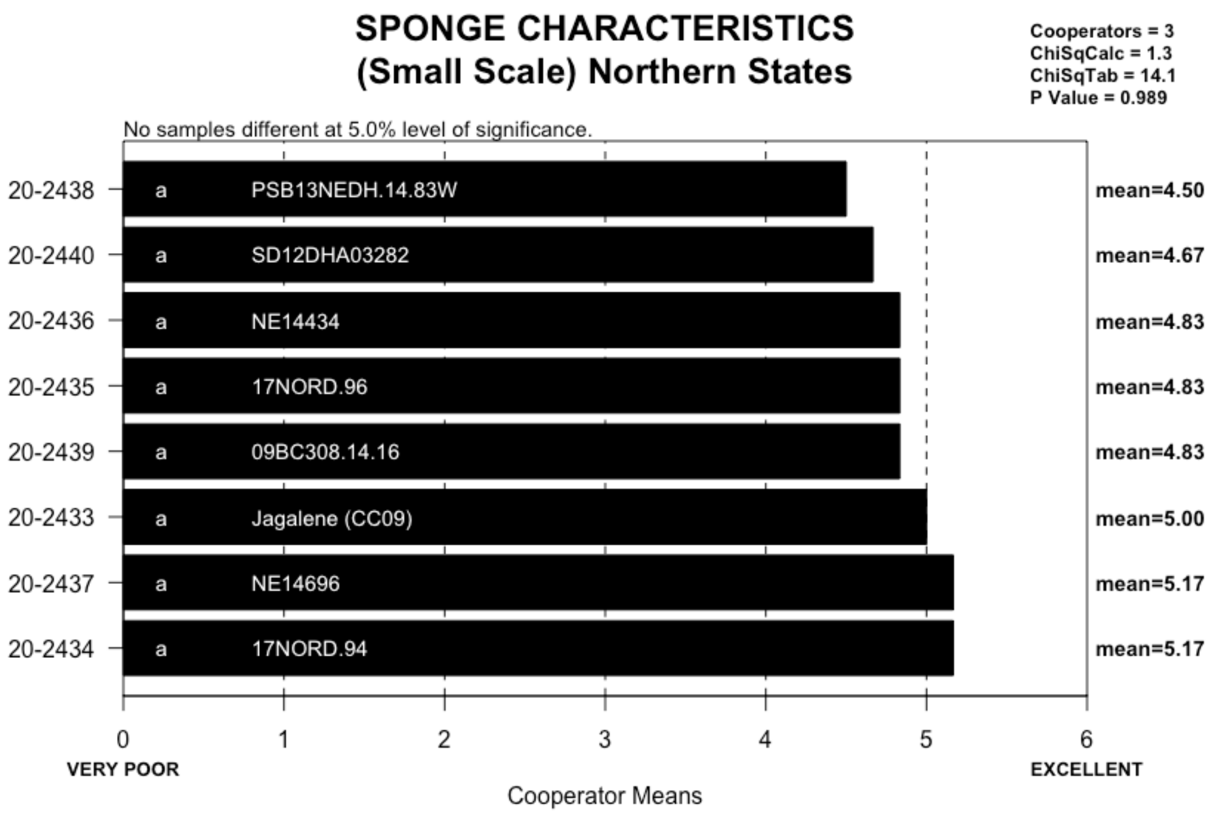


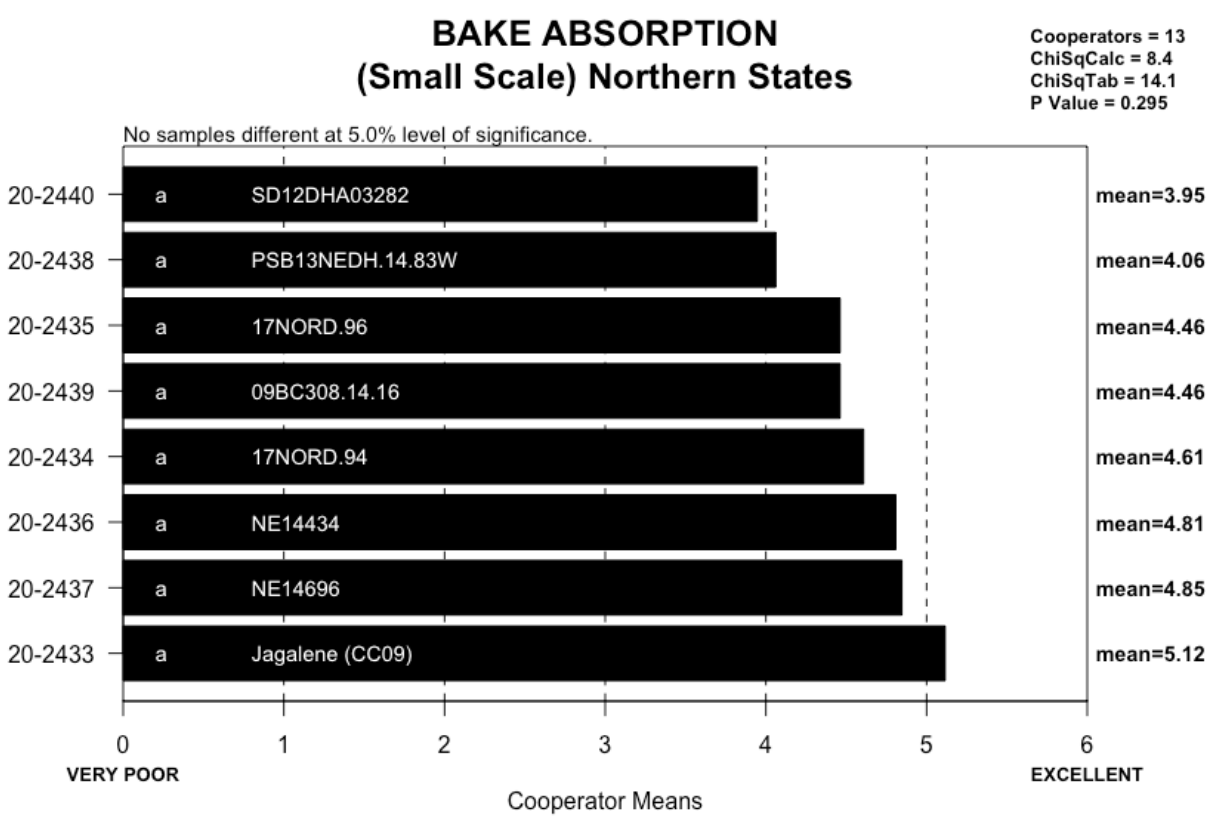
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2436	6773	111	3877	0.427	2.119	0.365	1.780	-5.09
2437	6966	117	3889	0.428	2.187	0.872	1.842	-7.73

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})
2438	6738	121	3818	0.434	2.207	0.785	1.785	-5.88
2439	7429	118	3857	0.444	2.337	3.095	1.790	-7.51

Northern States: C-Cell Bread Images and Analysis
2020 (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})
2440	6848	120	3900	0.429	2.111	0.717	1.811	-1.16


SPONGE CHARACTERISTICS
(Small Scale) Northern States
Cooperators = 3
ChiSqCalc = 1.3
ChiSqTab = 14.1
P Value = 0.989
No samples different at 5.0% level of significance.
20-2438 a PSB13NEDH.14.83W mean=4.50
20-2440 a SD12DHA03282 mean=4.67
20-2436 a NE14434 mean=4.83
20-2435 a 17NORD.96 mean=4.83
20-2439 a 09BC308.14.16 mean=4.83
20-2433 a Jagalene (CC09) mean=5.00
20-2437 a NE14696 mean=5.17
20-2434 a 17NORD.94 mean=5.17
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

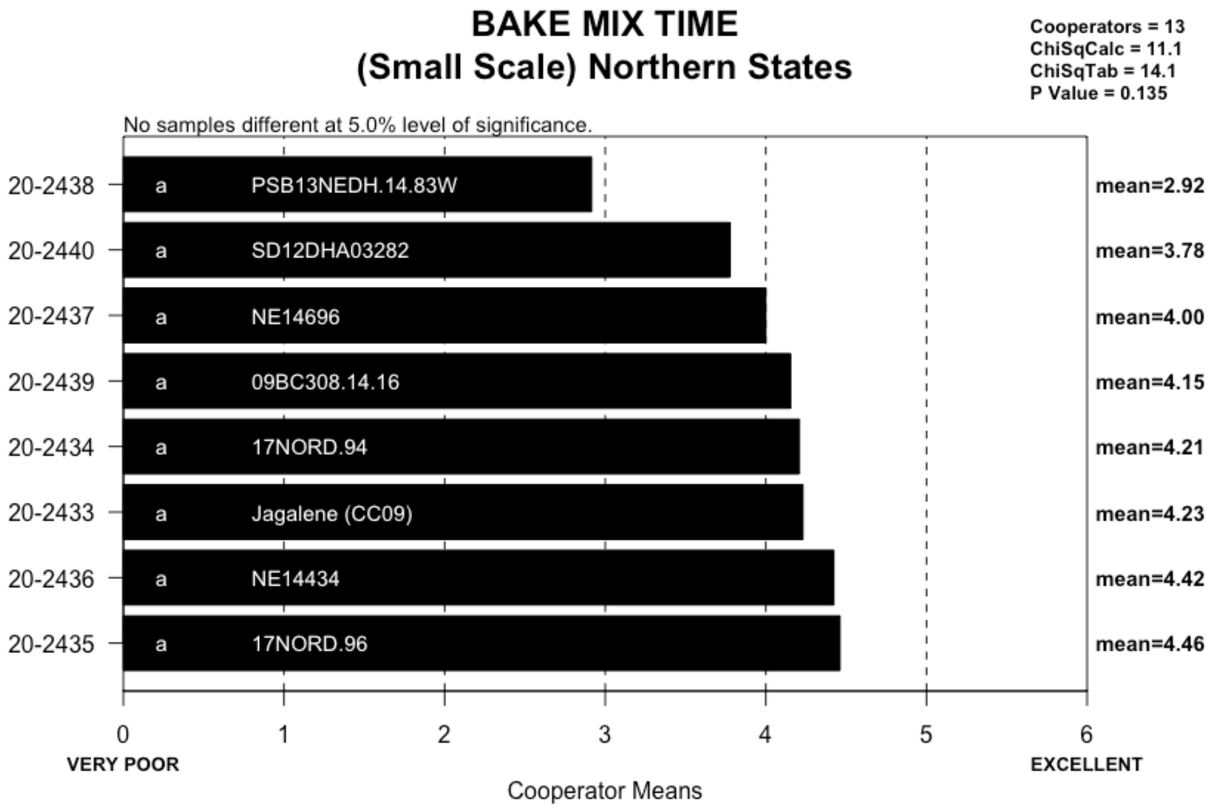

BAKE ABSORPTION
(Small Scale) Northern States
Cooperators = 13
ChiSqCalc = 8.4
ChiSqTab = 14.1
P Value = 0.295
No samples different at 5.0% level of significance.
20-2440 a SD12DHA03282 mean=3.95
20-2438 a PSB13NEDH.14.83W mean=4.06
20-2435 a 17NORD.96 mean=4.46
20-2439 a 09BC308.14.16 mean=4.46
20-2434 a 17NORD.94 mean=4.61
20-2436 a NE14434 mean=4.81
20-2437 a NE14696 mean=4.85
20-2433 a Jagalene (CC09) mean=5.12
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

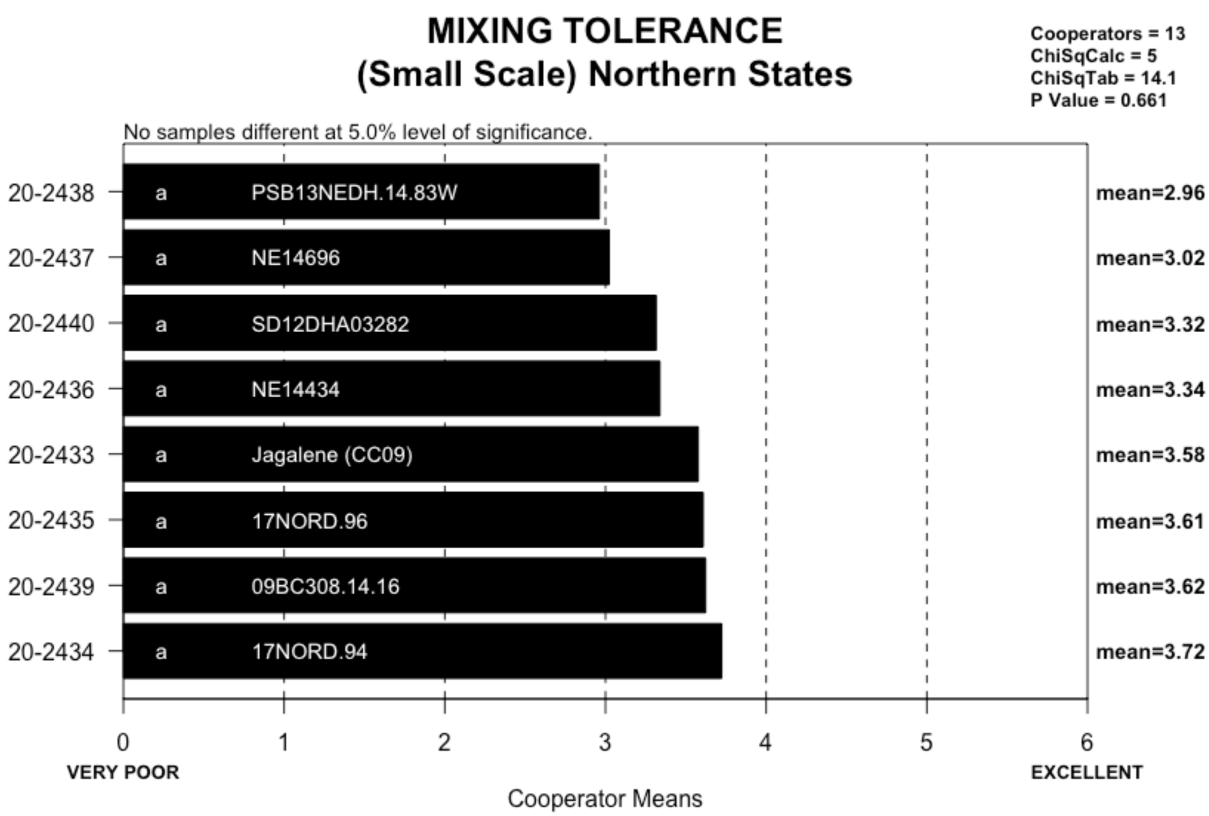
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Northern States
Cooperators A – M

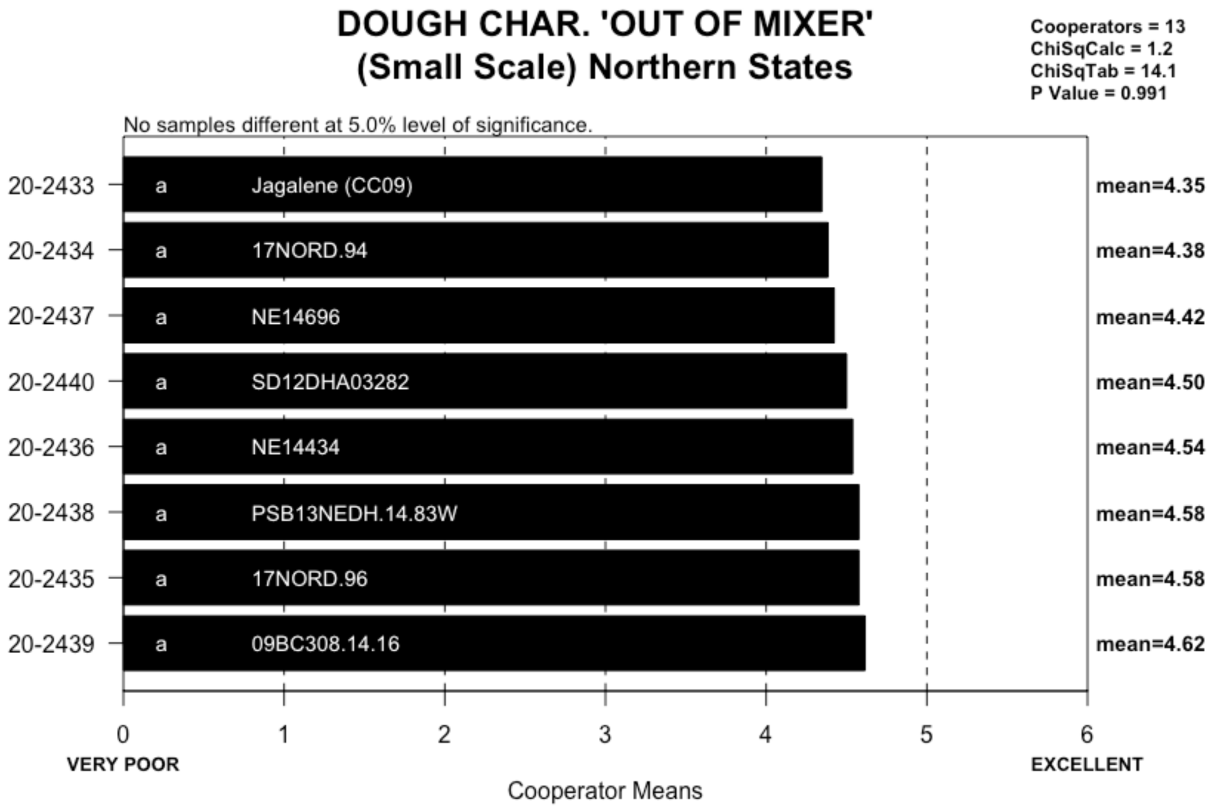
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2433	Jagalene (CC09)	59	69.8	70.0	68.7	66.5	65.1	68.9	68.2	64.8	63.3	60.5	68.3	65.3
20-2434	17NORD-94	58	67.2	68.3	68.0	65.3	64.9	68.1	67.0	62.8	61.2	57.8	67.0	63.2
20-2435	17NORD-96	58	67.2	67.8	66.4	64.9	64.0	66.1	66.5	62.1	61.1	57.8	66.4	63.1
20-2436	NE14434	59	68.6	68.5	68.7	65.6	65.0	66.9	67.2	63.1	62.1	58.5	66.9	64.1
20-2437	NE14696	59	68.9	69.3	68.0	66.8	66.0	67.9	67.5	63.6	62.9	59.8	67.9	64.9
20-2438	PSB13NEDH-14-83W	59	65.1	65.0	66.2	65.8	63.8	66.5	64.7	61.0	60.1	58.0	65.0	62.1
20-2439	09BC308-14-16	59	67.1	65.2	67.4	65.7	64.0	65.7	65.4	62.6	61.8	59.7	65.1	63.8
20-2440	SD12DHA03282	58	65.1	65.4	66.1	64.9	63.3	64.7	64.7	61.1	60.1	57.5	64.7	62.1

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2433	Jagalene (CC09)	6	4.5	5.5	5.7	4.5	7.4	5.0	6.3	5.0	8	4	4.6	20
20-2434	17NORD-94	8	4.5	5.3	6.0	4.3	5.7	4.8	6.5	4.8	8	4	5.1	17
20-2435	17NORD-96	7	5.5	5.6	5.5	4.5	6.8	5.0	6.4	5.0	8	4	5.0	20
20-2436	NE14434	8	4.5	5.6	5.4	4.5	6.7	4.8	6.1	5.3	8	5	4.5	20
20-2437	NE14696	5	4.5	4.7	5.3	4.3	6.5	4.5	6.5	4.3	8	4	4.1	20
20-2438	PSB13NEDH-14-83W	5	4.0	3.7	3.0	4.0	4.4	3.8	3.5	3.0	8	4	3.4	14
20-2439	09BC308-14-16	6	4.5	4.7	5.3	4.5	6.4	4.8	5.3	4.3	8	5	4.6	20
20-2440	SD12DHA03282	6	4.5	4.3	5.0	4.0	5.6	4.0	4.8	3.8	8	4	3.5	20

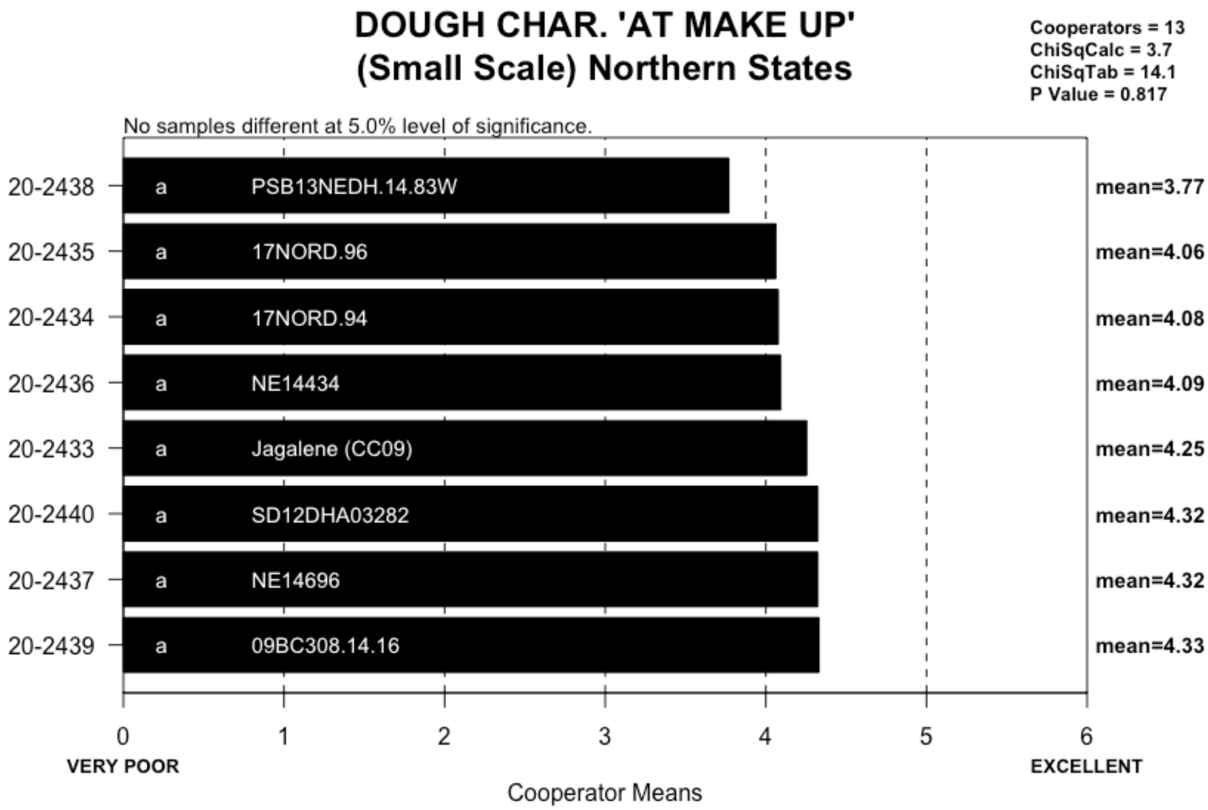

BAKE MIX TIME
(Small Scale) Northern States
Cooperators = 13
ChiSqCalc = 11.1
ChiSqTab = 14.1
P Value = 0.135
No samples different at 5.0% level of significance.
20-2438 a PSB13NEDH.14.83W mean=2.92
20-2440 a SD12DHA03282 mean=3.78
20-2437 a NE14696 mean=4.00
20-2439 a 09BC308.14.16 mean=4.15
20-2434 a 17NORD.94 mean=4.21
20-2433 a Jagalene (CC09) mean=4.23
20-2436 a NE14434 mean=4.42
20-2435 a 17NORD.96 mean=4.46
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Northern States
Cooperators = 13
ChiSqCalc = 5
ChiSqTab = 14.1
P Value = 0.661
No samples different at 5.0% level of significance.
20-2438 a PSB13NEDH.14.83W mean=2.96
20-2437 a NE14696 mean=3.02
20-2440 a SD12DHA03282 mean=3.32
20-2436 a NE14434 mean=3.34
20-2433 a Jagalene (CC09) mean=3.58
20-2435 a 17NORD.96 mean=3.61
20-2439 a 09BC308.14.16 mean=3.62
20-2434 a 17NORD.94 mean=3.72
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



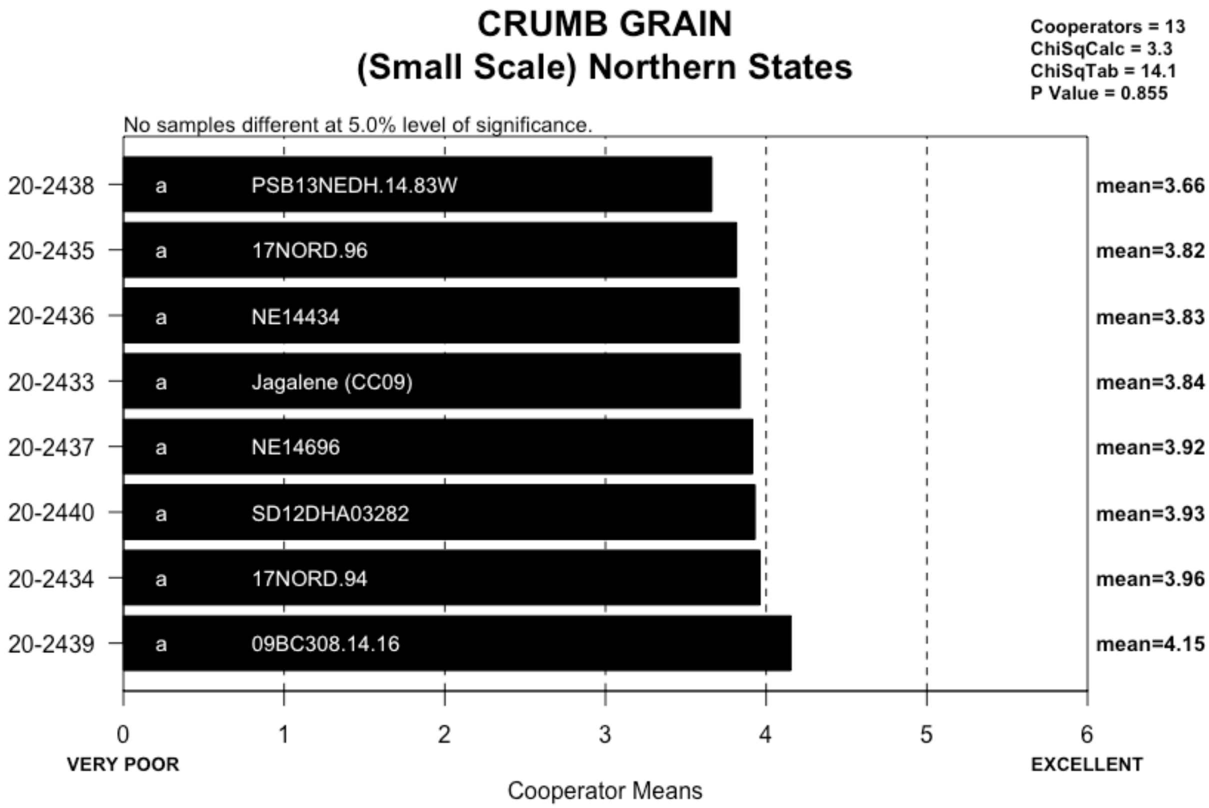
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Northern States

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2433	Jagalene (CC09)	0	0	3	9	1
20-2434	17NORD-94	0	1	2	8	2
20-2435	17NORD-96	0	1	0	10	2
20-2436	NE14434	0	1	2	8	2
20-2437	NE14696	1	1	1	9	1
20-2438	PSB13NEDH-14-83W	2	1	0	8	2
20-2439	09BC308-14-16	1	0	2	7	3
20-2440	SD12DHA03282	1	1	1	9	1



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2433	Jagalene (CC09)	1	1	2	9	0
20-2434	17NORD-94	0	0	3	10	0
20-2435	17NORD-96	1	0	2	9	1
20-2436	NE14434	1	0	1	11	0
20-2437	NE14696	1	0	1	10	1
20-2438	PSB13NEDH-14-83W	1	1	1	10	0
20-2439	09BC308-14-16	1	0	1	10	1
20-2440	SD12DHA03282	1	0	2	9	1

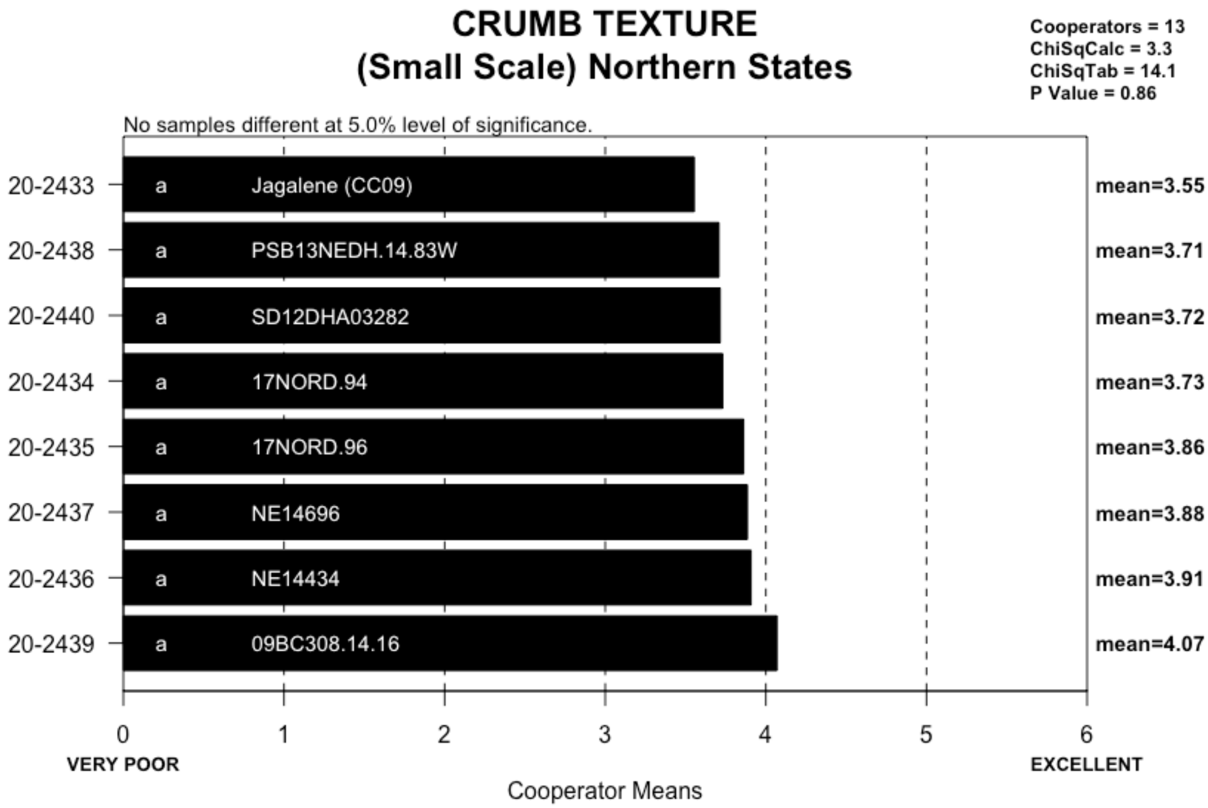


CRUMB GRAIN, DESCRIBED
(Small Scale) Northern States

IDCODE	ID	Open	Fine	Dense
20-2433	Jagalene (CC09)	6	6	1
20-2434	17NORD-94	6	6	1
20-2435	17NORD-96	6	7	0
20-2436	NE14434	4	8	1
20-2437	NE14696	8	5	0
20-2438	PSB13NEDH-14-83W	6	4	3
20-2439	09BC308-14-16	4	8	1
20-2440	SD12DHA03282	5	7	1

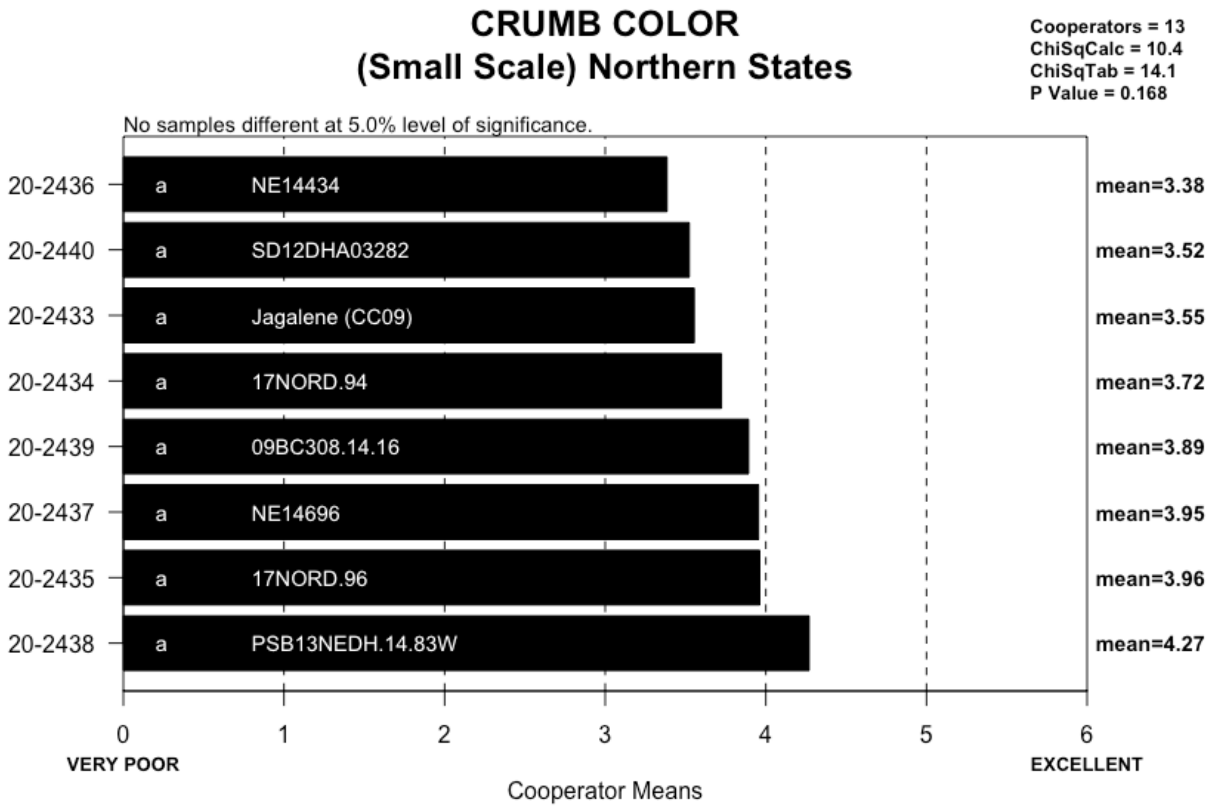
CELL SHAPE, DESCRIBED
(Small Scale) Northern States

IDCODE	ID	Round	Irregular	Elongated
20-2433	Jagalene (CC09)	1	8	4
20-2434	17NORD-94	3	6	4
20-2435	17NORD-96	2	7	4
20-2436	NE14434	3	5	5
20-2437	NE14696	3	6	4
20-2438	PSB13NEDH-14-83W	5	5	3
20-2439	09BC308-14-16	2	5	6
20-2440	SD12DHA03282	3	5	5



CRUMB TEXTURE, DESCRIBED
(Small Scale) Northern States

IDCODE	ID	Harsh	Smooth	Silky
20-2433	Jagalene (CC09)	3	7	3
20-2434	17NORD-94	1	11	1
20-2435	17NORD-96	2	9	2
20-2436	NE14434	3	8	2
20-2437	NE14696	3	7	3
20-2438	PSB13NEDH-14-83W	3	8	2
20-2439	09BC308-14-16	1	9	3
20-2440	SD12DHA03282	2	9	2



CRUMB COLOR, DESCRIBED
(Small Scale) Northern States

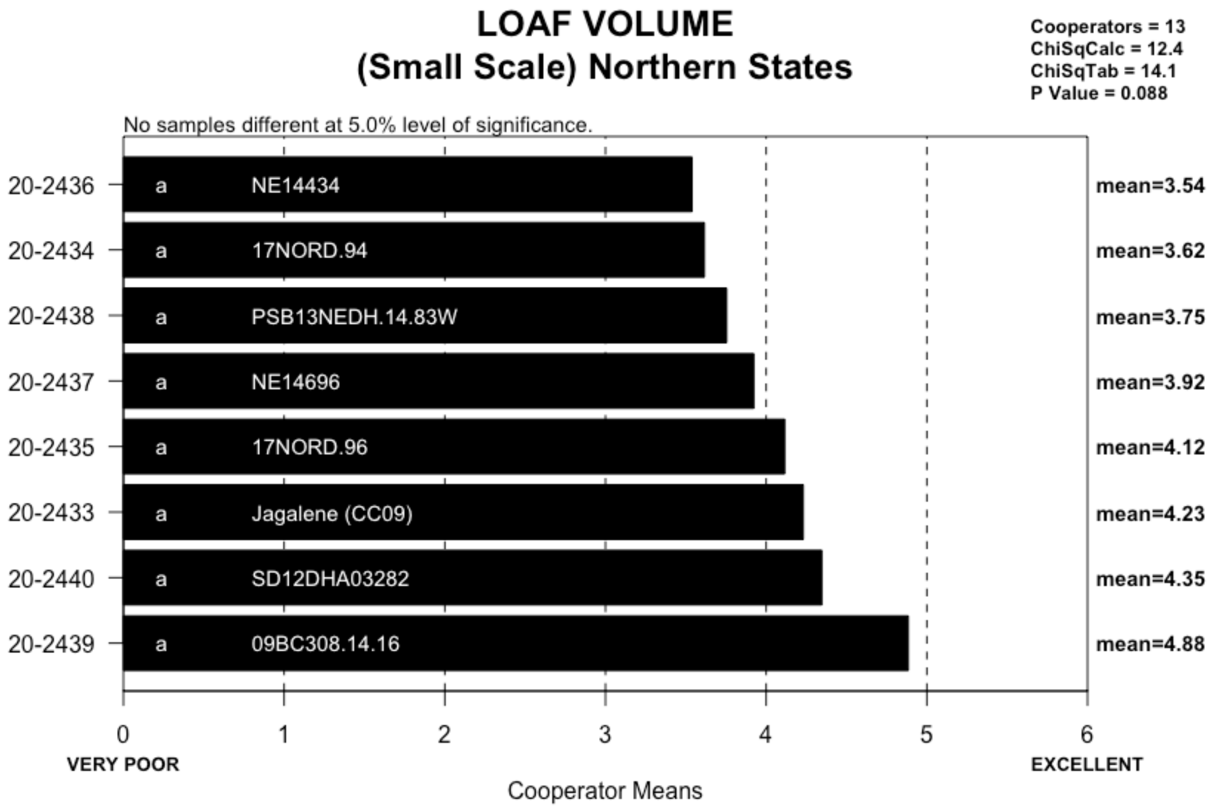
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2433	Jagalene (CC09)	1	1	2	1	7	1	0
20-2434	17NORD-94	1	0	0	6	5	1	0
20-2435	17NORD-96	0	0	1	4	6	2	0
20-2436	NE14434	0	0	2	6	5	0	0
20-2437	NE14696	0	0	1	4	5	3	0
20-2438	PSB13NEDH-14-83W	0	0	0	2	9	2	0
20-2439	09BC308-14-16	0	0	2	1	9	1	0
20-2440	SD12DHA03282	0	0	3	3	6	1	0

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

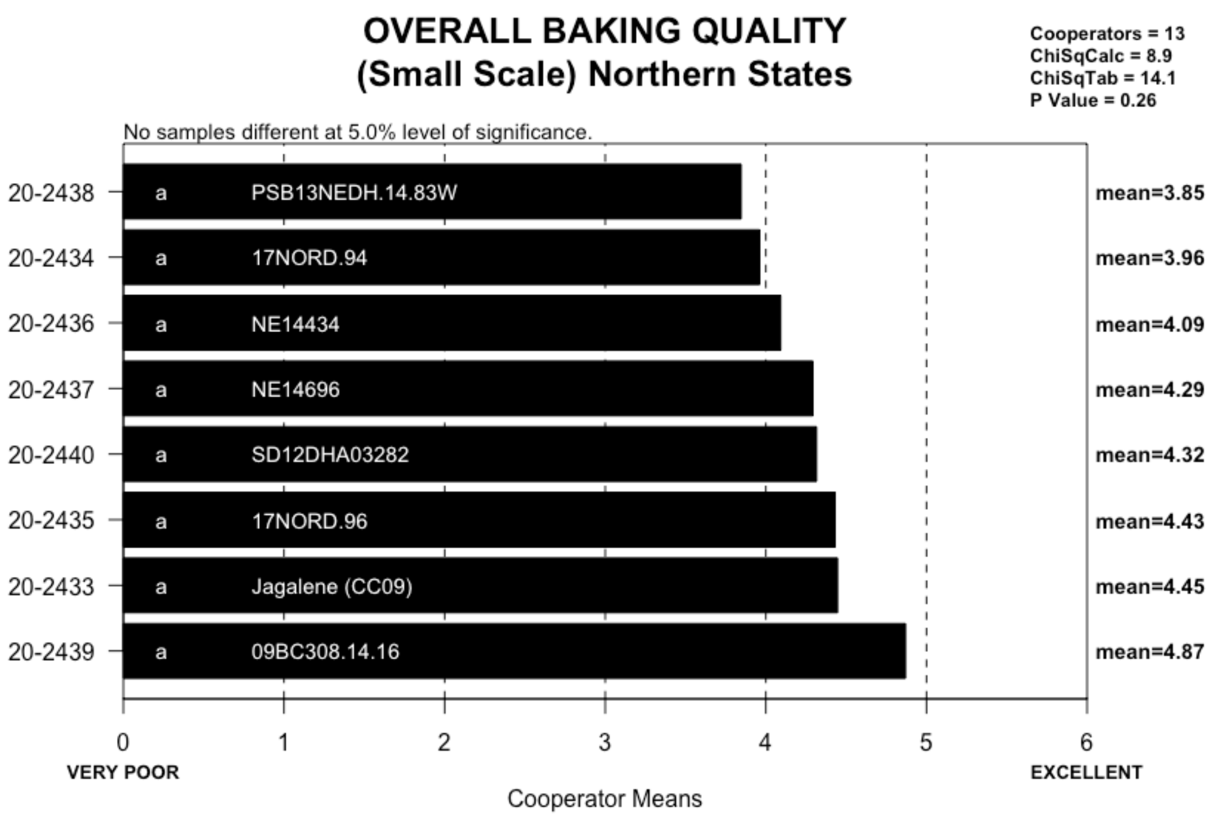
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2433	Jagalene (CC09)	410	135.6	137.0	156.8	145.6	139.1	147.6	152.1	139	456.3	482.5	146.0	424.2
20-2434	17NORD-94	415	130.1	139.2	155.7	143.0	141.8	146.3	150.5	139	460.3	480.8	144.1	429.8
20-2435	17NORD-96	408	131.1	138.3	152.9	142.1	136.3	145.6	151.6	141	459.1	481.4	143.8	431.4
20-2436	NE14434	412	133.4	136.6	154.3	143.9	141.6	145.9	149.6	140	459.6	484.8	142.9	429.9
20-2437	NE14696	409	135.8	138.8	152.6	145.1	141.6	144.5	151.7	142	460.4	479.2	143.4	430.6
20-2438	PSB13NEDH-14-83W	410	130.6	138.0	153.7	145.3	143.9	143.9	151.4	140	461.2	479.9	141.1	427.0
20-2439	09BC308-14-16	413	132.6	136.4	150.7	144.4	135.5	142.2	150.5	140	461.4	477.5	144.0	429.6
20-2440	SD12DHA03282	416	130.2	138.0	150.8	144.4	140.8	142.6	151.2	139	462.8	477.3	144.6	432.1

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2433	Jagalene (CC09)	3100	950	902	913	990	908	985	960	812	2634	2563	870	2700
20-2434	17NORD-94	2725	865	848	918	925	860	900	915	829	2589	2438	875	2475
20-2435	17NORD-96	2900	885	878	918	970	900	965	895	780	2703	2450	935	2750
20-2436	NE14434	2825	875	866	948	880	910	875	910	763	2596	2263	900	2550
20-2437	NE14696	2825	875	870	895	915	910	910	940	819	2605	2438	905	2725
20-2438	PSB13NEDH-14-83W	2775	945	870	898	900	948	890	910	865	2693	2438	900	2550
20-2439	09BC308-14-16	2800	1010	948	1033	1025	983	1025	1010	899	2741	2675	900	2900
20-2440	SD12DHA03282	2750	960	892	970	955	1000	900	955	890	2524	2625	850	2700



LOAF VOLUME
(Small Scale) Northern States
Cooperators = 13
ChiSqCalc = 12.4
ChiSqTab = 14.1
P Value = 0.088
No samples different at 5.0% level of significance.
20-2436 a NE14434 mean=3.54
20-2434 a 17NORD.94 mean=3.62
20-2438 a PSB13NEDH.14.83W mean=3.75
20-2437 a NE14696 mean=3.92
20-2435 a 17NORD.96 mean=4.12
20-2433 a Jagalene (CC09) mean=4.23
20-2440 a SD12DHA03282 mean=4.35
20-2439 a 09BC308.14.16 mean=4.88
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



OVERALL BAKING QUALITY
(Small Scale) Northern States
Cooperators = 13
ChiSqCalc = 8.9
ChiSqTab = 14.1
P Value = 0.26
No samples different at 5.0% level of significance.
20-2438 a PSB13NEDH.14.83W mean=3.85
20-2434 a 17NORD.94 mean=3.96
20-2436 a NE14434 mean=4.09
20-2437 a NE14696 mean=4.29
20-2440 a SD12DHA03282 mean=4.32
20-2435 a 17NORD.96 mean=4.43
20-2433 a Jagalene (CC09) mean=4.45
20-2439 a 09BC308.14.16 mean=4.87
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Northern States

COOP. 20-2433 Jagalene (CC09)

A. No comment.
B. No comment.
C. No comment.
D. Weak dough type for protein level, volume and crumb grain performed as expected for protein.
E. Good.
F. Very High Protein & Water Abs, Long MT, Slightly Sticky & Strong Dough, High Volume, Dark Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
G. Excellent loaf externals.
H. High absorption, avg grain, good volume.
I. No comment.
J. No comment.
K. Avg absorption, good grain, avg volume.
L. No comment.
M. Good stability and MTI, high volume, great dough notes. Recommend.

COOP. 20-2434 17NORD-94

A. No comment.
B. Good crumb, best symmetry.
C. No comment.
D. Weak dough type for protein level, volume and crumb grain performed as expected for protein.
E. Good.
F. High Protein & Water Abs, Normal MT, Slight Sticky & Strong Dough, Medium Volume, Dull Crumb, Open Elongated Cells, Resilient & Slightly Harsh Texture.
G. Good loaf externals.
H. High absorption, avg grain, good volume.
I. Bright creamy crumb color.
J. No comment.
K. Low absorption, avg grain, tough doughs at makeup, low volume.
L. No comment.
M. Overall sample is good, volume has room for improvement.

COOP. 20-2435 17NORD-96

A. No comment.
B. Light crust color.
C. No comment.
D. Dough somewhat weak for protein level, bread volume is at expected level with good crumb grain.
E. Loaf volume exceeded predicted loaf volume.
F. High Protein & Water Abs, Long MT, Slightly Sticky & Strong Dough, High Volume, Yellow Crumb, Fine Elongated Cells with Keyhole, Resilient & Smooth Texture.
G. Excellent loaf externals.
H. High absorption, avg grain and volume.
I. No comment.
J. No comment.
K. Low absorption, avg grain, low volume.
L. No comment.
M. High protein and volume, good absorption, and dough notes. Recommend.

COOP. 20-2436 NE14434

A. No comment.
B. No comment.
C. No comment.
D. Dough somewhat weak for protein level, bread performance is at expected level for protein.
E. Good.
F. High Protein & Water Abs, Long MT, Sticky & Slightly Strong Dough, High Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. Yellow/brown dough.
H. High absorption, good grain and volume.
I. No comment.
J. No comment.
K. Low absorption, dense grain, loaf volume too low.
L. No comment.
M. Overall a good sample.

COOP. 20-2437 NE14696

A. No comment.
B. No comment.
C. No comment.
D. Dough somewhat weak for protein level, bread performance is somewhat low for protein level.
E. Good.
F. Very High Protein & Water Abs, Long MT, Sticky & Slightly Strong Dough, High Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. White dough.
H. High absorption, good grain, creamy color, good volume.
I. Bright creamy crumb color.
J. No comment.
K. Low mixing tolerance, avg absorption and grain, creamy color, low volume.
L. No comment.
M. High protein and volume, good absorption. Recommend for blending.

COOP. 20-2438 PSB13NEDH-14-83W

A. No comment.
B. No comment.
C. No comment.
D. Dough mixing strength low, bread performance low for protein.
E. Good.
F. High Protein & Water Abs, Normal MT, Slightly Sticky & Strong Dough, High Volume, Creamy Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. White dough.
H. Good absorption, good grain, and good volume.
I. Very soft crumb texture.
J. No comment.
K. Low mixing tolerance, low absorption, avg grain, creamy color, low volume.
L. No comment.
M. Fair absorption and dough notes, high protein, volume has room for improvement.

COOP. 20-2439 09BC308-14-16

A. No comment.
B. Largest loaf volume, good color, and good crumb.
C. No comment.
D. Good dough properties, loaf volume and crumb grain performance.
E. Loaf volume exceeded predicted loaf volume, best in set.
F. High Protein & Water Abs, Long MT, Slightly Sticky & Strong Dough, High Volume, Yellow Crumb, Slightly Open Elongated Cells, Resilient & Very Smooth Texture.
G. White dough.
H. Good absorption, excellent grain, excellent dough characteristics, excellent volume.
I. No comment.
J. No comment.
K. Avg absorption, fine grain, creamy color, good volume.
L. No comment.
M. High protein and volume, overall a nice sample. Recommend.

COOP. 20-2440 SD12DHA03282

A. No comment.
B. No comment.
C. No comment.
D. Dough somewhat weak for protein level, bread volume and crumb grain at good levels.
E. Loaf volume exceeded predicted loaf volume.
F. High Protein & Water Abs, Normal MT, Slightly Sticky & Strong Dough, Very High Volume, Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
G. No comment.
H. Good absorption, good grain, and good volume.
I. No comment.
J. No comment.
K. Low mixing tolerance, low absorption, good grain, good volume.
L. No comment.
M. High protein and volume, fair absorption. Recommend.

Notes: **A, K, and M** conducted sponge and dough bake tests

MICRO-QUALITY ANALYSIS

1. LOCATIONS AND ENTRIES

A. There are 4 locations:

Nebraska = NE;

Syngenta (Agripro) = AP;

North Dakota = ND;

South Dakota = SD.

B. There are 8 entries grown in each of locations:

Jagalene (CC09) = JGLN

17NORD-94 = ND94

17NORD-96 = ND96

NE14434 = NE34

NE14696 = NE96

PSB13NEDH-14-83W = PSB

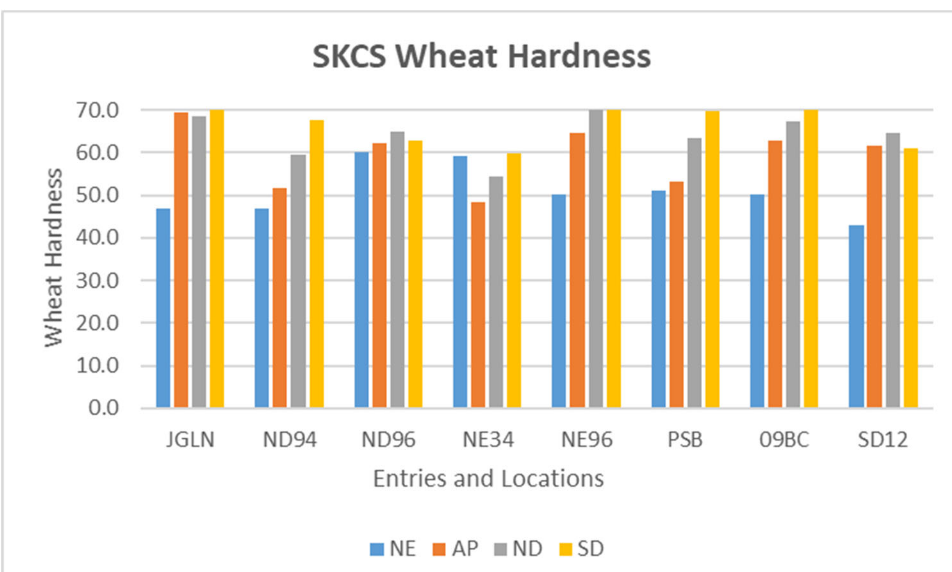
09BC308-14-16 = 09BC

SD12DHA03282 = SD12

2. SKCS SINGLE KERNEL INFORMATION

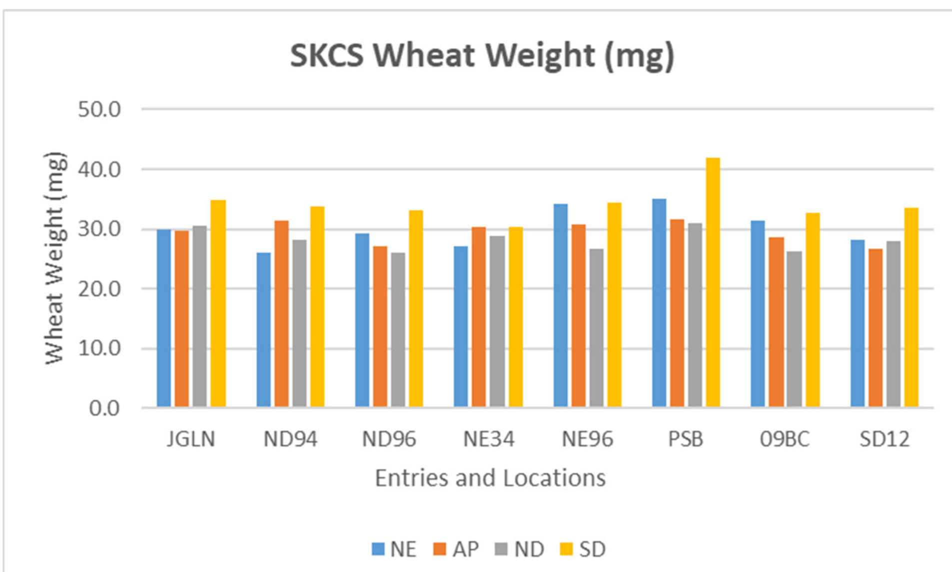
A. Kernel Hardness

SKCS Wheat Kernel Hardness						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	47.0	69.6	68.5	76.2	65.3	12.68
ND94	47.0	51.7	59.5	67.6	56.5	9.05
ND96	60.1	62.1	64.9	62.9	62.5	1.99
NE34	59.3	48.5	54.5	59.8	55.5	5.26
NE96	50.2	64.5	71.7	76.6	65.8	11.50
PSB	51.1	53.1	63.4	69.9	59.4	8.85
09BC	50.3	62.7	67.2	80.1	65.1	12.30
SD12	43.1	61.6	64.5	61.0	57.6	9.75
Avg.	51.0	59.2	64.3	69.3		
Std	5.94	7.28	5.36	7.75		



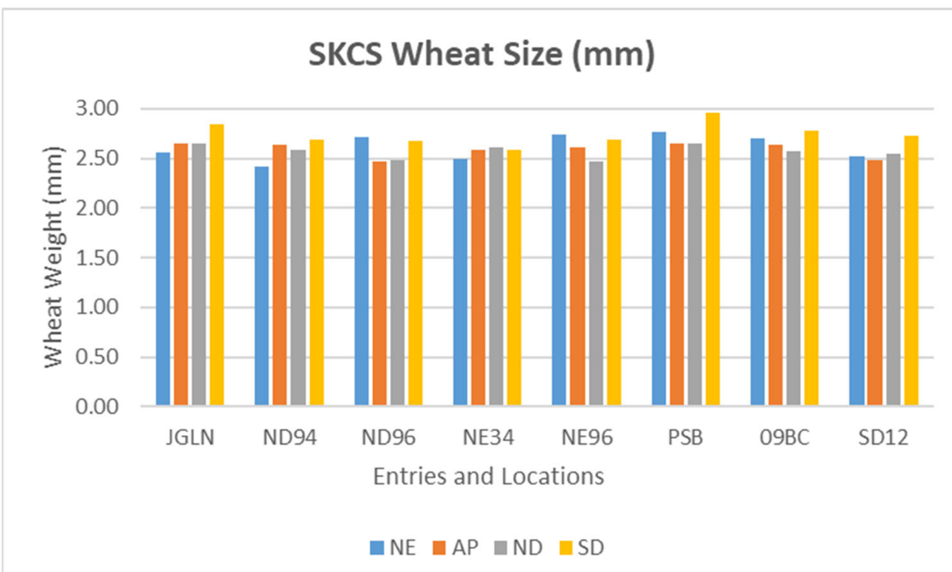
B. Kernel Weight (mg)

SKCS Wheat Kernel Weight (mg)						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	30.0	29.6	30.6	34.9	31.3	2.45
ND94	26.1	31.3	28.2	33.8	29.9	3.39
ND96	29.2	27.1	26.1	33.1	28.9	3.10
NE34	27.0	30.3	28.8	30.4	29.1	1.59
NE96	34.1	30.7	26.6	34.5	31.5	3.67
PSB	35.1	31.6	31.0	41.9	34.9	5.00
09BC	31.4	28.5	26.2	32.7	29.7	2.92
SD12	28.2	26.6	27.9	33.6	29.1	3.10
Avg.	30.1	29.5	28.2	34.4		
Std	3.22	1.89	1.89	3.34		



C. Kernel Size

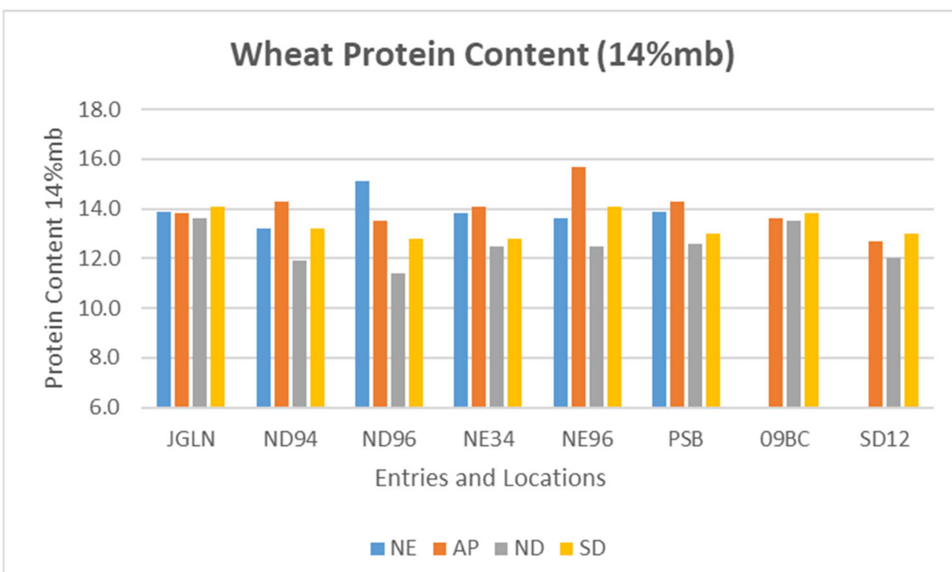
SKCS Wheat Kernel Size (mm)						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	2.56	2.65	2.65	2.84	2.68	0.12
ND94	2.42	2.63	2.59	2.69	2.58	0.12
ND96	2.71	2.47	2.48	2.68	2.59	0.13
NE34	2.50	2.59	2.61	2.59	2.57	0.05
NE96	2.74	2.61	2.47	2.69	2.63	0.12
PSB	2.77	2.65	2.65	2.96	2.76	0.15
09BC	2.70	2.63	2.57	2.78	2.67	0.09
SD12	2.52	2.48	2.55	2.72	2.57	0.11
Avg.	2.62	2.59	2.57	2.74		
Std	0.13	0.07	0.07	0.11		



3. PROTEN CONTENT

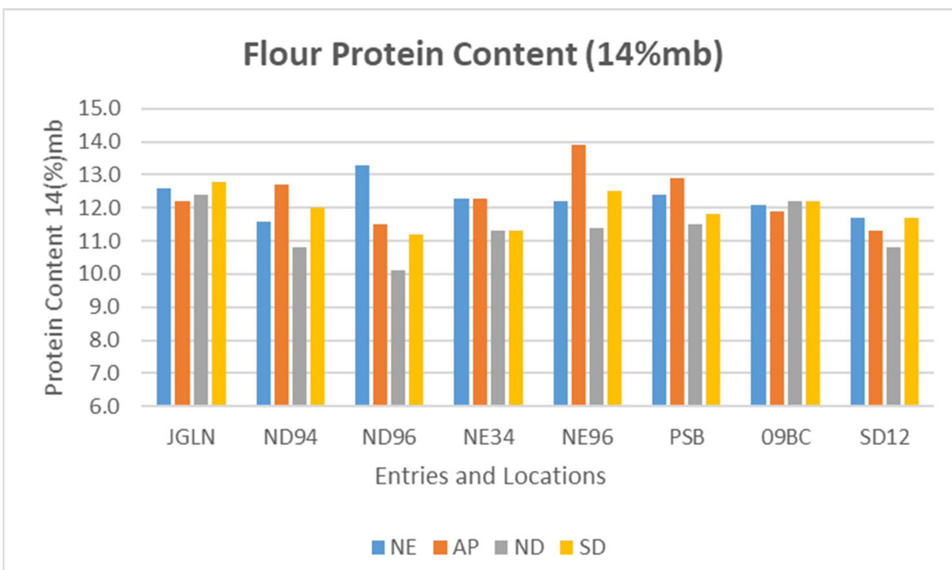
A. Wheat Protein

Wheat Protein Content (14%mb)						
	LOCATIONS					
Sample ID	NE	AP	ND	SD	Avg	Std
JGLN	13.9	13.8	13.6	14.1	13.9	0.21
ND94	13.2	14.3	11.9	13.2	13.2	0.98
ND96	15.1	13.5	11.4	12.8	13.2	1.54
NE34	13.8	14.1	12.5	12.8	13.3	0.77
NE96	13.6	15.7	12.5	14.1	14.0	1.33
PSB	13.9	14.3	12.6	13.0	13.5	0.79
09BC	13.5	13.6	13.5	13.8	13.6	0.14
SD12	13.7	12.7	12.0	13.0	12.9	0.70
Avg.	13.8	14.0	12.5	13.4		
Std	0.6	0.9	0.8	0.6		



B. Flour Protein

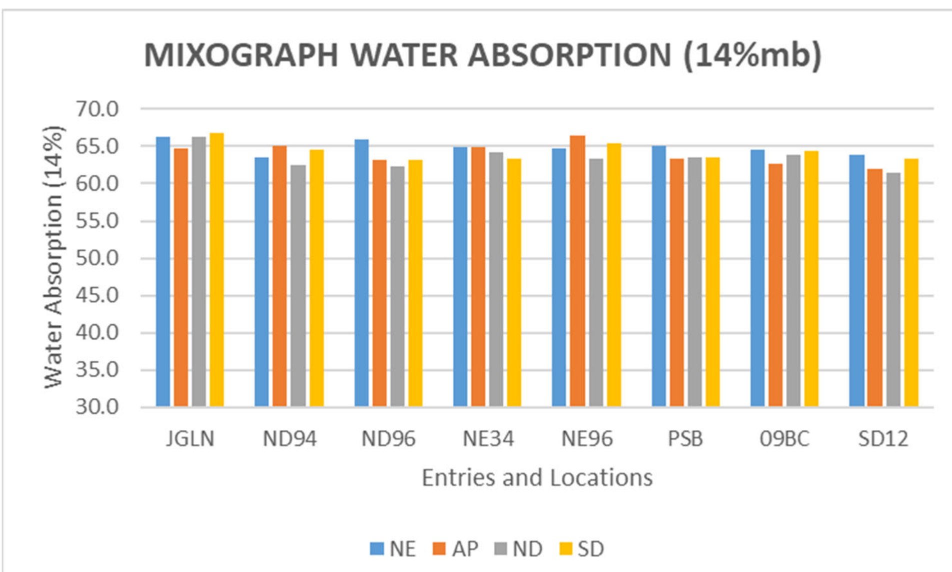
Flour Protein Content (14%)						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	12.6	12.2	12.4	12.8	12.5	0.26
ND94	11.6	12.7	10.8	12.0	11.8	0.79
ND96	13.3	11.5	10.1	11.2	11.5	1.33
NE34	12.3	12.3	11.3	11.3	11.8	0.58
NE96	12.2	13.9	11.4	12.5	12.5	1.04
PSB	12.4	12.9	11.5	11.8	12.2	0.62
09BC	12.1	11.9	12.2	12.2	12.1	0.14
SD12	11.7	11.3	10.8	11.7	11.4	0.43
Avg.	12.3	12.3	11.3	11.9		
Std	0.53	0.83	0.76	0.56		



4. MIXOGRAPH TEST RESULTS

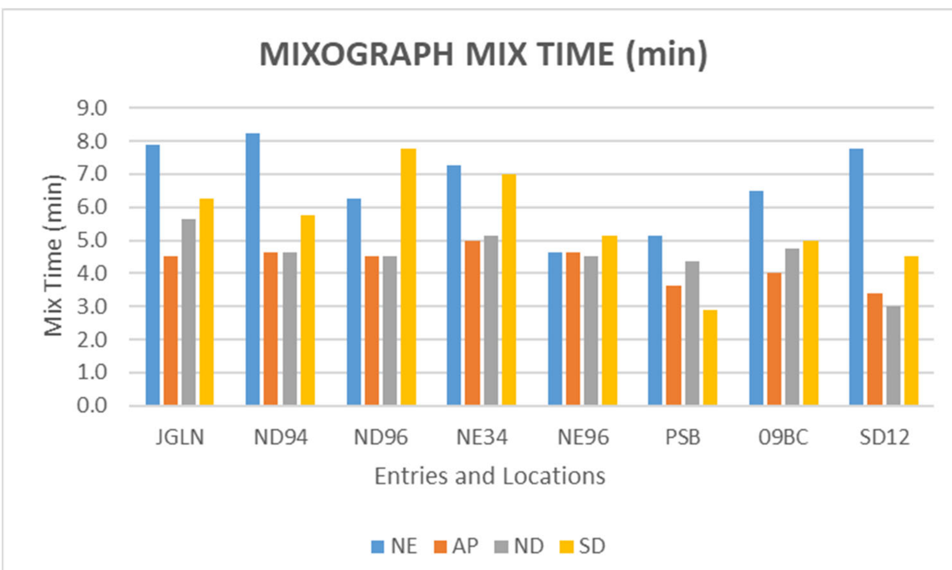
A. Mixograph Water Absorption

Mixograph Water Absorption (14%mb)						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	66.3	64.7	66.2	66.7	66.0	0.88
ND94	63.5	65.1	62.4	64.5	63.9	1.18
ND96	65.9	63.2	62.3	63.1	63.6	1.57
NE34	64.9	64.9	64.2	63.3	64.3	0.76
NE96	64.8	66.5	63.4	65.4	65.0	1.29
PSB	65.1	63.4	63.6	63.6	63.9	0.79
09BC	64.5	62.7	63.8	64.3	63.8	0.81
SD12	63.9	61.9	61.5	63.4	62.7	1.16
Avg.	64.9	64.1	63.4	64.3		
Std	0.93	1.50	1.44	1.24		



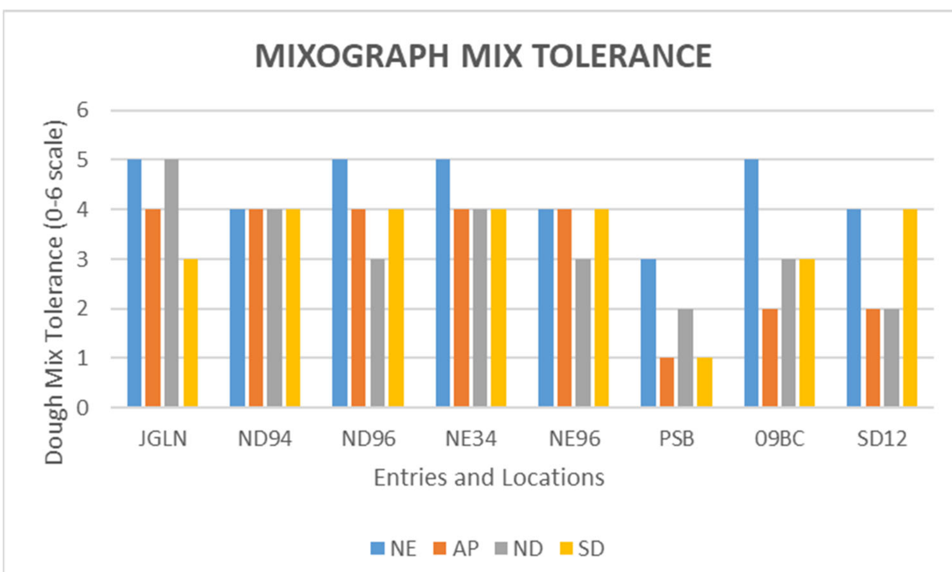
B. Mixograph Mix Time

Mixograph Mix Time (min)						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	7.9	4.5	5.6	6.3	6.1	1.41
ND94	8.3	4.6	4.6	5.8	5.8	1.71
ND96	6.3	4.5	4.5	7.8	5.8	1.57
NE34	7.3	5.0	5.1	7.0	6.1	1.19
NE96	4.6	4.6	4.5	5.1	4.7	0.28
PSB	5.1	3.6	4.4	2.9	4.0	0.97
09BC	6.5	4.0	4.8	5.0	5.1	1.05
SD12	7.8	3.4	3.0	4.5	4.7	2.16
Avg.	6.7	4.3	4.6	5.5		
Std	1.32	0.56	0.75	1.52		



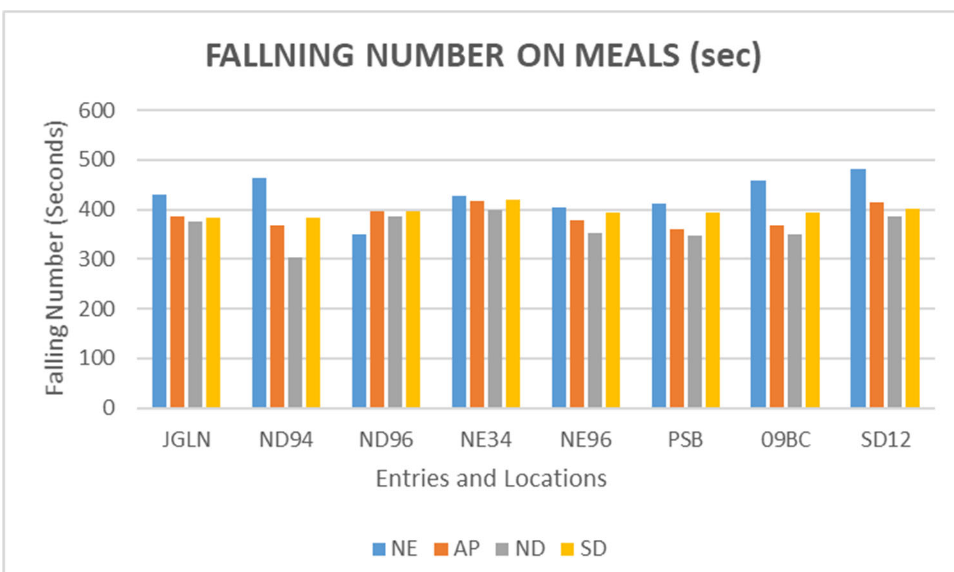
C. Mixograph Mix Tolerance

Mixograph Mix Tolerance						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	5	4	5	3	4.3	0.96
ND94	4	4	4	4	4.0	0.00
ND96	5	4	3	4	4.0	0.82
NE34	5	4	4	4	4.3	0.50
NE96	4	4	3	4	3.8	0.50
PSB	3	1	2	1	1.8	0.96
09BC	5	2	3	3	3.3	1.26
SD12	4	2	2	4	3.0	1.15
Avg.	4.4	3.1	3.3	3.4		
Std	0.74	1.25	1.04	1.06		



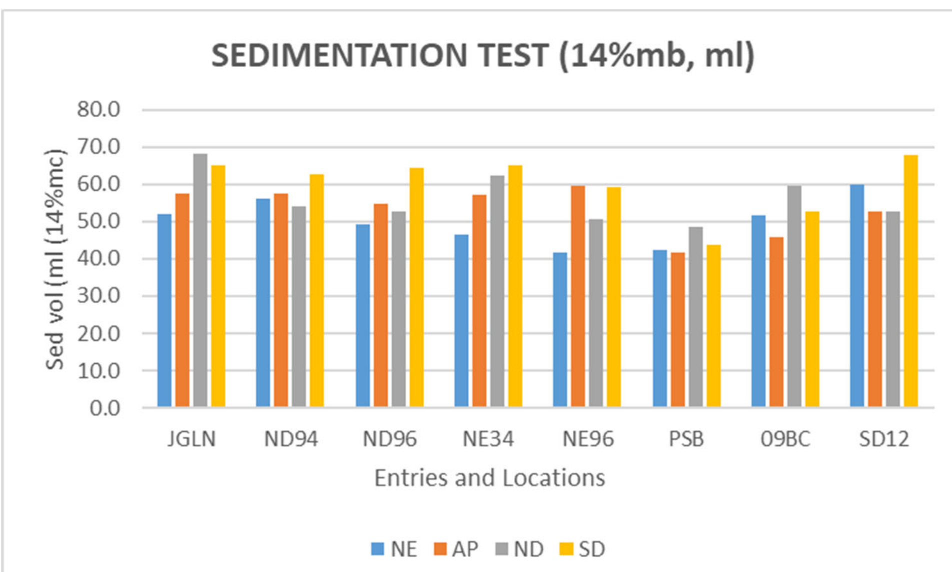
5. FALLING NUMBER TEST

Falling Number on Meals (sec)						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	429	386	376	383	394	24
ND94	463	369	304	384	380	65
ND96	350	397	385	396	382	22
NE34	426	418	399	419	416	12
NE96	403	379	353	394	382	22
PSB	412	361	348	395	379	30
09BC	459	367	351	395	393	48
SD12	481	414	387	401	421	42
Avg.	428	386	363	396		
Std	41	22	30	11		



6. SEDIMENTATION TEST

Sedimentation Test (Vol at 14%mb, ml)						
	LOCATIONS					
Sample ID	**NE**	**AP**	**ND**	**SD**	**Avg**	**Std**
JGLN	52.1	57.4	68.3	65.0	60.7	7.3
ND94	56.1	57.6	54.1	62.6	57.6	3.6
ND96	49.3	54.7	52.6	64.2	55.2	6.4
NE34	46.6	57.3	62.4	64.9	57.8	8.1
NE96	41.8	59.5	50.7	59.3	52.8	8.4
PSB	42.2	41.6	48.5	43.7	44.0	3.1
09BC	51.7	45.9	59.4	52.6	52.4	5.5
SD12	59.9	52.7	52.8	67.9	58.3	7.2
Avg.	50.0	53.3	56.1	60.0		
Std	6.4	6.4	6.7	8.1		



JAGALENE CHECK

20-2402	Jagalene (CC01)
20-2406	Jagalene (CC02)
20-2409	Jagalene (CC03)
20-2413	Jagalene (CC04)
20-2416	Jagalene (CC05)
20-2419	Jagalene (CC06)
20-2425	Jagalene (CC07)
20-2430	Jagalene (CC08)
20-2433	Jagalene (CC09)

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 2020. Nine breeding programs submitted the common check with their breeding lines for WQC baking evaluation. They were:

20-2402	Jagalene (CC01)	Colorado
20-2406	Jagalene (CC02)	BASF
20-2409	Jagalene (CC03)	Limagrain
20-2413	Jagalene (CC04)	Kansas-Hays
20-2416	Jagalene (CC05)	Bayer
20-2419	Jagalene (CC06)	Oklahoma
20-2425	Jagalene (CC07)	Montana
20-2430	Jagalene (CC08)	Kansas-Manhattan
20-2433	Jagalene (CC09)	Northern States

In order to facilitate relational database output overview of statistical data for the common checks 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.

Wheat and Flour Quality Characteristics of the Common Checks

Entry No.	20-2402	20-2406	20-2409	20-2413	20-2416	20-2419	20-2425	20-2430	20-2433
Breeding Programs	CO	BASF	Limagrain	KS-Hays	Bayer	OK	MT	KS-MHK	North States
Wheat Protein (12%mb)	14.4	15.3	11.0	15.0	12.6	11.1	14.6	13.4	14.2
Flour Protein (14%mb)	13.4	14.0	10.0	13.9	11.5	10.3	13.7	12.2	13.1
Flour Ash (14%mb)	0.57	0.64	0.60	0.53	0.57	0.48	0.54	0.71	0.61
TPP/TMP*	0.81	0.90	0.95	0.82	0.82	0.79	0.75	0.79	0.98
Sedimentation (ml 14%mc)	67.9	66.8	45.3	68.1	49.9	47.0	68.5	42.1	61.6
Mixograph Abs (14%mb)	69.2	69.3	62.6	70.1	73.1	67.2	70.8	66.3	68.3
Mix Time (min)	4.8	7.6	5.5	4.5	3.0	4.4	2.9	4.5	4.6
Tolerance	4	6	3	4	1	4	3	4	4
Farinograph Abs (14%mb)	64.2	64.5	59.6	66.5	73.7	69.0	71.0	67.3	63.3
Peak time (min)	8.9	7.7	4.9	8.0	4.2	5.4	6.2	4.3	5.5
Stability (min)	20.8	24.8	12.6	11.6	6.1	9.5	7.4	6.8	12.4
MTI (FU)	18	14	18	23	41	27	32	39	14
Bake Abs (14%mb)	68.4	69.0	62.7	69.5	70.7	68.5	71.4	68.4	67.8
Bake Mix Time (min)	5.2	8.0	6.4	5.1	3.2	5.0	4.0	5.0	5.5
Loaf Volume (cc)	918	936	748	913	750	777	898	834	927
Crumb Color Rating (0-5)	2.9	3.1	3.4	3.2	2.5	2.4	2.9	3.3	3.3
Crumb Grain Rating (0-5)	3.4	3.3	3.0	3.3	1.8	2.9	3.5	3.2	3.8
Crumb Texture Rating (0-5)	3.8	3.6	2.9	3.5	2.8	2.8	3.3	3.1	3.2
Over All Bake Performance	3.8	3.9	3.1	3.7	2.7	3.1	3.5	3.6	4.3

Bake data average based on 8 cooperators' pup loaf straight grade dough method

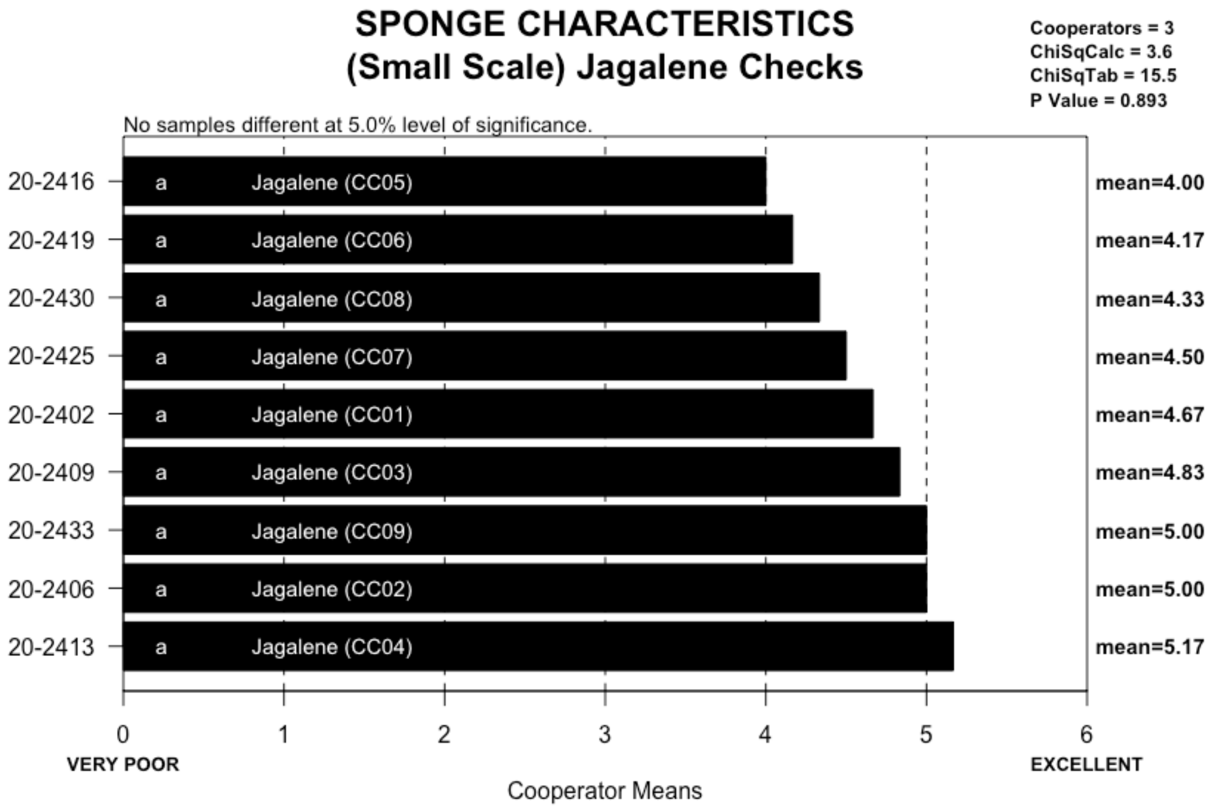
[1] CC = Common Check.

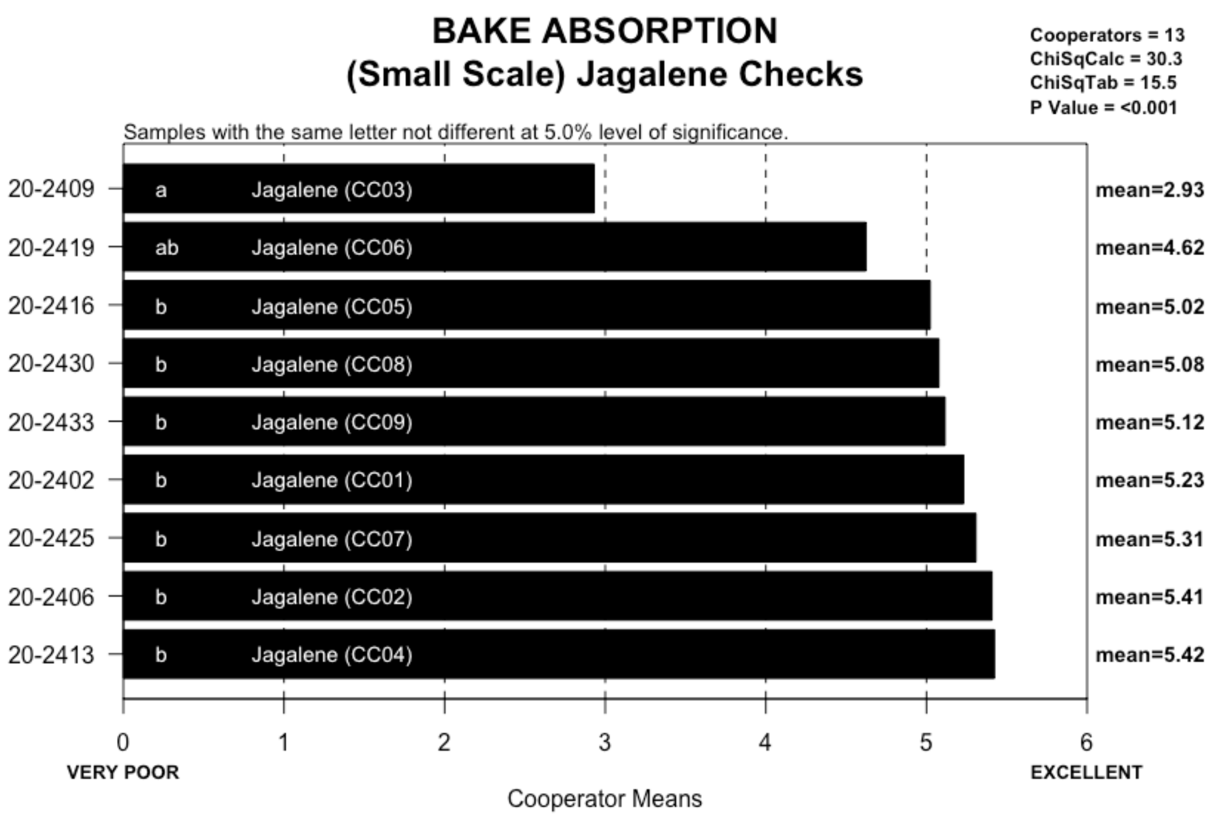
* TPP/TMP= total polymeric protein/total monomeric protein.

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

Brief Conclusions

Three of 13 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, mixing tolerance and crumb grain of the common checks showed significant difference based on data from 13 cooperators while the crumb texture and crumb color didn’t show such significant difference at the 5% level of signficance. However, other baking performance quality characteristics, such as 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.


SPONGE CHARACTERISTICS
(Small Scale) Jagalene Checks
Cooperators = 3
ChiSqCalc = 3.6
ChiSqTab = 15.5
P Value = 0.893
No samples different at 5.0% level of significance.
20-2416 a Jagalene (CC05) mean=4.00
20-2419 a Jagalene (CC06) mean=4.17
20-2430 a Jagalene (CC08) mean=4.33
20-2425 a Jagalene (CC07) mean=4.50
20-2402 a Jagalene (CC01) mean=4.67
20-2409 a Jagalene (CC03) mean=4.83
20-2433 a Jagalene (CC09) mean=5.00
20-2406 a Jagalene (CC02) mean=5.00
20-2413 a Jagalene (CC04) mean=5.17
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

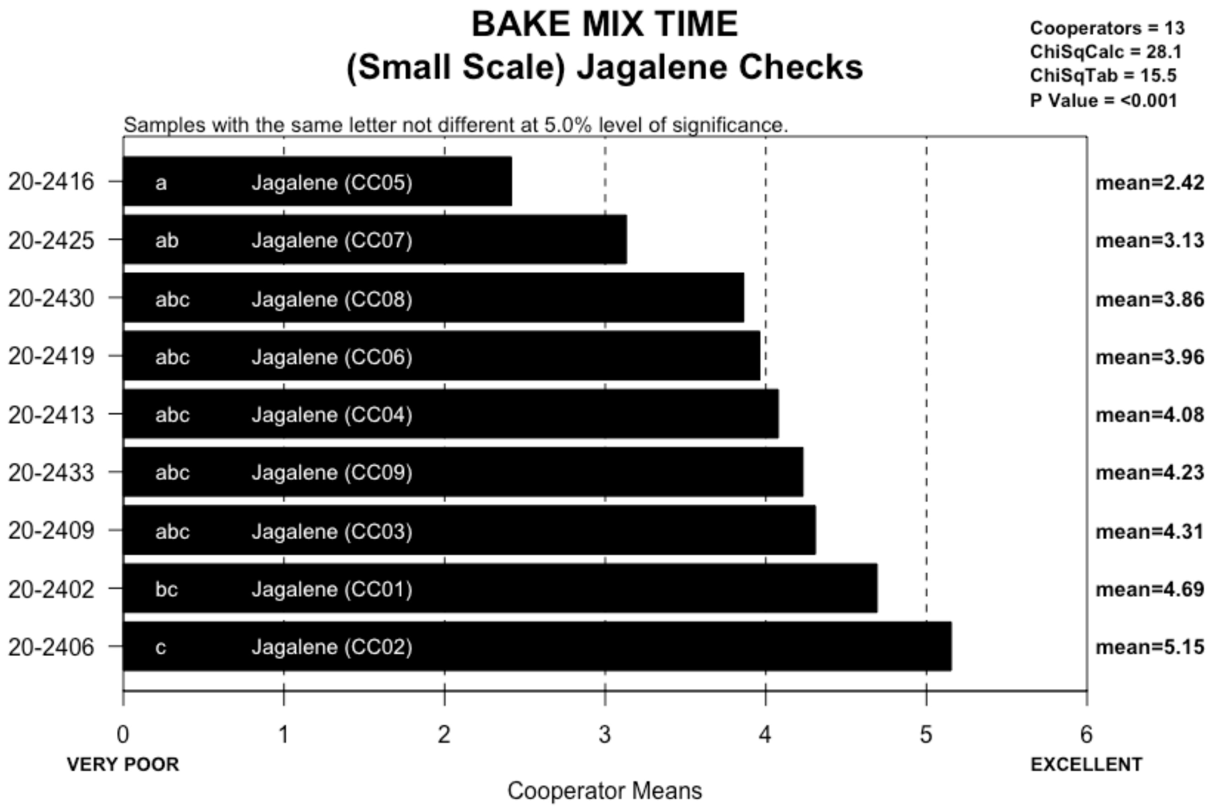

BAKE ABSORPTION
(Small Scale) Jagalene Checks
Cooperators = 13
ChiSqCalc = 30.3
ChiSqTab = 15.5
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2409 a Jagalene (CC03) mean=2.93
20-2419 ab Jagalene (CC06) mean=4.62
20-2416 b Jagalene (CC05) mean=5.02
20-2430 b Jagalene (CC08) mean=5.08
20-2433 b Jagalene (CC09) mean=5.12
20-2402 b Jagalene (CC01) mean=5.23
20-2425 b Jagalene (CC07) mean=5.31
20-2406 b Jagalene (CC02) mean=5.41
20-2413 b Jagalene (CC04) mean=5.42
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

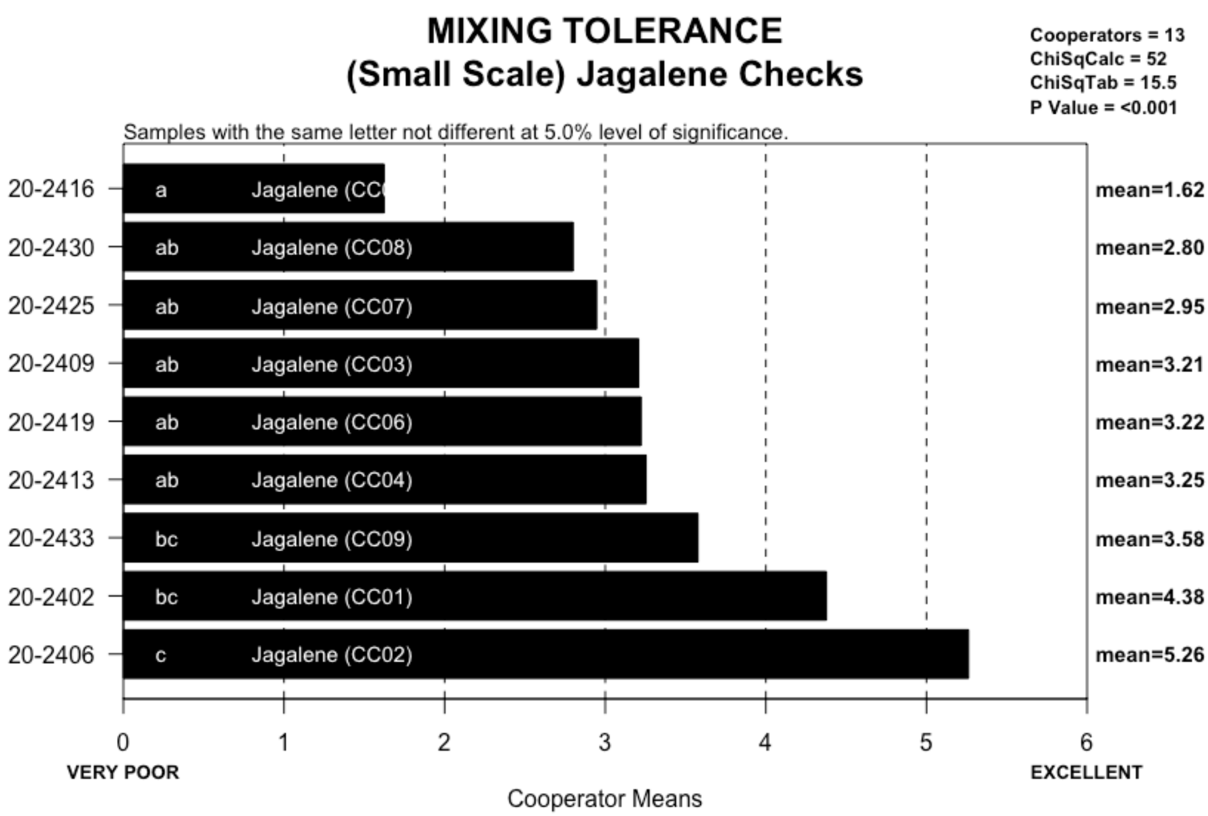
BAKE ABSORPTION, ACTUAL (14% MB)
(Small Scale) Jagalene Checks
Cooperators A – M

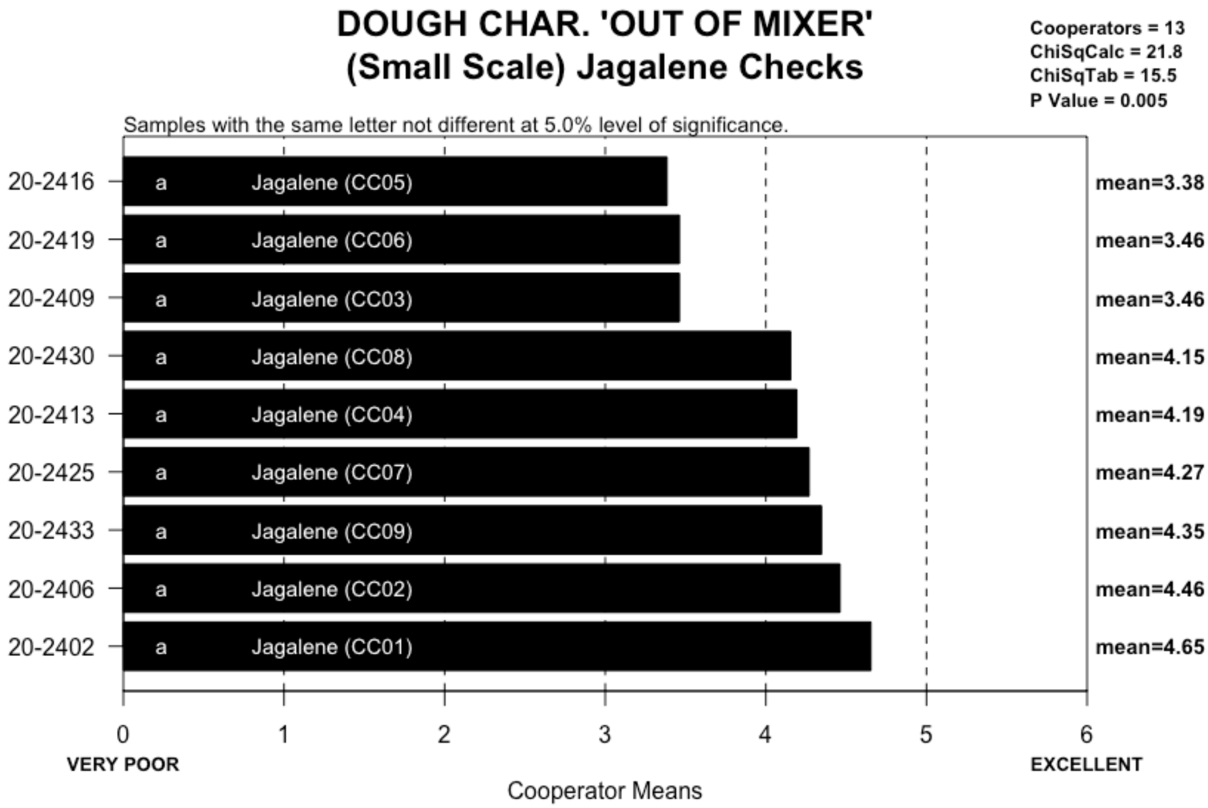
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2402	Jagalene (CC01)	59	71.8	69.1	70.1	66.9	65.4	67.4	72.1	64.4	64.1	62.4	69.2	66.1
20-2406	Jagalene (CC02)	60	71.1	70.2	71.3	68.0	64.8	68.6	72.7	65.0	64.5	63.0	69.3	66.5
20-2409	Jagalene (CC03)	56	65.1	64.0	62.7	61.2	62.1	63.1	62.2	61.1	59.6	57.5	62.6	61.6
20-2413	Jagalene (CC04)	60	71.9	71.5	71.8	67.9	66.3	69.3	70.4	67.3	66.5	60.7	70.1	68.5
20-2416	Jagalene (CC05)	58	81.0	74.4	68.9	63.6	63.8	65.6	73.5	74.7	73.7	62.8	73.1	75.7
20-2419	Jagalene (CC06)	56	77.9	69.5	70.0	61.9	62.1	67.3	67.5	72.0	69.0	61.8	67.2	71.0
20-2425	Jagalene (CC07)	60	74.8	73.1	73.0	67.7	68.0	70.3	72.5	71.5	71.0	61.8	70.8	73.0
20-2430	Jagalene (CC08)	58	73.9	68.2	69.1	64.8	66.0	68.4	68.7	68.1	67.3	62.0	66.3	69.3
20-2433	Jagalene (CC09)	59	69.8	70.0	68.7	66.5	65.1	68.9	68.2	64.8	63.3	60.5	68.3	65.3

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2402	Jagalene (CC01)	10	5.0	4.9	5.1	4.5	6.5	4.3	6.5	5.0	8	9	4.8	20
20-2406	Jagalene (CC02)	15	7.0	8.3	8.4	7.2	8.6	7.0	10.0	7.3	8	9	7.6	20
20-2409	Jagalene (CC03)	6	6.0	6.5	6.0	3.0	10.0	5.8	8.0	6.0	8	5	5.5	17
20-2413	Jagalene (CC04)	6	4.8	5.6	5.4	4.0	6.8	4.5	5.0	4.8	8	5	4.5	17
20-2416	Jagalene (CC05)	5	3.8	3.0	2.7	3.5	3.4	3.0	3.3	3.0	8	4	3.0	8
20-2419	Jagalene (CC06)	9	4.5	5.3	4.5	5.0	7.0	4.5	5.0	4.5	8	4	4.4	10
20-2425	Jagalene (CC07)	7	4.0	4.0	4.0	3.0	5.2	3.5	4.8	3.8	8	4	2.9	12
20-2430	Jagalene (CC08)	5	5.5	4.7	5.3	4.0	4.7	4.8	6.0	5.3	8	4	4.5	11
20-2433	Jagalene (CC09)	6	4.5	5.5	5.7	4.5	7.4	5.0	6.3	5.0	8	4	4.6	20

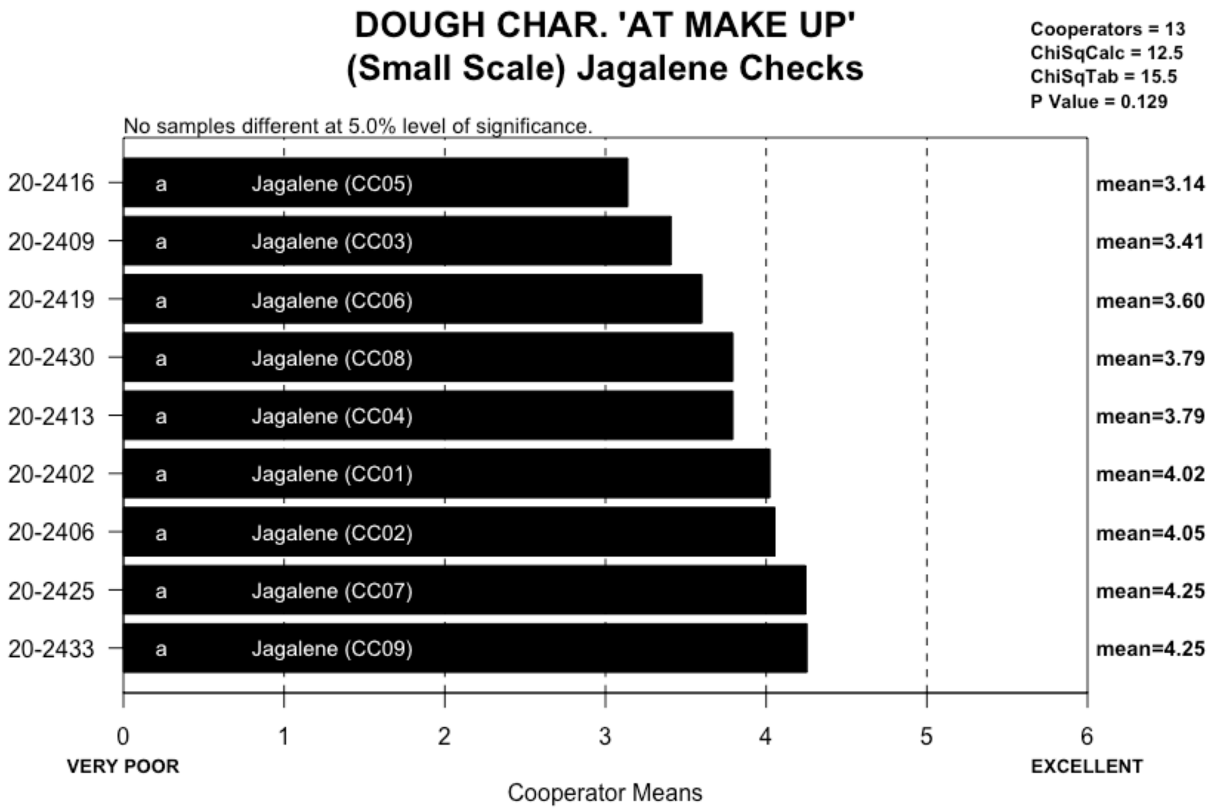

BAKE MIX TIME
(Small Scale) Jagalene Checks
Cooperators = 13
ChiSqCalc = 28.1
ChiSqTab = 15.5
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2416
a
Jagalene (CC05)
mean=2.42
20-2425
ab
Jagalene (CC07)
mean=3.13
20-2430
abc
Jagalene (CC08)
mean=3.86
20-2419
abc
Jagalene (CC06)
mean=3.96
20-2413
abc
Jagalene (CC04)
mean=4.08
20-2433
abc
Jagalene (CC09)
mean=4.23
20-2409
abc
Jagalene (CC03)
mean=4.31
20-2402
bc
Jagalene (CC01)
mean=4.69
20-2406
c
Jagalene (CC02)
mean=5.15
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Jagalene Checks
Cooperators = 13
ChiSqCalc = 52
ChiSqTab = 15.5
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2416
a
Jagalene (CC
mean=1.62
20-2430
ab
Jagalene (CC08)
mean=2.80
20-2425
ab
Jagalene (CC07)
mean=2.95
20-2409
ab
Jagalene (CC03)
mean=3.21
20-2419
ab
Jagalene (CC06)
mean=3.22
20-2413
ab
Jagalene (CC04)
mean=3.25
20-2433
bc
Jagalene (CC09)
mean=3.58
20-2402
bc
Jagalene (CC01)
mean=4.38
20-2406
c
Jagalene (CC02)
mean=5.26
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



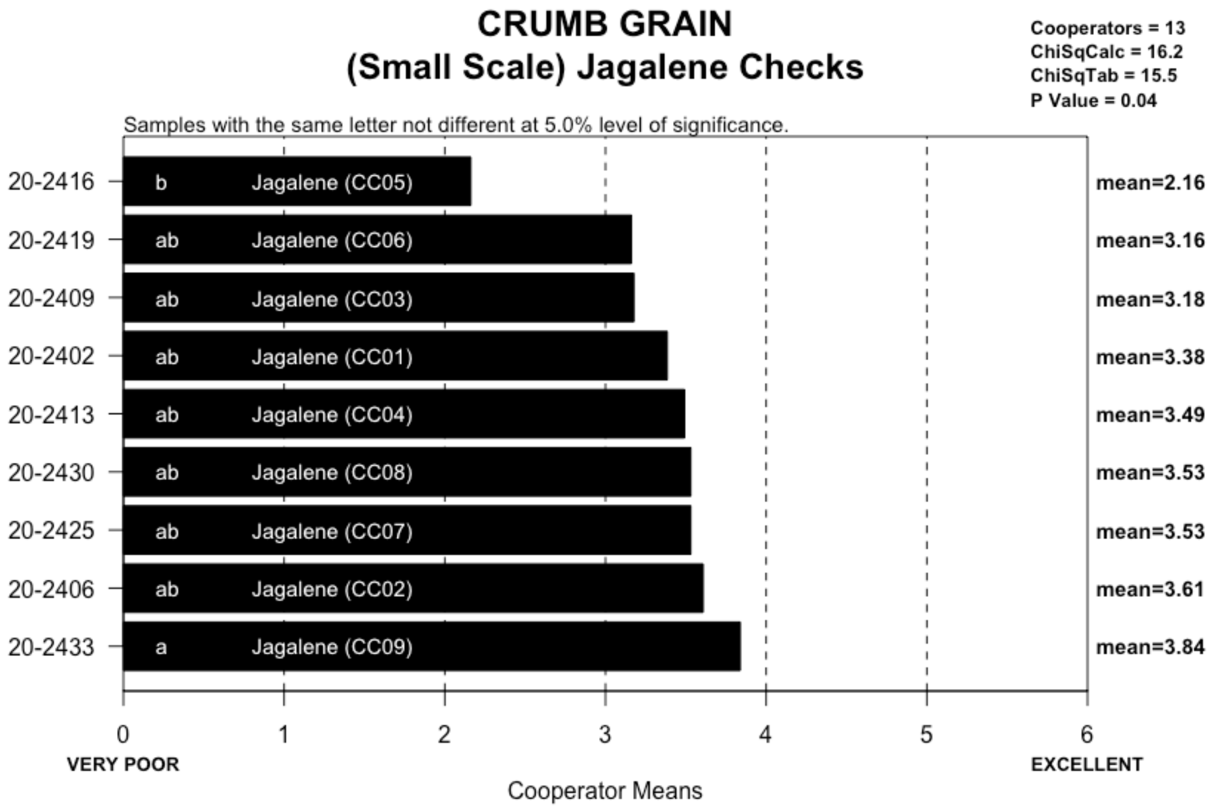
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Jagalene Checks

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2402	Jagalene (CC01)	0	1	2	6	4
20-2406	Jagalene (CC02)	0	0	5	4	4
20-2409	Jagalene (CC03)	3	0	3	7	0
20-2413	Jagalene (CC04)	1	0	2	10	0
20-2416	Jagalene (CC05)	5	1	3	4	0
20-2419	Jagalene (CC06)	1	3	2	7	0
20-2425	Jagalene (CC07)	0	0	2	10	1
20-2430	Jagalene (CC08)	0	0	2	9	2
20-2433	Jagalene (CC09)	0	0	3	9	1



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

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
20-2402	Jagalene (CC01)	0	0	5	6	2
20-2406	Jagalene (CC02)	0	0	6	5	2
20-2409	Jagalene (CC03)	2	0	4	7	0
20-2413	Jagalene (CC04)	2	0	2	9	0
20-2416	Jagalene (CC05)	5	1	1	6	0
20-2419	Jagalene (CC06)	4	2	2	5	0
20-2425	Jagalene (CC07)	0	0	2	9	2
20-2430	Jagalene (CC08)	1	0	2	10	0
20-2433	Jagalene (CC09)	1	1	2	9	0

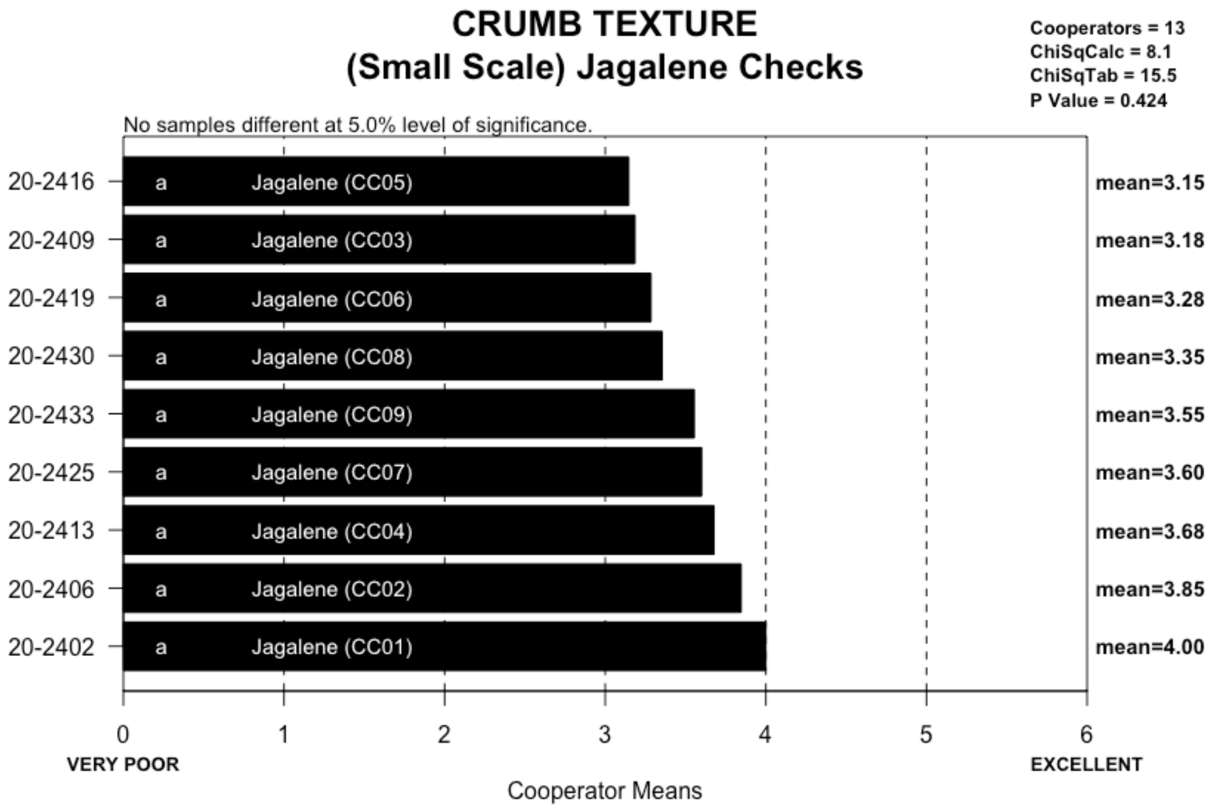


CRUMB GRAIN, DESCRIBED
(Small Scale) Jagalene Checks

IDCODE	ID	Open	Fine	Dense
20-2402	Jagalene (CC01)	8	5	0
20-2406	Jagalene (CC02)	6	5	2
20-2409	Jagalene (CC03)	2	6	5
20-2413	Jagalene (CC04)	7	6	0
20-2416	Jagalene (CC05)	8	2	3
20-2419	Jagalene (CC06)	8	5	0
20-2425	Jagalene (CC07)	6	6	1
20-2430	Jagalene (CC08)	3	9	1
20-2433	Jagalene (CC09)	6	6	1

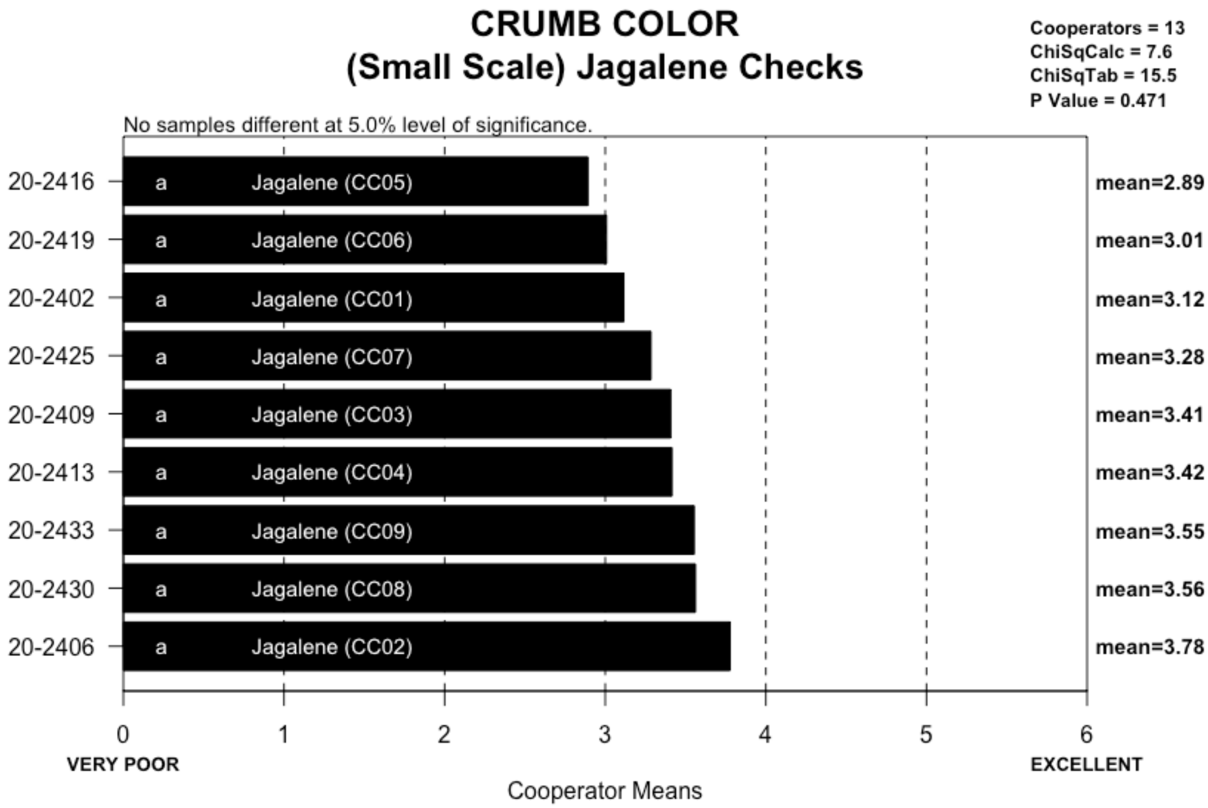
CELL SHAPE, DESCRIBED
(Small Scale) Jagalene Checks

IDCODE	ID	Round	Irregular	Elongated
20-2402	Jagalene (CC01)	2	6	5
20-2406	Jagalene (CC02)	5	4	4
20-2409	Jagalene (CC03)	4	8	1
20-2413	Jagalene (CC04)	5	5	3
20-2416	Jagalene (CC05)	6	6	1
20-2419	Jagalene (CC06)	4	6	3
20-2425	Jagalene (CC07)	7	3	3
20-2430	Jagalene (CC08)	6	3	4
20-2433	Jagalene (CC09)	1	8	4



CRUMB TEXTURE, DESCRIBED
(Small Scale) Jagalene Checks

IDCODE	ID	Harsh	Smooth	Silky
20-2402	Jagalene (CC01)	3	6	4
20-2406	Jagalene (CC02)	4	6	3
20-2409	Jagalene (CC03)	4	8	1
20-2413	Jagalene (CC04)	2	9	2
20-2416	Jagalene (CC05)	7	2	4
20-2419	Jagalene (CC06)	6	6	1
20-2425	Jagalene (CC07)	3	6	4
20-2430	Jagalene (CC08)	4	7	2
20-2433	Jagalene (CC09)	3	7	3



CRUMB COLOR, DESCRIBED
(Small Scale) Jagalene Checks

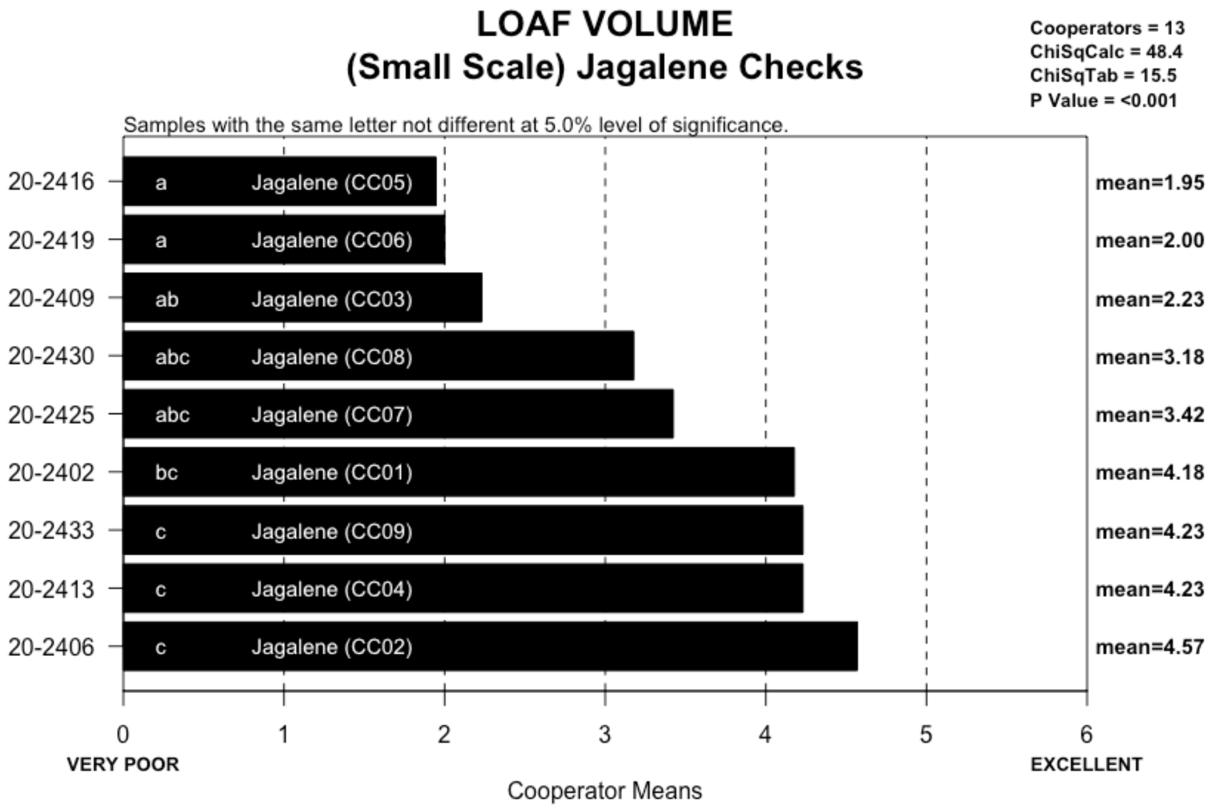
IDCODE	ID	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright_White
20-2402	Jagalene (CC01)	0	0	4	4	5	0	0
20-2406	Jagalene (CC02)	0	1	0	4	5	3	0
20-2409	Jagalene (CC03)	0	0	2	6	5	0	0
20-2413	Jagalene (CC04)	1	1	1	2	7	1	0
20-2416	Jagalene (CC05)	0	1	3	5	4	0	0
20-2419	Jagalene (CC06)	0	0	6	2	4	1	0
20-2425	Jagalene (CC07)	0	1	2	4	5	1	0
20-2430	Jagalene (CC08)	0	0	1	6	5	1	0
20-2433	Jagalene (CC09)	1	1	2	1	7	1	0

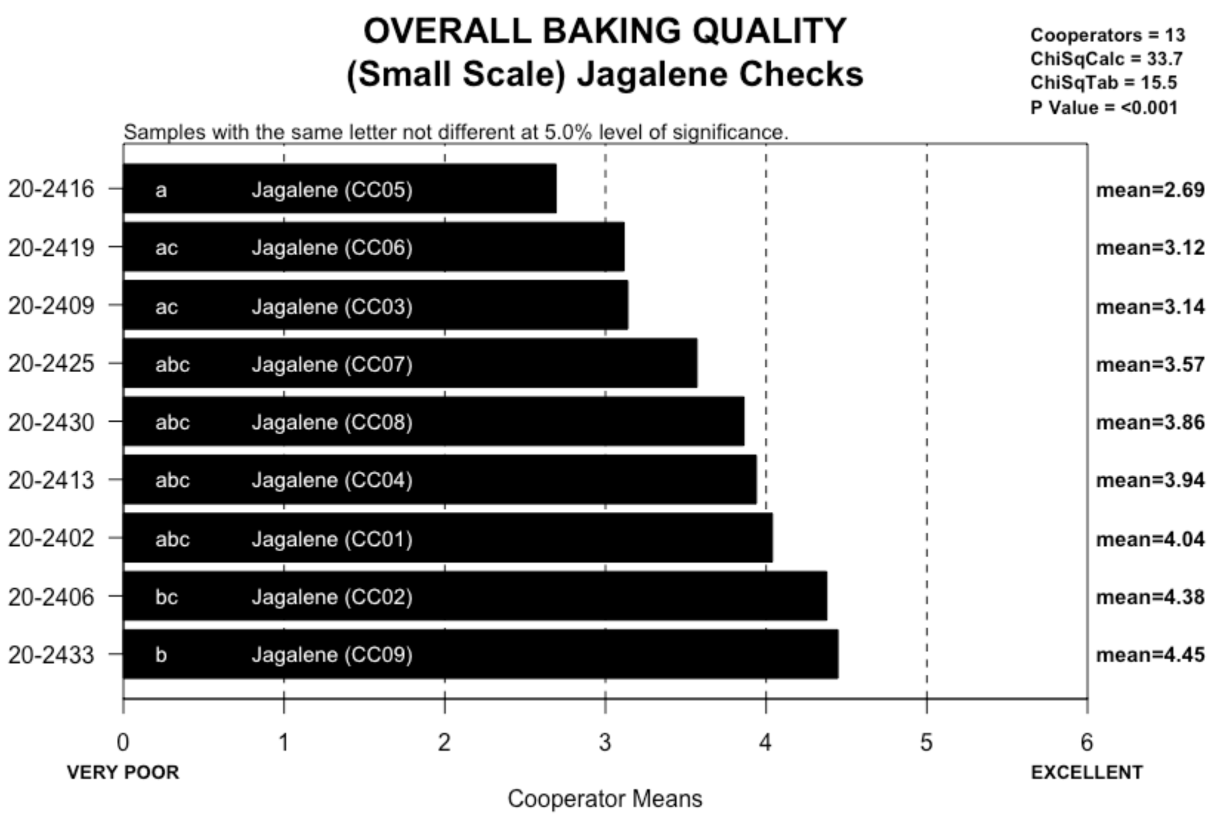
LOAF WEIGHT, ACTUAL
(Small Scale) Jagalene Checks
Cooperators A – M

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2402	Jagalene (CC01)	414	133.2	137.4	153.4	144.7	138.3	144.1	155.6	144	453.3	477.2	145.8	416.1
20-2406	Jagalene (CC02)	417	135.4	135.8	160.0	144.9	140.4	143.5	153.5	141	457.9	478.1	144.8	422.0
20-2409	Jagalene (CC03)	414	134.2	139.7	149.2	145.3	139.0	142.1	147.2	142	458.9	477.6	142.8	427.4
20-2413	Jagalene (CC04)	417	136.8	136.7	156.4	145.2	140.5	145.6	155.4	142	459.0	475.9	146.9	419.9
20-2416	Jagalene (CC05)	410	140.7	137.4	158.5	146.7	141.5	144.2	158.8	147	442.8	477.0	149.3	409.9
20-2419	Jagalene (CC06)	415	141.9	139.7	153.6	145.0	141.5	142.9	153.6	145	447.4	478.7	146.0	418.1
20-2425	Jagalene (CC07)	417	137.6	137.4	161.6	146.1	141.7	149.6	158.3	147	452.5	478.9	150.0	419.3
20-2430	Jagalene (CC08)	414	139.2	138.5	153.1	144.0	139.7	145.0	153.7	146	462.5	474.9	143.8	421.9
20-2433	Jagalene (CC09)	410	135.6	137.0	156.8	145.6	139.1	147.6	152.1	139	456.3	482.5	146.0	424.2

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

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M
20-2402	Jagalene (CC01)	2800	985	926	960	830	978	1035	960	668	2918	2638	785	2700
20-2406	Jagalene (CC02)	3000	975	982	960	930	841	1130	955	714	2539	2638	910	2800
20-2409	Jagalene (CC03)	2750	730	798	805	640	813	895	685	620	2327	2625	780	2275
20-2413	Jagalene (CC04)	2850	885	898	973	850	930	1040	950	780	2501	2700	840	2775
20-2416	Jagalene (CC05)	2550	705	740	733	515	840	780	855	829	1718	2388	740	2600
20-2419	Jagalene (CC06)	2675	955	777	795	620	815	840	740	672	2098	2375	775	2300
20-2425	Jagalene (CC07)	2750	920	850	820	855	1050	885	930	877	2491	2513	770	2475
20-2430	Jagalene (CC08)	2900	815	881	843	855	870	965	790	652	2406	2575	810	2625
20-2433	Jagalene (CC09)	3100	950	902	913	990	908	985	960	812	2634	2563	870	2700


LOAF VOLUME
(Small Scale) Jagalene Checks
Cooperators = 13
ChiSqCalc = 48.4
ChiSqTab = 15.5
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2416 a Jagalene (CC05) mean=1.95
20-2419 a Jagalene (CC06) mean=2.00
20-2409 ab Jagalene (CC03) mean=2.23
20-2430 abc Jagalene (CC08) mean=3.18
20-2425 abc Jagalene (CC07) mean=3.42
20-2402 bc Jagalene (CC01) mean=4.18
20-2433 c Jagalene (CC09) mean=4.23
20-2413 c Jagalene (CC04) mean=4.23
20-2406 c Jagalene (CC02) mean=4.57
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Small Scale) Jagalene Checks
Cooperators = 13
ChiSqCalc = 33.7
ChiSqTab = 15.5
P Value = <0.001
Samples with the same letter not different at 5.0% level of significance.
20-2416 a Jagalene (CC05) mean=2.69
20-2419 ac Jagalene (CC06) mean=3.12
20-2409 ac Jagalene (CC03) mean=3.14
20-2425 abc Jagalene (CC07) mean=3.57
20-2430 abc Jagalene (CC08) mean=3.86
20-2413 abc Jagalene (CC04) mean=3.94
20-2402 abc Jagalene (CC01) mean=4.04
20-2406 bc Jagalene (CC02) mean=4.38
20-2433 b Jagalene (CC09) mean=4.45
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Common Checks

COOP. **20-2441 Jagalene (CC01)**

A. No comment.
B. No comment.
C. No comment.
D. Good dough properties and overall bread performance.
E. Good mix time, loaf volume less than predicted.
F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, High Volume, Yellow Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. Excellent loaf externals.
H. Very high absorption (72%), open grain, good volume.
I. Dough felt rubbery and lifeless.
J. No comment.
K. Long mix time, very tolerant to mixing, good absorption, avg grain, good volume.
L. No comment.
M. Good performance, higher protein and absorption. Recommend.

COOP. **20-2442 Jagalene (CC02)**

A. No comment.
B. Nice loaf.
C. No comment.
D. Dough mix time somewhat long but generally good overall properties, high absorption, loaf volume somewhat low for protein level.
E. One large hole in loaf.
F. Very High Protein & Water Abs, Long MT, Slight Sticky & Weak Dough, Low Volume, Dark Yellow Crumb, Tight Round Cells, Resilient & Harsh Texture.
G. Yellowish dough, excellent loaf externals.
H. Long mix time, very high absorption (73%), open grain, good volume.
I. High protein, tough dough, hard spots throughout the crumb.
J. No comment.
K. Long mix time, very tolerant to mixing, high absorption, avg grain, creamy color, good volume.
L. No comment.
M. High protein, absorption, and mix time. Recommend for blending.

COOP. 20-2443 Jagalene (CC03)

A. No comment.
B. No comment.
C. No comment.
D. Long mix time but dough generally weaker looking, volume very low with weaker looking crumb grain but performed well for protein level.
E. Protein and absorption do not meet targets.
F. Low Protein, Low Water Abs, Very Long MT, Slight Sticky & Weak Dough, Low Volume, Yellow Crumb, Dense Round Cells, Resilient & Slightly Harsh Texture.
G. Slight cap, rough break.
H. Low protein flour, long mix time, dense grain, tough doughs, very low volume.
I. No comment.
J. No comment.
K. Low absorption, good grain, good volume.
L. No comment.
M. Low protein, fair absorption, good dough notes and mix time, dough did not perform well in the final product. Needs blending.

COOP. 20-2444 Jagalene (CC04)

A. No comment.
B. No comment.
C. No comment.
D. Good dough properties and absorption, loaf volume somewhat low for protein level but crumb grain was good.
E. Should have had higher loaf volume given high protein, meets target, best in set.
F. Very High Protein, Very High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Volume, Dark Yellow Crumb, Slightly Open Elongated Cells, Resilient & Smooth Texture.
G. Excellent loaf externals.
H. Very high absorption (70%), avg grain, tough doughs, good volume.
I. Undesirable crumb grain-open, large cells, loaf center had a dull sheen.
J. No comment.
K. Avg absorption, avg grain, creamy crumb, excellent volume.
L. No comment.
M. High protein and absorption, good volume.

COOP. 20-2445 Jagalene (CC05)

A. No comment.
B. Good absorption, small loaf.
C. No comment.
D. Very weak dough, very low volume for protein level with very poor crumb grain.
E. Poor.
F. Normal Protein & Water Abs, Short MT, Slight Sticky & Strong Dough, Medium Volume, Dark Yellow Crumb, Open Round Cells, Resilient & Slightly Harsh Texture.
G. Dark crust.
H. Low mixing tolerance, very high absorption (74%), poor grain, sticky at makeup, avg volume.
I. Considering the crumb grain, the texture exceeded expectations-surprisingly smooth and silky.
J. No comment.
K. Low mixing tolerance, high absorption, open grain, sticky wet doughs, very low volume.
L. No comment.
M. Huge absorption, fair protein and volume, low mix time and tolerance, unfavorable end-product. Recommend for blending.

COOP. 20-2446 Jagalene (CC06)

A. No comment.
B. Dark crust color.
C. No comment.
D. Good dough performance for protein level, volume and crumb grain at good level for protein.
E. Protein does not meet target.
F. Normal Protein & Water Abs, Long MT, Slight Sticky & Strong Dough, Fair Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Smooth Texture.
G. Cap, rough break.
H. Low protein flour, high absorption, poor grain, very low volume.
I. Crumb felt moist and spongy.
J. No comment.
K. Low mixing tolerance, good absorption, avg grain, very low volume.
L. No comment.
M. Low volume and protein, fair mix time, high absorption. Recommend for blending.

COOP. 20-2447 Jagalene (CC07)

A. No comment.
B. No comment.
C. No comment.
D. Exceptionally poor performance for protein level.
E. Given protein level should have had higher loaf volume.
F. Very High Protein & Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Volume, Dark Yellow Crumb, Slightly Open Elongated Cells, Resilient & Very Smooth Texture.
G. Good loaf externals.
H. Very high absorption (73%), open grain, good volume.
I. No comment.
J. No comment.
K. Low mixing tolerance, good absorption, avg grain and volume.
L. No comment.
M. High absorption and protein, lower stability and mix time, volume has room for improvement.

COOP. 20-2448 Jagalene (CC08)

A. No comment.
B. No comment.
C. No comment.
D. Good mix time but generally weaker dough type, loaf volume low for protein with weaker looking crumb grain.
E. Good.
F. Very High Protein & Water Abs, Normal MT, Slight Sticky & Strong Dough, High Volume, Creamy Crumb, Fine Elongated Cells, Resilient & Very Smooth Texture.
G. Excellent loaf externals.
H. High absorption, open grain, very low volume.
I. Poor crumb color.
J. No comment.
K. Low mixing tolerance, good absorption, fine grain, avg volume.
L. No comment.
M. Good protein and volume, fair mix time and dough notes. Recommend.

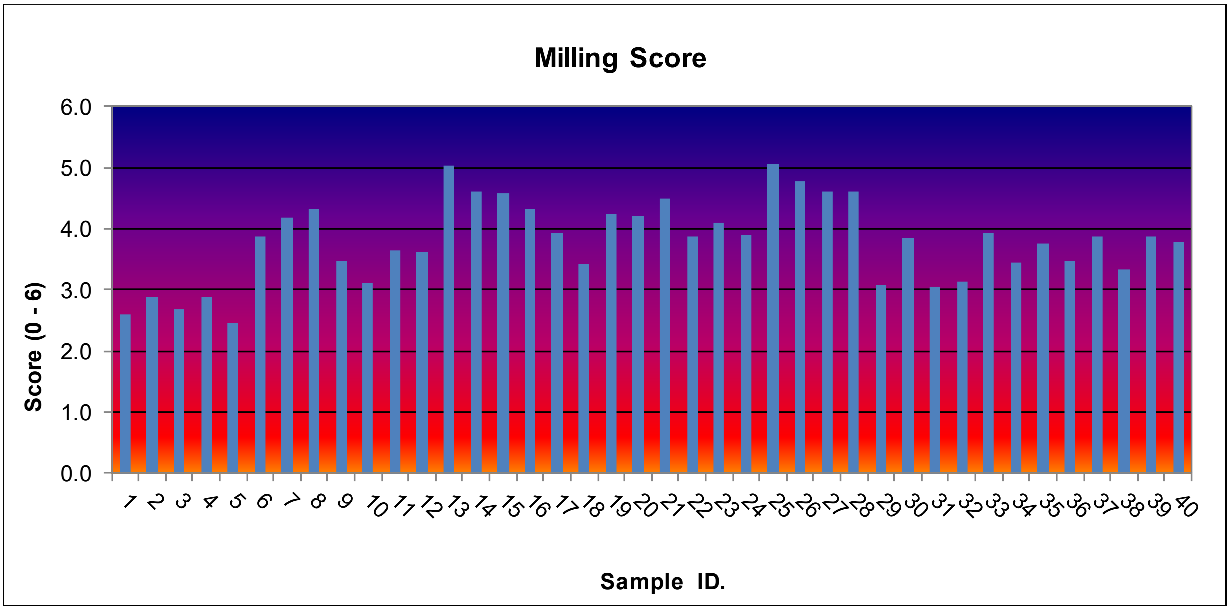
COOP. 20-2449 Jagalene (CC09)

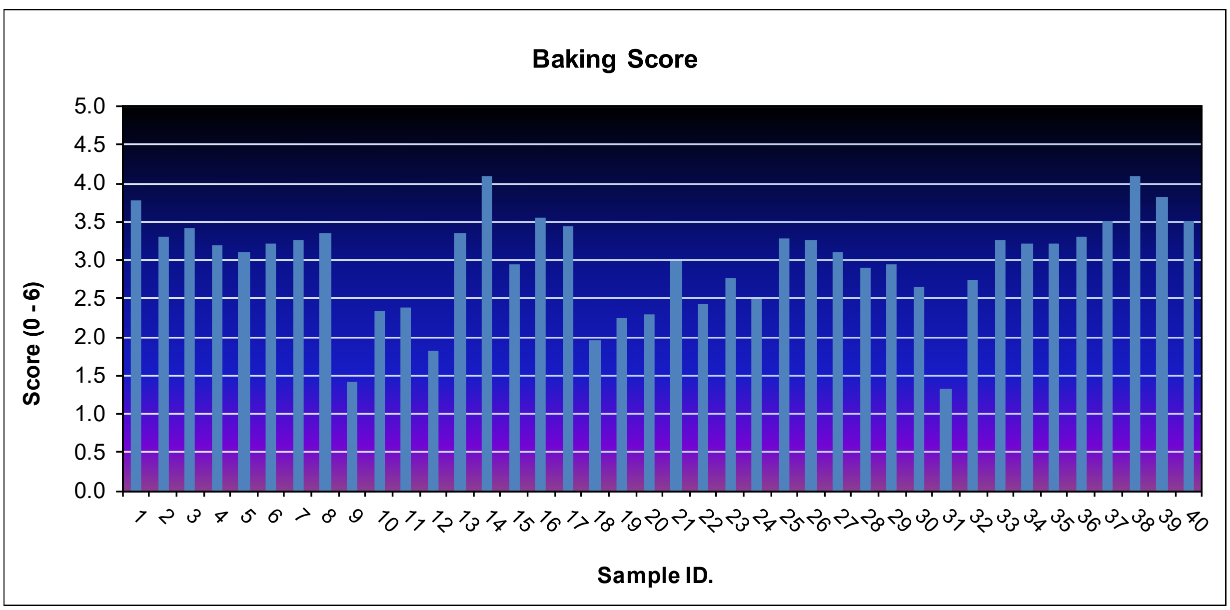
A. No comment.
B. No comment.
C. No comment.
D. Weak dough type for protein level, volume and crumb grain performed as expected for protein.
E. Good.
F. Very High Protein & Water Abs, Long MT, Slightly Sticky & Strong Dough, High Volume, Dark Yellow Crumb, Open Elongated Cells, Resilient & Smooth Texture.
G. Excellent loaf externals.
H. High absorption, avg grain, good volume.
I. No comment.
J. No comment.
K. Avg absorption, good grain, avg volume.
L. No comment.
M. Good stability and MTI, high volume, great dough notes. Recommend.

Notes: **A, K, and M** conducted sponge and dough bake tests

2020 WQC Milling and Baking Marketing Scores

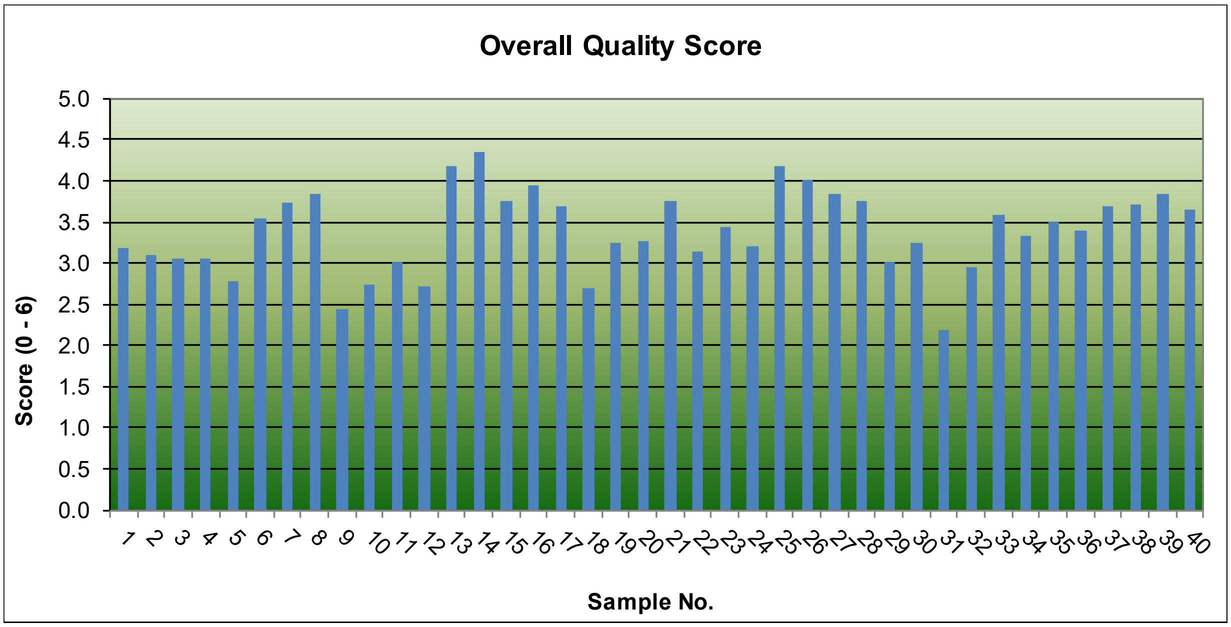
2020 WQC Milling & Baking Marketing Scores
(Based upon HWWQL Quality Data and KSU Milling Data)





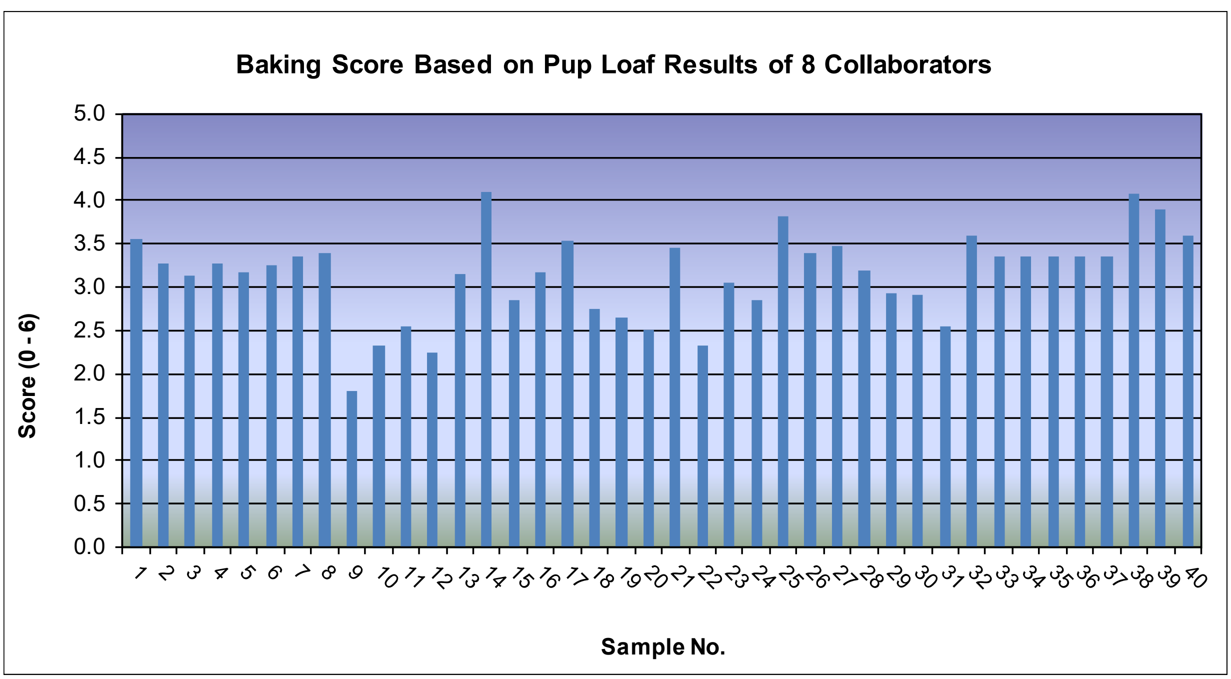
2020 WQC Milling & Baking Marketing Scores

(Based upon HWWQL Quality Data and KSU Milling Data)



2020 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 Target Value:	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
	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).

Variation(+/-) from Target Value:	SCORE	Absorption Actual (%)	Volume Actual (cc)	Color Rating Score	Grain Rating Score	Texture Rating Score	SCORE	Mix Time Actual (min)
	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
2020 WQC Hard Winter Wheat Entries

USDA-ARS Hard Winter Wheat Quality Laboratory
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Alkaline Noodle Quality Report

Objectives: Evaluate alkaline noodle color and cooking characteristics.

Materials: 40 WQC hard winter wheat samples harvested in 2020.

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:

Formulation:
Alkaline Noodle was made with 100 g flour, 1 g Na_2CO_3, and 35 mL of water (fixed).

Procedure:

100 g flour 1 g Na_2CO_3 + 35 mL Water

Mix at medium speed for 10 min (100 g Micro Mixer-no pins in the bowl, National MFG. Co., Lincoln, NE)

Rest for 30 min in a plastic bag

Plug roll gap with plastic tubing and pour mixed dough

Sheeting: roll gaps 4 (2 x), 3, 2.3, 1.75, 1.35, 1.1 (mm) → Measure color at 0 and 24 hr

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 21ºC.
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:

<u>Cooking Loss:</u>

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 $\pm$5ºC.
   Drying time is about 20 hr.
4. Cool beakers and weigh to 0.01 g.
   For 25 g sample, multiply by 4 → % cooking loss.

<u>Water Uptake:</u>

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***: 2418 (81.77), 2420(81.16), 2419 (80.23)

Noodle Color (*L* value, Higher is better.) ***at 24 hr***: 2418 (71.19), 2420 (70.57), 2422 (68.68)

Delta L (Change of *L* value, Lower absolute value is better.)
2422 (-9.85), 2418 (-10.58), 2420(-10.59)

PPO (Lower is better.): 2417 (0.105), 2421 (0.140), 2423 (0.149)

Table II shows the following:

Hardness: 2413(2.761), 2408 (2.737), 2436 (2.737)

Springiness: 2421 (0.913), 2420 (0.911), 2416 (0.909)

Chewiness: 2413 (1.701), 2407 (1.641), 2415 (1.639)

Resilience: 2426 (0.464), 2421 (0.461), 2422 (0.458)

Cohesiveness: 2426(0.711), 2422 (0.708), 2421 (0.708)

Water Uptake: 2429 (89.76), 2440 (88.00), 2418 (87.64)

Cooking Loss: 2421 (6.28), 2433 (6.52), 2407 (6.72)

Discussion

Sample 2420 had second highest L-value (brightness) at both 0 and 24 hrs, and third lowest delta L^*value and higher b-value at 24 hrs. This sample also had second highest springiness in texture after cooking. Bright noodle color 24 hrs after production and a firmer texture following cooking are considered desirable characteristics for alkaline noodles. Thus, sample 2420 would be considered the most favourable variety overall for alkaline noodle quality.

Sample 2418 had the highest L-value (brightness) at both 0 and 24 hrs, and had second lowest delta L^*value and relatively lower PPO value. This sample also had lower hardness and chewiness after cooking, and had third highest water uptake. Therefore, sample 2418 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 2422 had third highest L-value (brightness) at 24 hrs and the lowest delta L^*value. This sample also had third highest hardness and second highest chewiness after cooking.

Table I. Noodle Color and PPO Level

Sample ID	*L** @ 0	*L** @ 24	*a** @ 0	*a** @ 24	*b** @ 0	*b**@ 24	delta *L**	delta *a**	delta *b**	PPO
2401	77.41	61.31	-0.88	1.54	21.76	24.17	-16.10	2.42	2.41	0.477
2402	75.30	60.88	-0.23	2.19	25.92	26.26	-14.42	2.42	0.34	0.402
2403	76.87	62.34	-0.53	2.12	22.58	25.31	-14.53	2.65	2.73	0.395
2404	75.66	59.52	-0.58	2.28	24.55	26.25	-16.14	2.85	1.71	0.466
2405	75.14	59.24	-0.64	2.44	23.68	25.34	-15.90	3.08	1.66	0.520
2406	75.54	60.22	-0.36	1.83	21.53	23.28	-15.32	2.19	1.75	0.506
2407	73.02	59.44	0.28	3.00	23.15	25.76	-13.58	2.72	2.61	0.597
2408	76.63	62.49	-0.30	2.07	20.99	24.13	-14.14	2.37	3.15	0.607
2409	78.06	65.16	-0.64	1.86	20.87	23.88	-12.90	2.50	3.02	0.476
2410	78.50	64.89	-0.98	1.43	22.47	26.36	-13.61	2.40	3.89	0.411
2411	79.73	67.18	-1.02	1.49	21.26	24.49	-12.56	2.51	3.23	0.571
2412	75.67	61.88	-0.26	2.60	22.25	25.24	-13.80	2.86	2.99	0.708
2413	74.79	60.77	0.22	3.01	22.06	24.46	-14.02	2.79	2.40	0.583
2414	77.14	64.25	-1.19	1.77	24.60	27.42	-12.89	2.96	2.82	0.632
2415	75.41	61.65	-0.14	2.84	23.83	26.29	-13.76	2.98	2.46	0.665
2416	78.09	61.82	-0.69	1.74	20.45	21.74	-16.27	2.43	1.29	0.266
2417	79.23	66.91	-0.72	1.55	19.92	24.00	-12.33	2.27	4.08	0.105
2418	81.77	71.19	-1.33	0.41	20.89	23.66	-10.58	1.74	2.77	0.278
2419	80.23	67.67	-1.11	0.54	21.23	24.53	-12.56	1.65	3.30	0.417
2420	81.16	70.57	-1.36	0.31	22.77	27.87	-10.59	1.66	5.10	0.166
2421	75.07	61.17	0.24	3.27	22.52	26.22	-13.90	3.04	3.70	0.140
2422	78.53	68.68	-0.27	1.97	20.69	24.21	-9.85	2.24	3.52	0.157
2423	79.26	68.55	-1.01	1.24	23.72	28.22	-10.71	2.25	4.51	0.149
2424	80.16	67.36	-1.69	0.73	22.44	24.99	-12.80	2.41	2.56	0.511
2425	76.54	60.79	-0.32	2.66	21.30	24.87	-15.76	2.98	3.58	0.440
2426	77.23	63.25	-0.11	2.65	20.68	24.71	-13.99	2.75	4.03	0.378
2427	73.11	59.79	0.12	3.24	22.17	25.53	-13.32	3.13	3.36	0.370
2428	76.16	62.62	0.17	2.78	21.72	25.50	-13.54	2.61	3.78	0.470
2429	75.87	62.56	-0.04	2.43	19.66	22.42	-13.32	2.47	2.76	0.677
2430	76.91	64.31	-0.14	2.09	18.67	21.83	-12.61	2.23	3.16	0.566
2431	76.44	64.37	-0.31	2.12	21.05	24.88	-12.07	2.43	3.83	0.246
2432	78.33	63.91	-1.09	1.54	21.52	25.47	-14.42	2.62	3.96	0.713
2433	74.65	59.44	-0.10	2.61	21.10	23.67	-15.21	2.71	2.57	0.615
2434	74.04	59.04	0.04	3.11	20.39	23.49	-15.00	3.07	3.10	0.692
2435	74.40	58.92	-0.03	2.93	20.18	23.46	-15.48	2.96	3.28	0.608
2436	73.71	57.65	0.05	3.08	20.15	23.33	-16.06	3.03	3.19	0.569
2437	73.59	58.25	0.20	3.09	21.04	23.47	-15.34	2.89	2.43	0.580
2438	74.34	61.50	-0.22	2.16	22.45	24.14	-12.84	2.38	1.70	0.627
2439	75.58	60.98	-0.35	2.17	20.98	24.44	-14.60	2.51	3.46	0.574
2440	74.32	61.63	-0.48	2.08	23.67	25.50	-12.69	2.55	1.83	0.631
Avg	76.59	62.85	-0.44	2.12	21.82	24.77	-13.74	2.57	2.95	0.474

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

Sample ID	Hardness	Springiness	Chewiness	Resilience	Cohesiveness	Water Uptake (%)	cooking loss(%)
2401	2.322	0.876	1.346	0.396	0.662	84.48	7.08
2402	2.473	0.892	1.496	0.416	0.678	82.12	7.04
2403	2.559	0.878	1.498	0.399	0.667	77.16	8.08
2404	2.511	0.907	1.557	0.405	0.684	84.08	6.92
2405	2.735	0.863	1.518	0.367	0.643	84.36	7.88
2406	2.322	0.896	1.453	0.429	0.698	82.24	7.68
2407	2.676	0.900	1.641	0.411	0.681	83.48	6.72
2408	2.737	0.867	1.613	0.423	0.680	79.52	8.04
2409	2.536	0.873	1.413	0.376	0.638	85.84	8.16
2410	2.467	0.871	1.403	0.404	0.653	86.88	7.48
2411	2.420	0.842	1.281	0.372	0.628	83.28	8.28
2412	2.687	0.859	1.459	0.370	0.632	85.40	7.16
2413	2.761	0.902	1.701	0.425	0.683	84.20	6.80
2414	2.651	0.890	1.574	0.421	0.667	86.72	7.12
2415	2.704	0.898	1.639	0.418	0.675	82.00	7.48
2416	2.131	0.909	1.312	0.418	0.678	83.96	8.16
2417	2.127	0.902	1.319	0.423	0.687	80.64	8.48
2418	2.164	0.898	1.268	0.399	0.652	87.64	8.32
2419	2.277	0.894	1.388	0.430	0.682	84.52	8.04
2420	2.401	0.911	1.505	0.445	0.688	86.64	8.16
2421	2.375	0.913	1.535	0.461	0.708	83.40	6.28
2422	2.246	0.898	1.428	0.458	0.708	84.84	6.88
2423	2.569	0.892	1.479	0.390	0.645	82.72	8.48
2424	2.555	0.880	1.403	0.366	0.624	85.32	7.56
2425	2.399	0.896	1.480	0.429	0.688	85.32	7.24
2426	2.424	0.900	1.551	0.464	0.711	75.16	7.36
2427	2.365	0.902	1.474	0.436	0.691	79.28	7.04
2428	2.566	0.907	1.619	0.448	0.696	79.36	7.44
2429	2.434	0.822	1.287	0.357	0.643	89.76	6.88
2430	2.449	0.873	1.411	0.381	0.660	81.08	8.20
2431	2.372	0.797	1.144	0.340	0.605	81.88	8.24
2432	2.486	0.861	1.412	0.388	0.660	84.60	7.08
2433	2.537	0.890	1.550	0.414	0.687	83.08	6.52
2434	2.730	0.826	1.450	0.387	0.643	73.52	7.60
2435	2.571	0.878	1.485	0.382	0.658	84.20	6.96
2436	2.737	0.882	1.617	0.390	0.670	84.92	6.84
2437	2.611	0.871	1.531	0.401	0.673	82.40	6.76
2438	2.415	0.890	1.414	0.376	0.658	83.00	7.52
2439	2.304	0.905	1.398	0.396	0.671	83.08	7.20
2440	2.668	0.876	1.537	0.389	0.658	88.00	7.20
Avg	2.487	0.882	1.465	0.405	0.668	83.25	7.46

TORTILLA BAKING TEST RESULTS of 2020 WQC SAMPLES

Cereal Quality Lab, Department of Soil and Crop Sciences
Texas A&M University, College Station, TX
(December 2020)

SUMMARY

This report includes the production and evaluation methods of wheat flour tortillas and the 2020 WQC samples' data. The data was collected over 17 days, including baking and shelf stability.

Samples 2405, 2414, 2438, 2439, and 2440 created tortillas that ranked as "Excellent," based on their final diameter (≥150 mm) and subjective rollability (v. little cracking when rolled 16 days after baking) as seen in Table 1. These samples also had good dough handling properties. Higher diameter and rollability scores suggest flour that is moderately strong with good extensibility characteristics, resulting in the tortillas' longer shelf life.

Samples 2401, 2402, 2403, 2404, 2407, 2410, 2425, 2427, 2434, 2436, and 2436 were ranked as "good" because it had a diameter that just missed the cutoff for good (≥148 mm) and had great rollability (≥3.0 = signs of cracking, but no breaking) over 16 days of storage.

Samples 2421 and 2428 ranked as "fair," based on their diameter (130-140 mm), though they had good rollability. The flours suggestively were strong and caused shrinkage to the tortilla dough when hot-pressed.

Sample 2422 created hard and rough dough. It resulted in tortillas with an inferior diameter (129 mm) that had reduced rollability over 16 days of storage, indicating very strong gluten proteins, which often increase shrinkage after hot-pressing, an undesirable dough trait in tortillas. Samples 2419, 2420, and 2423 also created stiff doughs, which were not highly extensible, and led to low-quality tortillas.

Samples 2409, 2429, and 2431 had acceptable diameters (≥150mm) but low rollability scores (<3), indicative of weak flours.

RESULTS

Table 1 – Physical properties of tortillas

Test #	Moisture [%]	Weight [g]	Thickness [mm]	Diameter [mm]	Sp. Vol [mm^3/g]	Lightness [L*-value]	Rollability Day 8	Rollability Day 16	Rating* score
2401	30.82	39.15	3.30	149	1.5	77.9	5.0	4.5	Good
2402	32.29	39.73	2.87	148	1.2	77.5	5.0	5.0	Good
2403	32.33	39.01	3.17	149	1.4	78.9	5.0	5.0	Good
2404	32.79	39.16	3.13	150	1.4	77.7	5.0	4.0	Good
2405	32.47	38.72	2.94	159	1.5	77.3	5.0	4.0	Excellent
2406	32.41	39.37	3.29	141	1.3	76.4	5.0	5.0	Good
2407	31.73	34.97	2.78	149	1.4	75.4	4.5	3.5	Good
2408	32.31	39.31	3.18	147	1.4	77.5	4.5	4.5	Good
2409	31.63	39.01	3.29	150	1.5	78.8	4.0	2.0	Poor
2410	31.88	39.12	2.80	154	1.3	77.1	4.0	3.5	Good
2411	32.76	39.24	2.99	146	1.3	77.6	4.0	1.5	Poor
2412	32.82	39.24	3.21	154	1.5	77.2	4.5	3.0	Good
2413	32.20	39.15	2.75	147	1.2	75.5	5.0	4.5	Good
2414	31.20	38.37	3.11	165	1.7	79.6	5.0	4.0	Excellent
2415	31.69	38.85	3.05	146	1.3	76.1	4.5	4.0	Good
2416	32.74	39.17	2.98	144	1.2	76.2	4.0	2.5	Poor
2417	31.79	38.74	3.44	143	1.4	78.9	4.0	2.0	Poor
2418	32.28	39.14	3.41	143	1.4	75.6	2.0	1.0	Poor
2419	32.00	39.53	3.20	136	1.2	77.7	3.0	2.0	Poor
2420	32.32	39.47	3.23	138	1.2	75.2	2.5	1.5	Poor
2421	33.12	39.65	3.08	136	1.1	74.4	5.0	3.5	Fairly good
2422	31.59	39.69	3.68	129	1.2	72.7	2.0	1.0	Poor
2423	32.62	39.46	3.42	139	1.3	77.3	3.5	1.5	Poor
2424	31.73	39.11	3.26	143	1.3	77.0	3.0	1.0	Poor
2425	31.94	39.39	3.24	148	1.4	78.0	5.0	4.0	Good
2426	33.14	39.66	3.44	143	1.4	76.9	5.0	4.0	Good
2427	32.06	39.11	3.18	148	1.4	75.1	5.0	5.0	Good
2428	32.05	39.88	3.36	137	1.2	77.3	4.0	3.0	Fairly good
2429	30.84	38.93	3.05	160	1.6	75.1	4.0	2.0	Poor
2430	31.65	39.40	3.16	140	1.2	75.9	3.5	2.5	Poor
2431	31.40	39.48	2.82	153	1.3	76.1	4.0	2.0	Poor
2432	32.69	39.55	3.30	142	1.3	77.9	5.0	3.0	Good
2433	32.75	39.66	3.23	147	1.4	75.6	5.0	4.0	Good
2434	32.35	39.05	3.02	150	1.4	75.0	4.5	3.0	Good
2435	32.16	39.27	2.99	150	1.3	74.8	5.0	3.0	Good
2436	31.95	29.36	3.24	148	1.9	74.3	5.0	4.5	Good
2437	31.95	39.35	3.19	145	1.3	74.7	5.0	5.0	Good
2438	32.45	38.54	3.14	162	1.7	76.6	4.5	5.0	Excellent
2439	32.42	38.81	2.89	156	1.4	76.9	5.0	4.5	Excellent
2440	32.37	38.82	2.84	159	1.4	76.7	4.5	4.0	Excellent

*Subjective rating based primarily on diameter and rollability. Excellent >3.5 on day 16, $\geq$150 mm diameter Good: rollability score >3.0 on day 16, $\geq$140-150mm diameter. Fair: rollability score >3.0 on day 16, 130-140 mm diameter. Poor: rollability score <3.0 on day 16, any diameter.

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%
Water	53%

Tortilla Processing

MIX

→

PROOF
5 min, 32 °C, 70% RH

→

DIVIDE and ROUND
Obtain 43-g dough balls

↓

PROOF
10 min, 32 °C, 70% RH

←

HOT-PRESS
Top and bottom of
press plate = 360 °F

↙

BAKE
Oven temperature = 340 °F;
Oven residence time = 40 sec

→

COOL and PACKAGE

Cool tortillas on cooling conveyor and on a clean table, then package in low density polyethylene bags.

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

An average of 10 tortillas weighed on an analytical balance.

2. Diameter

It is an average diameter of 10 tortillas, which is measured using a ruler at two points. This varied widely among wheat samples depending on flour quality; desired values are > 150 mm.

3. Thickness

This is the average height of 10 tortillas, which is measured using a digital caliper.

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.

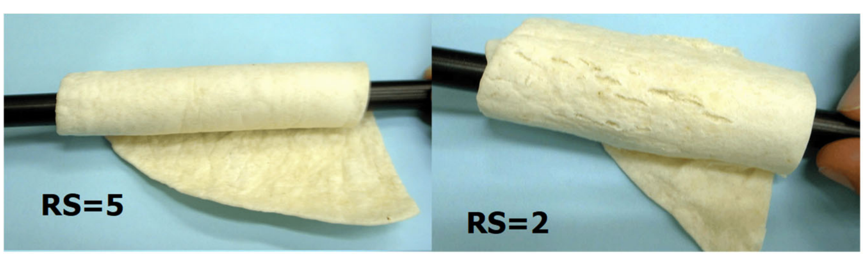
6. Specific Volume

$$\text{Specific volume } \left[\frac{\text{cm}^3}{g}\right] = \frac{\pi * (\frac{Diameter}{2})^2 * Height}{1000 * Weight}$$

This corresponds to the fluffiness of the tortilla; the desired value is > 1.0 cm^3/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 were rated using a continuous scale of 1-5 (5 = no cracking, 4 = signs of cracking, but no breaking, three = cracking and breaking beginning on the surface, two = cracking and breaking imminent on both sides, 1 = unrollable, breaks easily). This measured shelf stability and the desired value was >3 on the 16th day.



2020 WQC HARD WINTER WHEAT FLOUR PROTEIN ANALYSIS

Michael Tilley, Ph.D. and Amie Norton, Ph.D.

USDA, CGAHR, Manhattan, KS

Procedures

Procedure for the separation of glutenins for determination of HMW glutenin subunits on Lab-on –a –chip- analyzer

- 100 mg flour + 1 ml 50% 1-propanol, Include controls Karl (1, 7+8, 5+10) and Tam 111 (2*, 7+9, 2+12)
- Vortex shake for 15 min. and centrifuge for 5 min at 12,000 x g at room temp. discard the supernatant (contains gliadins).
- To the pellet added 1ml of 1 ml 50% 1-propanol + 2% BME. Break up pellt with plastic pick stick
- Vortex shake for 30 minutes, centrifuge for 5 min. at 12,000 x g room temp. and collect the supernatant

Determination of polymeric to monomeric protein ratio

Protein extraction

- 20 mg flour + 1 ml 0.05M Sodium phosphate buffer, pH 6.9, containing 0.5% SDS (w/v) - sonicate for 15s at 10W. Collect the supernatant (contains total protein).
- Filter the supernatant in a 0.45 μm filter and analyze by size-exclusion HPLC (SE-HPLC).

SE-HPLC

- SE-HPLC was conducted using a 300.0 x 7.8 mm BioSep S4000 column (Phenomenex, Torrance, CA), kept at 50°C, with a constant gradient composed of 50/50 ratio of deionized water + 0.1% Trifluoroacetic acid (TFA) and Acetonitrile + 0.1%TFA flow rate of 1.0 ml/min during 20 min.
- The chromatograms were manually integrated. The area of the first peak corresponds to polymeric proteins and the area of the second peak to monomeric proteins. The ratio was determined using the areas of the chromatograms.

Results of Flour Protein Analysis
Hard Winter Wheat WQC 2020 Crop Protein Analysis

	High Molecular Weight Glutenin Subunits				Polymeric/Monomeric protein
	Glu-A1	Glu-B1	Glu-D1		
20-2401	2*	7+8	5+10		0.901
20-2402	1,2*	17+18	5+10		0.808
20-2403	2*	7+8	5+10		0.781
20-2404	2*	7+9	5+10		0.797
20-2405	2*	7+9	5+10		0.791
20-2406	1,2*	17+18	5+10		0.898
20-2407	2*	7+9	5+10		0.936
20-2408	1,2*	7+9,17+18	5+10		0.788
20-2409	1,2*	17+18	5+10		0.950
20-2410	2*	7+8	5+10		0.831
20-2411	1	7+8	5+10		0.844
20-2412	2*	7+8	5+10		0.806
20-2413	1,2*	17+18	5+10		0.821
20-2414	1,2*	7+9	5+10		0.911
20-2415	1	7+8	5+10		0.775
20-2416	1,2*	17+18	5+10		0.820
20-2417	2*	7+8	5+10		0.858
20-2418	2*	7+8	5+10		0.912
20-2419	1,2*	17+18	5+10		0.787
20-2420	1	7+8	5+10		0.657
20-2421	1	7+9	2+12		0.961
20-2422	2*	7OE+8	5+10		0.745
20-2423	2*	7+9	5+10		0.845
20-2424	1	7+9	2+12		0.960
20-2425	1,2*	17+18	5+10		0.746
20-2426	1	7+8	5+10		0.787
20-2427	1	7+9	5+10		0.845
20-2428	1	7+9	5+10		0.879
20-2429	1	7+8	2+12		0.642
20-2430	1,2*	17+18	5+10		0.791
20-2431	2*	7+9	5+10		0.722
20-2432	2*	7+8	5+10		0.787
20-2433	1,2*	17+18	5+10		0.978
20-2434	1	7+9	5+10		0.865
20-2435	2*	7+9	5+10		0.757
20-2436	1	7+8	5+10		0.843
20-2437	2*	7+9	5+10		0.902
20-2438	2*	7+8	5+10		0.857
20-2439	2*	7+8	5+10		0.832
20-2440	2*	7+9	5+10		0.801

APPENDIX A
Credits and Methods

CREDITS

Milling, Sample Analysis, Ingredients and Report Preparation

Single Kernel Analysis, Kernel Size Distribution, and Test Weight	USDA/ARS/HWWQL Manhattan, KS
Flour Milling (Miag Multomat)	KSU Dept. Grain Science & Ind. Manhattan, KS
Wheat Grading	GIPSA Kansas City, MO
Moisture, Ash, Protein, and Minolta Flour Color	USDA/ARS/HWWQL Manhattan, KS
Mixograph, Farinograph Tests, Extensigraph, and Alveograph Tests	USDA/ARS/HWWQL Manhattan, KS
Rapid Visco-Analyzer, and Sedimentation Tests	USDA/ARS/HWWQL Manhattan, KS
Marketing Scores Sedimentation Tests	USDA/ARS/HWWQL Manhattan, KS
Flour Protein Analysis	USDA/ARS/GQSRU Manhattan, KS
Falling Number Test and Starch Damage	USDA/ARS/HWWQL Manhattan, KS
Doh-Tone 2 as Fungi α-amylase	Corbion 3947 Broadway Kansas City, MO 64111
Tortilla Evaluation	TAMU, Cereal Quality Lab College Station, TX
Alkaline Noodle Evaluation	USDA/ARS/HWWQL Manhattan, KS
Data Compilation and Final Report	USDA/ARS/HWWQL Manhattan, KS
Bake Data Processing	Scott Haley at CSU Ft. Collins, CO

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METHODS

Test Weight – 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.

Weight per Hectoliter - 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.

Wheat and Flour Moisture - 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 130^0 C for one hour.

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

Ash - 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.

Miag Multomat (Small Scale) Milling - 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.

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

Wet Gluten - 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.

Wheat Hardness - 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 flour-and-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.

Rapid Visco-Analyzer Test – AACC Approved Methods (61-02).

Sedimentation Test - AACC Approved Methods (56-60).

Alveograph – 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.

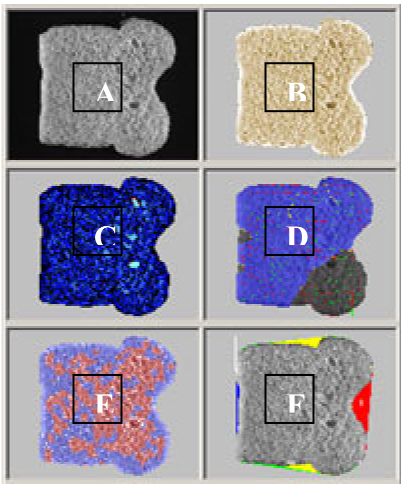
LI, Y. Z., and POSNER, E. S. 1989. An experimental milling techniquefor various flour extraction levels. Cereal Chem. 66:324-328.

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:



(A) Raw Image *(B) Brightness Correction Image*

(C) Cell Image *(D) Elongation Image*

(E) Cell Distribution Image *(F) Cell Size & Shape Image*

Data:

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

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

Cell Elongation and Orientation: Cell alignment and elongation, circulation and curvature

Dimensions: Sample area, height, breadth, ratios and wrapper length.

Brightness: Sample brightness and cell contrast.

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

Slice Area: The total area of a product slice (mm^2).

Slice Brightness: 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.

Number of Cells: 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.

Wall Thickness: 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.

Cell Diameter: 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.

Non-Uniformity: 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.

Average Cell Elongation: 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.

Cell Angle to Vertical (^{0}): 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

2020 WQC COLLABORATORS' BAKING TEST PROFILES AND OTHER INFORMATION

Coop	No.	Test Methods	Est. Flour and Dough Wt (g)	Mixing Tolerance	Fermentation time (min)	Oven Temp (F)	Baking Time (min)
A	1	Sponge and dough	600 g flour, 480 g dough	Other	240 min (sponge time) and 45 min (fermentation)	420	20
B	2	Pup-loaf straight dough	100 g flour, approx 160 g dough	Farinograph	120 min	425	20
C	3	Pup-loaf straight dough	200g, 170 g dough	Mixograph	180 min	419	24
D	4	Pup-loaf straight dough	100 g flour, approx 175 g dough	Mixograph	90 min	425	21
E	5	Pup-loaf straight dough	100 g	Mixograph	90 min	400	25
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	100 g, approx 170 g	Mixograph	90 min	400	25
H	8	Pup-loaf straight dough	100 g flour, approx 170 g dough	Mixograph	120 min	420	18
I	9	Pup-loaf straight dough	100 g flour	Farinograph	120 min	390	25
J	10	Straight dough	700 g flour, 525 g dough	Mixing series	120 min	400	25
K	11	Sponge and dough	700 g flour, 524 g dough	Farinograph with mixing evalu	240 min (sponge time) and 60 min (fermentation)	420	20
L	12	Pup-loaf straight dough	100 g	Miograph	90 min	420	24
M	13	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

2020 Technical Board Officers

CHAIR:	**Tess Brensing**, Corbion
VICE CHAIR:	**Rich Kendrick,** Great Plains Analytical Lab
SECRETARY:	**Stephen Baenziger,** University of Nebraska
MEMBER:	**Chris Kirby,** Oklahoma Wheat Commission
MEMBER:	Gang Guo, Ardent Mills

2020 Quality Evaluation & Advisory Committee

Brad Seabourn, USDA/ARS/HWWQL

Reuben McLean, Grain Craft

Jon Rich, Syngenta/AgriPro

Shawn Simpson, 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.

	Objective	**Minimum 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)
Str.-Gr. Agtron Color	50	40 (minimum)
Str.-Gr. 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*** *must accompany all published forms of the RQT."* *HWWQT Committee, 2006*

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***
Mixograph:	
Water Absorption (%, 14% mb)	***62+***
Peak Time (min)	***3.00 – 6.00***
Mixing Tolerance (HWWQL Score, 0-6)	***3.0***
Straight Dough Pup Method:	
Water Absorption (%, 14% mb)	***62+***
Mix Time (min)	***3.00 – 5.00***
Loaf Volume (cc)	***> 850***
Crumb Score (HWWQL Score, 0-6)	***> 3.0***

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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 27^0C 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 Noodles	Chinese Northern-Type Steamed Bread	Hamburger/Hotdog 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. 19, 2020

Minutes for 2020 Hard Winter Wheat Quality Council

February 19, 2020

Welcome & Opening Comments – Dave Green and Reuben McLean

Review of 2019 Minutes – Rich Kendrick, Secretary

Minutes approved and accepted by council.

Nomination and election of new members – Reuben McLean, Chair

Rich Kendrick nominated Gang Guo as new member of HWW board.
Second – Brian Walker, Miller Milling.
Approved by the council

2020 Board announced by Reuben McLean

Chairman	Tess Brensing	ADM Milling
Vice Chairman	Rich Kendrick	Great Plains Analytical Lab
Secretary	Stephen Baenziger	University of Nebraska
Member	Chris Kirby	Oklahoma Wheat Commission
Member	Gang Gua	Ardent Mills

Overview of Wheat Tours – Dave Green, WQC
Dave provided an overview of the wheat tours with an invitation for all to attend. HRW dates have been selected as May 4th – May 7th. This is a great training for people new to the industry.
There is also a HRS tour in July.

Overview of Milling of Wheat Samples - Paul Blodgett, KSU Manhattan
Paul provided an additional update on building activities at K-State and relocation of Miag mill. No major breakdowns this year. Samples started on October 24, completed on November 10.

Wheat Quality Council HRW Report for 2019 – Richard Chen, USDA/ARS Manhattan

Review of 2019 Wheat Crop – Mark Hodges, Plains Grains Inc.- Crop was similar to 2017. Much lower protein than 2018. But despite low protein, the protein quality was good, and the bakers have been able to make good bread.

Review of Hard Winter Wheat Quality Targets – Brad Seabourn, USDA/ARS Manhattan
Targets were developed in 2006, with minimal changes since that time.

Soft Wheat Update – Byung-Kee Baik, USDA/ARS Wooster

Extended invitation to attend Soft Wheat Quality council in Wooster. March 16-17

State Crop Reports –

- Texas – Audrey Girard, TAMU
- Oklahoma – Chris Kirby, Oklahoma Wheat Commission
- Kansas – Aaron Harries, Kansas Wheat Commission
- Nebraska – Royce Schaneman, Nebraska Wheat Board
- Colorado – Brad Erker, Colorado Wheat
- South Dakota – Reid Christopherson, South Dakota Wheat Commission
- Montana – Cassidy Marn, Montana Wheat and Barley Committee

Financial Report – Dave Green, WQC- Financials are in good shape.

Adjourn

APPENDIX F

Historical WQC Hard Winter Wheat Entries from 2001 to 2020

A History of WQC Hard Winter Wheat Entries

2020

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Byrd	20-2401					Colorado
Jagalene (CC01)	20-2402					Colorado
CO14A055-258	20-2403	HRW	yes	Kivari AX	2020	Colorado
CO15D098R	20-2404	HRW	yes	Steamboat	2020	Colorado
CO16SF070	20-2405					Colorado
Jagalene (CC02)	20-2406					BASF
BASF1	20-2407					BASF
BASF2	20-2408					BASF
Jagalene (CC03)	20-2409					Limagrain
DH11HRW55-4	20-2410					Limagrain
LCH13DH-47-1675	20-2411					Limagrain
LCH15ACC-13-4	20-2412					Limagrain
Jagalene (CC04)	20-2413					Kansas-Hays
Danby	20-2414					Kansas-Hays
KS15H137-2-2	20-2415	HRW	yes	KS Hamilton	2020	Kansas-Hays
Jagalene (CC05)	20-2416					Bayer
MODI4-6036	20-2417					Bayer
NEDI4-5064	20-2418					Bayer
Jagalene (CC06)	20-2419					Oklahoma
Baker's Ann	20-2420					Oklahoma
OK14124-2	20-2421	HRW	Yes	Butler's Gold	2020	Oklahoma
OK15MASBx7 ARS8-22	20-2422		not yet			Oklahoma
OK15818	20-2423	HRW	unofficiall	Gallagher	2019	Oklahoma
OK12716W Comp I	20-2424		not yet			Oklahoma
Jagalene (CC07)	20-2425					Montana
Yellowstone	20-2426					Montana
MTCL1737	20-2427		no			Montana
MT1745	20-2428					Montana
Everest	20-2429					Kansas-Manhattan
Jagalene (CC08)	20-2430					Kansas-Manhattan
KS12DH0156-88	20-2431					Kansas-Manhattan
KS090616K-1	20-2432					Kansas-Manhattan
Jagalene (CC09)	20-2433					Northern States
17NORD-94	20-2434		no			North Dakota
17NORD-96	20-2435		no			North Dakota
NE14434	20-2436		no			Nebraska
NE14696	20-2437		no			Nebraska
PSB13NEDH-14-83W	20-2438		no			Nebraska
09BC308-14-16	20-2439	HRW	yes	AP EverRock		Syngenta
SD12DHA03282	20-2440					South Dakota

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
2019						
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	yes	Steamboat	2020	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	yes	Uncharted	2020	Oklahoma
OK168512	19-2412	HRW	yes	Breakthrough	2020	Oklahoma
OCW04S717T-6W	19-2413	HW	yes	Big Country	2020	Oklahoma
OK12912C-138407-2	19-2414	HRW	yes	Strad CL+	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	StandClear CLP	2019	Montana
MT1683	19-2429					Montana
2018						
Jagalene (CC01)	18-2401					Texas
TAM 111	18-2402					Texas
TX12V7415	18-2403	HRW	yes	TAM 205	2019	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
08BC379-40-1	18-2417					Syngenta
Jagalene (CC06)	18-2418					Oklahoma

Entry ID	**Entry No.**	Entry Class	Released	Release Name	Release Year	Program
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	yes	TAM 115	2019	Texas
TX12M4068	17-2408	HRW	no			Texas
Byrd	17-2409	HRW				Colorado
CO12D1770	17-2410	HRW	yes	Canvas	2018	Colorado
Jagalene (CC03)	17-2411	HRW				Colorado
CO13D1783	17-2412	HRW	yes	Whistler	2018	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	yes	Numont	2020	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 Consideration			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
Jagalene (CC19)	15-2419	HRW				Montana

Entry ID	**Entry No.**	Entry Class	Released	Release Name	Release Year	Program
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	2015	Colorado
CO11D446	14-2413	HRW	yes	Langin	2016	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	yes	Bentley	2015	Oklahoma
OK10126	14-2425	HRW	yes	Spirit Rider	2017	Oklahoma
Jagalene (CC26)	14-2426	HRW				Kansas_Manhattan
KanMark	14-2427	HRW				Kansas_Manhattan
06BC722#25	14-2428	HRW	yes	SY Flint	2015	Agripro
06BC796#68	14-2429	HRW	yes	SY Sunrise	2015	Agripro
2013						
Check Blend (check)	13-2401	HRW				Limagrain
LCH08-80	13-2402	HRW				Limagrain
lCS Mint	13-2403	HRW	yes	LCS Mint	2012	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
Postorock (check)	13-2410	HRW				Agripro

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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	yes		2012	Oklahoma
Iba (OK07209)	12-2414	HRW	yes		2012	Oklahoma
OK09634	12-2415	HRW	no			Oklahoma
Lyman (check)	12-2416	HRW				South Dakota
SD08080	12-2417	HRW				South Dakota
SD06158	12-2418	HRW	yes	Redfield	2013	South Dakota
Yellowstone (check)	12-2419	HRW				Montana
MT08172	12-2420	HRW	yes	Colter	2012	Montana
MT0978	12-2421	HRW	yes	Northern	2015	Montana
TAM 111 (check)	12-2422	HRW				Texas
TX07A001505	12-2423	HRW				Texas
TX03A0563-07	12-2424	HRW				Texas
2011						
Danby (check)	11-2401	HWW				Kansas-Hays
Tiger	11-2402	HWW	yes			Kansas-Hays
KS08HW35-1	11-2403	HWW	yes	Clara CL	2011	Kansas-Hays
PostRock (check)	11-2404	HRW				AgriPro
SY Wolf	11-2405	HRW	yes			AgriPro
Syngenta Exp 138-45	11-2406	HRW	yes	SY Southwind	2012	AgriPro
Fuller (check)	11-2407	HRW				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
NE05496	11-2411	HRW	no			Nebraska

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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
SY Gold (AP00x0100-51)	09-2413	HRW	yes	SY Gold	2010	AgriPro

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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	Thunder CL	2008	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
Genou (check)	07-2417	HRW				MSU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
MT0495	07-2418	HRW	no			MSU
MTS04114	07-2419	HRW	no			MSU

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
Tandem (check)	05-2417	HRW				SDSU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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	yes	OK Bullet	2005	OSU
OK02909C	04-2415	HRW	yes	Okfield	2005	OSU
Tandem (check)	04-2416	HRW				SDSU
SD97W609	04-2417	HWW	yes	Alice	2006	SDSU
SD97538	04-2418	HRW	no			SDSU
SD98102	04-2419	HRW	yes	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	yes	Endurance	2004	OSU
OK98690	03-2415	HRW	yes	Deliver	2004	OSU
Crimson (check)	03-2416	HRW				SDSU
SD97W604	03-2417	HWW	yes	Wendy	2004	SDSU
SD92107-5	03-2418	HRW	no			SDSU
2002						
Jagger (check)	02-2401	HRW				AgriPro
Cutter	02-2402	HRW	yes			AgriPro
Dumas	02-2403	HRW	yes			AgriPro

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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
OK98699	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 2020 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, Richard.chen@usda.gov