Milling and Baking Test Results for Hard Winter Wheat

Harvested in 2012

63rd Report on Wheat Quality

Hard Winter Wheat Technical Board of the Wheat Quality Council

A coordinated effort by the agricultural, milling and baking industries to improve wheat quality

This program was carried out in cooperation with the Wheat Quality Council, Pierre, SD, The United States Department of Agriculture (USDA), The Agricultural Experiment Stations of Colorado, Kansas, Montana, Nebraska, Oklahoma, South Dakota, and Texas, Private wheat breeding companies including Syngenta (AgriPro Wheat) and Monsanto (Westbred, LLC), and laboratories from milling, baking, grain trade and other firms and research organizations. This technical report was prepared by the USDA-ARS, Hard Winter Wheat Quality Laboratory in Manhattan, KS. Trade names, if used, are used to identify products. No endorsement is intended, nor is criticism implied of similar products not mentioned.

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2012

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 2012 Testing Program

Founded in 1949, this is the **63rd** 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 were submitted by public and private breeding programs in the Great Plains growing region. This technical report includes FGIS wheat market classification, physical grain testing, milling, analytical, rheological, and bread baking results.

All entries this year were grown in special locations and submitted for small-scale testing by seven wheat breeding programs. 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 nineteen cooperators (18 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 in Manhattan, KS, and tortilla data generated by Texas A&M University. Methods used to evaluate wheat lines are listed in Appendix A.

2012 WQC Hard Winter Wheat Entries

	Test Entry Number	Sample Identification
WESTBRED	12-2401	WB-Stout (check)
	12-2402	HV9W07-1028
NEBRASKA	12-2403	Millennium (check)
	12-2404	NW07505
	12-2405	NE06545
	12-2406	NE06607
COLORADO	12-2407	Byrd (check)
	12-2408	Snowmass (check)
	12-2409	Antero
	12-2410	CO07W722-F5
OKLAHOMA	12-2411	Billings (check)
	12-2412	Ruby Lee
	12-2413	Gallagher (OK07214)
	12-2414	Iba (OK07209)
	12-2415	OK09634
SOUTH DAKOTA	12-2416	Lyman (check)
	12-2417	SD08080
	12-2418	SD06158
MONTANA	12-2419	Yellowstone (check)
	12-2420	MT08172
	12-2421	MT0978
TEXAS-AMARILLO	12-2422	TAM 111(check)
	12-2423	TX07A001505
	12-2424	TX03A0563-07

Wheat Classification Results from GIPSA

GIPSA Wheat Market Classification

Sample ID	Program	Entry ID	ODOR	CL	DKG	MOIST	TW	DKT	FM	SHBN	DEF	CCL	WOCL	GRADE	REMARKS
12-2401	Westbred	WB-Stout (check)	OK	HRW	0.0	10.3	59.2	0.0	0.0	1.1	1.1	0.0	0.0	US NO. 2 HRW DKG 0.0%	
12-2402	Westbred	HV9W07-1028	OK	HRW	0.0	10.9	61.7	0.1	0.0	0.9	1.0	0.0	0.0	US NO. 1 HRW DKG 0.0%	
12-2403	Nebraska	Millennium (check)	OK	HRW	0.0	11.0	60.6	0.4	0.0	1.1	1.5	0.0	0.2	US NO. 1 HRW DKG 0.0%	DKT-SPROUT 0.3%/MOLD 0.1%
12-2404	Nebraska	NW07505	OK	HDWH	0.1	10.9	60.0	5.3	0.0	1.6	6.9	2.8	2.8	US NO. 3 HDWH DKG 0.1%	DKT-SPROUT, CCL/WOCL HRW
12-2405	Nebraska	NE06545	OK	HRW	0.0	10.7	59.2	0.0	0.0	1.8	1.8	0.0	0.2	US NO. 2 HRW DKG 0.0%	
12-2406	Nebraska	NE06607	OK	HRW	0.1	11.0	59.8	0.0	0.0	1.1	1.1	0.0	0.0	US NO. 2 HRW DKG 0.0%	
12-2407	Colorado	Byrd (check)	OK	HRW	0.0	8.5	59.6	0.2	0.0	1.6	1.8	0.0	0.2	US NO. 2 HRW DKG 0.0%	DKT- MOLD
12-2408	Colorado	Snowmass (check)	OK	HDWH	0.0	8.2	60.2	0.0	0.0	0.8	0.8	0.9	0.9	US NO. 1 HDWH DKG 0.0%	CCL/WOCL HRW
12-2409	Colorado	Antero	OK	HDWH	0.0	8.6	61.9	0.0	0.0	0.9	0.9	3.2	3.2	US NO. 4 HDWH DKG 0.0%	CCL/WOCL HRW
12-2410	Colorado	CO07W722-F5	OK	HDWH	0.0	8.3	59.9	0.0	0.0	1.1	1.1	1.9	1.9	US NO. 2 HDWH DKG 0.0%	CCL/WOCL HRW
12-2411	Oklahoma	Billings (check)	OK	HRW	0.1	10.7	62.8	0.0	0.0	0.3	0.3	0.0	0.0	US NO. 1 HRW DKG 0.1%	
12-2412	Oklahoma	Ruby Lee	OK	HRW	1.0	9.8	60.5	0.0	0.0	0.6	0.6	0.0	0.0	US NO. 1 HRW DKG 1.0%	
12-2413	Oklahoma	Gallagher (OK07214)	OK	HRW	0.4	10.7	63.0	0.0	0.0	1.0	1.0	0.0	0.0	US NO.1 HRW DKG 0.4%	
12-2414	Oklahoma	Iba (OK07209)	OK	HRW	0.3	11.0	62.9	0.0	0.0	1.0	1.0	0.0	0.0	US NO. 1 HRW DKG 0.3%	
12-2415	Oklahoma	OK09634	OK	HRW	0.3	10.4	60.7	0.0	0.0	2.1	2.1	0.0	0.0	US NO. 1 HRW DKG 0.3%	
12-2416	South Dakota	Lyman (check)	OK	HRW	0.0	11.3	62.5	0.0	0.0	0.1	0.1	0.0	0.0	US NO.1 HRW DKG 0.0%	
12-2417	South Dakota	SD08080	OK	HRW	0.0	11.1	60.3	0.0	0.0	0.2	0.2	0.0	0.0	US NO. 1 HRW DKG 0.0%	
12-2418	South Dakota	SD06158	OK	HRW	0.0	12.2	61.0	0.0	0.0	0.1	0.1	0.0	0.2	US NO.1 HRW DKG 0.0%	
12-2419	Montana	Yellowstone (check)	OK	HRW	0.1	9.5	59.2	0.0	0.0	0.4	0.4	0.0	0.3	US NO. 2 HRW DKG 0.1%	
12-2420	Montana	MT08172	OK	HRW	0.3	8.9	59.7	0.0	0.0	0.1	0.1	0.0	0.0	US NO. 2 HRW DKG 0.3%	
12-2421	Montana	MT0978	OK	HRW	0.0	9.0	58.6	9.0	0.0	0.5	0.5	0.0	0.3	US NO.2 HRW DKG 0.0%	
12-2422	Texas-Amarilla	TAM 111 (check)	OK	HRW	0.0	9.6	61.0	0.0	0.0	1.2	1.2	0.0	0.0	US NO. 1 HRW DKG 0.0%	
12-2423	Texas-Amarilla	TX07A001505	OK	HRW	0.0	9.4	60.5	0.0	0.0	0.7	0.7	0.0	0.0	US NO. 1 HRW DKG 0.0%	
12-2424	Texas-Amarilla	TX03A0563-07	OK	HRW	0.0	9.5	61.7	0.0	0.0	1.4	1.4	0.0	0.0	US 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.

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

Description of Test Plots and Breeder Entries

Westbred – Sid Perry

The samples were produced at our Mount Hope, Kansas location. The plots were seeded on October 10, 2011 at a rate of 70 lb/acre. A pre-plant fertilizer application of 30 lb N was followed up with a top-dress application of 40 lb N and a late boot application of 10 lb N.

Yield levels were 50 bushels/acre. Plots were sprayed with a fungicide.

WB-Stout (check)

This variety was tested by the WQC as HV9W03-539. It is a HRWW with excellent baking properties.

HV9W07-1028

A hard red winter wheat derived from the cross TX97V2838//KS940786-7/X940793-10-4. It is medium-early heading, MS to LR and YR, and is S to SBMV. It is resistant to Hessian Fly. Best performance has been in northern and western areas of the southern Great Plains. Predictive bake tests have indicated very good baking quality.

Westbred: 2012 (Small-Scale) Samples

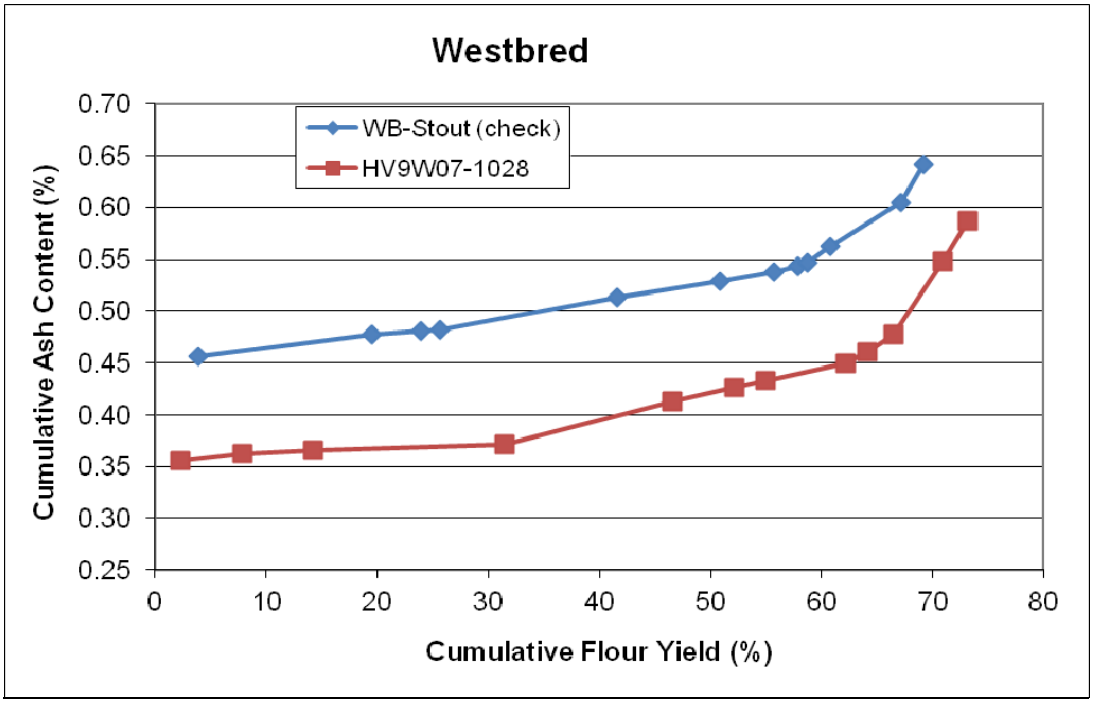
Test entry number	12-2401	12-2402
Sample identification	**WB-Stout (check)**	**HV9W07-1028**
Wheat Data		
GIPSA classification	2 HRW	1 HRW
Test weight (lb/bu)	58.9	62.4
Hectoliter weight (kg/hl)	77.5	82.0
1000 kernel weight (gm)	28.9	24.2
Wheat kernel size (Rotap)		
Over 7 wire (%)	62.7	42.4
Over 9 wire (%)	34.4	55.7
Through 9 wire (%)	2.9	1.9
Single kernel (skcs)[a]		
Hardness (avg /s.d)	77.0/16.5	72.6/15.9
Weight (mg) (avg/s.d)	28.9/8.9	24.2/6.9
Diameter (mm)(avg/s.d)	2.64/0.34	2.49/0.28
Moisture (avg/s.d)	10.0/0.4	10.3/0.5
SKCS distribution	00-02-11-87-01	01-03-15-81-01
Classification	Hard	Hard
Wheat protein (12% mb)	14.0	14.1
Wheat ash (12% mb)	1.61	1.60
Milling and Flour Quality Data		
Flour yield (%, str. grade)		
Miag Multomat Mill	69.2	73.1
Quadrumat Sr. Mill	65.2	69.6
Flour moisture (%)	11.1	11.1
Flour protein (14% mb)	12.4	12.8
Flour ash (14% mb)	0.64	0.58
Rapid Visco-Analyser		
Peak Time (min)	6.5	6.4
Peak Viscosity (RVU)	218.8	227.0
Breakdown (RVU)	65.1	72.7
Final Viscosity at 13 min (RVU)	261.8	266.7
Minolta color meter		
L*	91.8	91.9
a*	-0.99	-1.02
b*	9.78	9.83
PPO value	0.402	0.421
Falling number (sec)	513	521
Damaged Starch		
(AI%)	97.89	96.04
(AACC76-31)	7.82	6.30

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

Westbred: Physical Dough Tests and Gluten Analysis For 2012 (Small-Scale) Samples

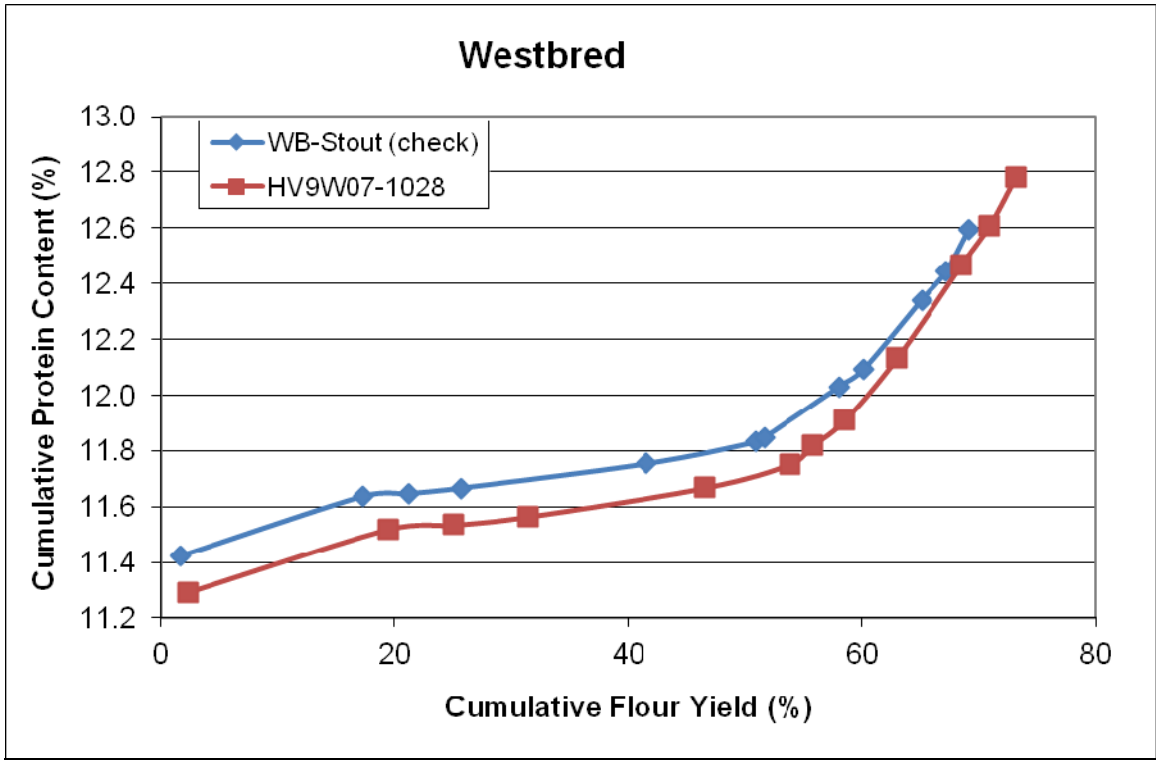
Test Entry Number	**12-2401**	**12-2402**
Sample Identification	**WB-Stout (check)**	**HV9W07-1028**
MIXOGRAPH		
Flour Abs (% as-is)	67.4	67.5
Flour Abs (14% mb)	64.2	64.3
Mix Time (min)	3.0	5.0
Mix tolerance (0-6)	3	5
FARINOGRAPH		
Flour Abs (% as-is)	70.2	64.9
Flour Abs (14% mb)	67.3	62.1
Development time (min)	5.8	7.2
Mix stability (min)	11.2	16.1
Mix Tolerance Index (FU)	19	20
Breakdown time (min)	12.5	13.3
ALVEOGRAPH		
P(mm): Tenacity	116	89
L(mm): Extensibility	90	126
G(mm): Swelling index	21.1	25.0
W(10^{-4} J): strength (curve area)	344	379
P/L: curve configuration ratio	1.29	0.71
Ie(P_{200}/P): elasticity index	55.9	63.3
EXTENSIGRAPH		
Resist (BU at 45/90/135 min)	282/293/320	374/465/557
Extensibility (mm at 45/90/135 min)	174/169/169	163/165/157
Energy (cm^2 at 45/90/135 min)	95/95/103	121/149/158
Resist $_{max}$ (BU at 45/90/135 min)	404/431/464	594/731/811
Ratio (at 45/90/135 min)	1.62/1.74/1.90	2.30/2.82/3.55
PROTEIN ANALYSIS		
HMW-GS Composition	2*, 7+8, 5+10	2*, 7+8, 5+10
%IPP	45.35	45.40
SEDIMENTATION TEST		
Volume (ml)	58.5	65.8

Westbred: Cumulative Ash Curves



WB-Stout (check)					HV9W07-1028				
Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash
1BK	3.9	0.46	3.9	0.46	1M Red	2.27	0.36	2.3	0.36
2M	15.6	0.48	19.5	0.48	1M	5.58	0.37	7.8	0.36
1M	4.5	0.49	24.0	0.48	1BK	6.44	0.37	14.3	0.37
1M Red	1.7	0.49	25.7	0.48	2M	17.18	0.38	31.5	0.37
3M	15.9	0.56	41.5	0.51	3M	15.12	0.50	46.6	0.41
4M	9.3	0.60	50.8	0.53	2BK	5.58	0.53	52.2	0.43
2BK	4.9	0.63	55.8	0.54	Grader	2.78	0.56	54.9	0.43
Grader	2.1	0.70	57.9	0.54	4M	7.27	0.58	62.2	0.45
FILTER FLR	0.8	0.76	58.7	0.55	FILTER FLR	1.89	0.82	64.1	0.46
3BK	2.1	0.98	60.8	0.56	3BK	2.36	0.92	66.5	0.48
5M	6.4	1.01	67.2	0.60	5M	4.41	1.62	70.9	0.55
BRAN FLR	1.9	1.93	69.1	0.64	BRAN FLR	2.25	1.80	73.1	0.59
Break Shorts	5.6	3.07	74.8	0.83	Break Shorts	4.27	3.48	77.4	0.75
Red Dog	2.9	3.31	77.7	0.92	Red Dog	1.73	3.73	79.1	0.81
Red Shorts	2.0	3.47	79.7	0.98	Red Shorts	1.04	3.76	80.2	0.85
Filter Bran	0.6	2.58	80.3	0.99	Filter Bran	0.66	2.79	80.8	0.87
Bran	19.7	4.33	100.0	1.65	Bran	19.18	4.71	100.0	1.60
Wheat		1.57			Wheat		1.56		
St. Grd. Fl.		0.64			St. Grd. Fl.		0.58		

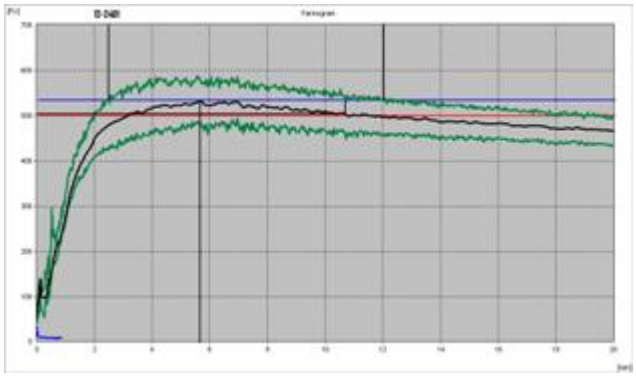
Westbred: Cumulative Protein Curves



WB-Stout (check)					HV9W07-1028				
Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein
1M Red	1.7	11.4	1.7	11.4	1M Red	2.3	11.3	2.3	11.3
2M	15.6	11.7	17.3	11.6	2M	17.2	11.5	19.5	11.5
1BK	3.9	11.7	21.2	11.6	1M	5.6	11.6	25.0	11.5
1M	4.5	11.8	25.7	11.7	1BK	6.4	11.7	31.5	11.6
3M	15.9	11.9	41.5	11.8	3M	15.1	11.9	46.6	11.7
4M	9.3	12.2	50.8	11.8	4M	7.3	12.3	53.9	11.8
FILTER FLR	0.8	12.9	51.6	11.8	FILTER FLR	1.9	13.7	55.7	11.8
5M	6.4	13.5	58.0	12.0	Grader	2.8	13.8	58.5	11.9
Grader	2.1	13.9	60.2	12.1	5M	4.4	15.1	62.9	12.1
2BK	4.9	15.3	65.1	12.3	2BK	5.6	16.3	68.5	12.5
3BK	2.1	15.6	67.2	12.4	3BK	2.4	16.6	70.9	12.6
BRAN FLR	1.9	17.8	69.1	12.6	BRAN FLR	2.2	18.3	73.1	12.8
Break Shorts	5.6	15.1	74.8	12.8	Break Shorts	4.3	15.4	77.4	12.9
Red Dog	2.9	15.8	77.7	12.9	Red Dog	1.7	15.5	79.1	13.0
Red Shorts	2.0	14.7	79.7	12.9	Red Shorts	1.0	14.4	80.2	13.0
Filter Bran	0.6	12.8	80.3	12.9	Filter Bran	0.7	14.2	80.8	13.0
Bran	19.7	16.0	100.0	13.5	Bran	19.2	16.8	100.0	13.7
Wheat		13.7			Wheat		13.8		
St. Grd. Fl		12.4			St. Grd. Fl		12.8		

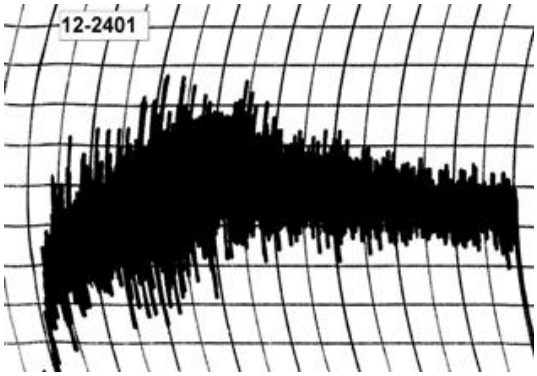
Physical Dough Tests
2012 (Small Scale) Samples – Westbred

Farinograms



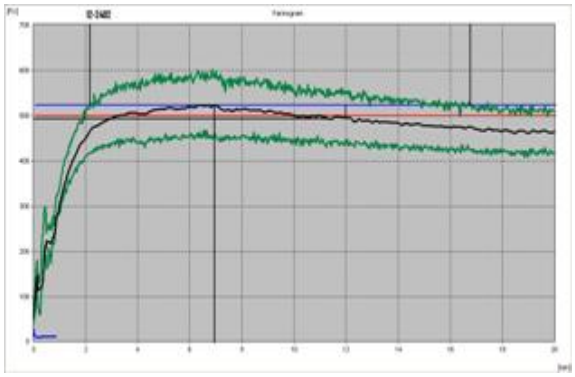
Water abs = 67.3%, Peak time = 5.8 min,
Mix stab = 11.2 min, MTI = 19 FU

Mixograms

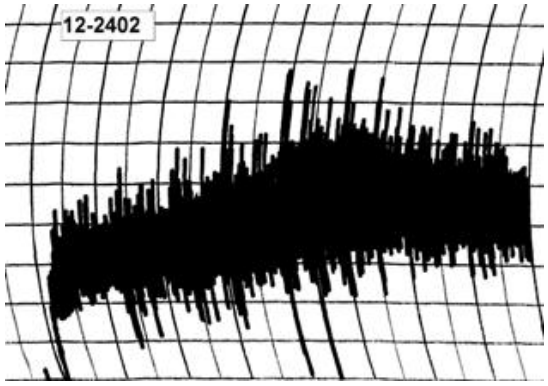


Water abs = 64.2%
Mix time = 3.0 min

12-2401, WB-Stout (check)



Water abs = 62.1%, Peak time = 7.2 min,
Mix stab = 16.1 min, MTI = 20 FU

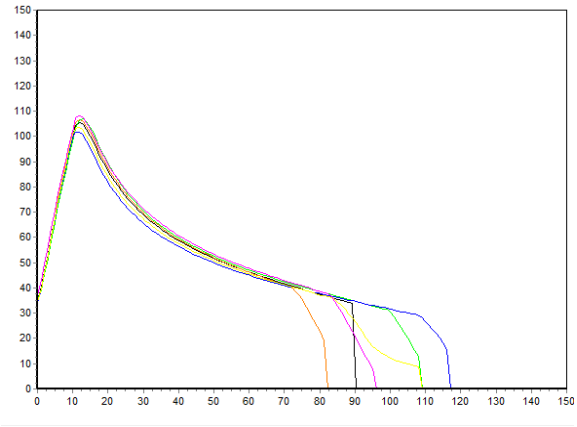


Water abs = 64.3%
Mix time = 5.0 min

12-2402, HV9W07-1028

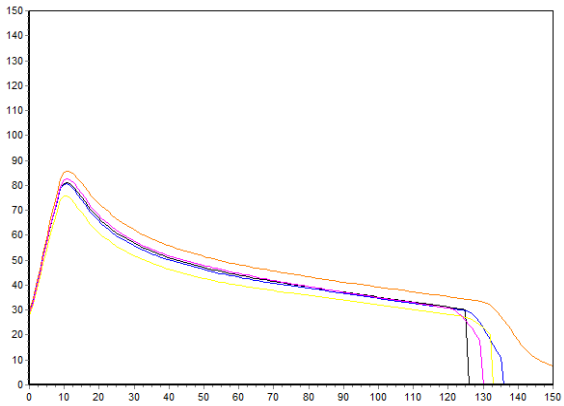
Physical Dough Tests - Alveograph

2012 (Small Scale) Samples – Westbred



12-2014, WB-Stout (check)

P (mm H_20) = 116, L (mm) = 90, W ($10E^{-4}J$) = 344

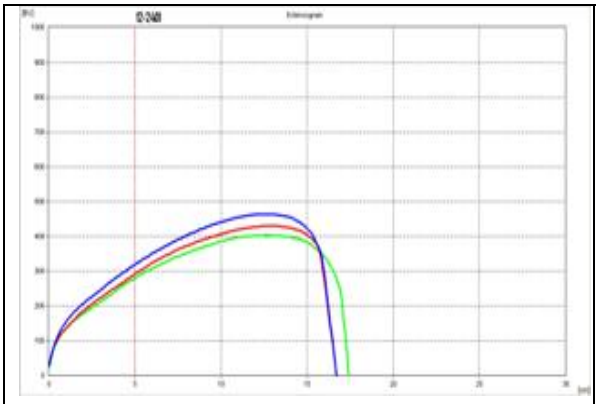
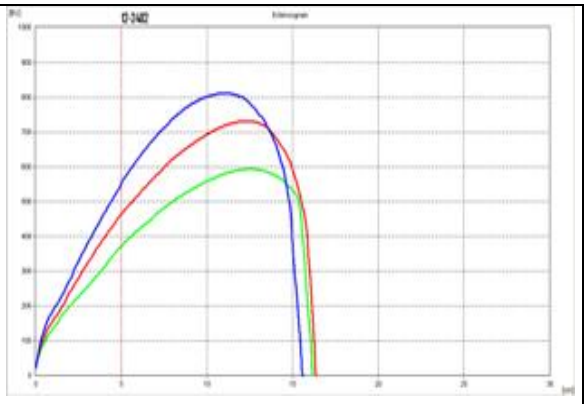


12-2402, HV9W07-1028

P (mm H_20) = 89, L (mm) = 126, W ($10E^{-4}J$) = 379

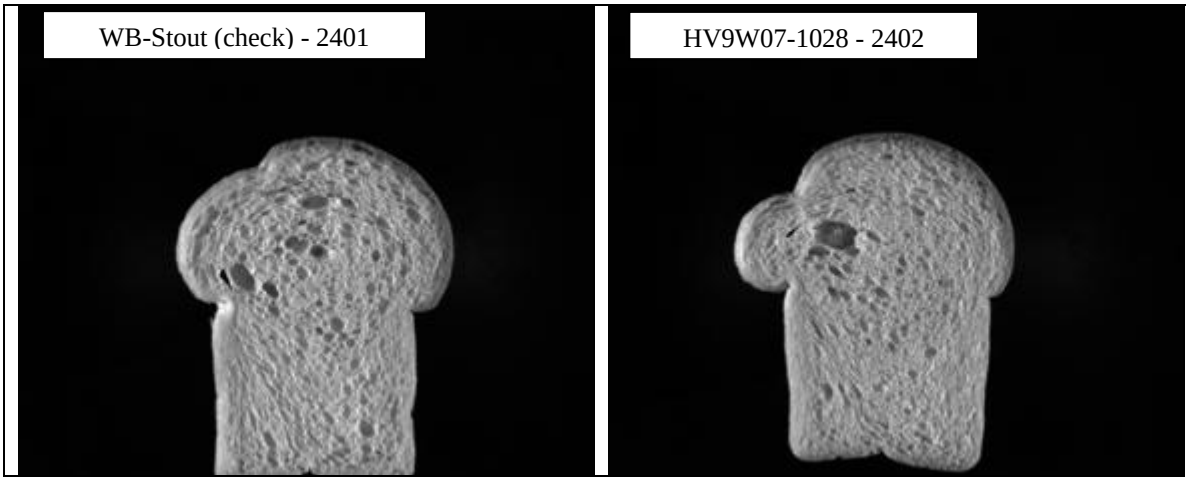
Physical Dough Tests - Extensigraph

2012 (Small Scale) Samples – Westbred

	
WB-Stout (check) - 2401 R (BU) = 293, E (mm) = 168.5, W (cm^2) = 95.1 Rmax (BU) = 431, Ratio = 1.74 at 90 min	**HV9W07-1028 - 2402** R (BU) = 465, E (mm) = 164.9, W (cm^2) = 149.1 Rmax (BU) = 731, Ratio = 2.82 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.

Westbred: C-Cell Bread Images and Analysis for 2012 (Small-Scale) Samples



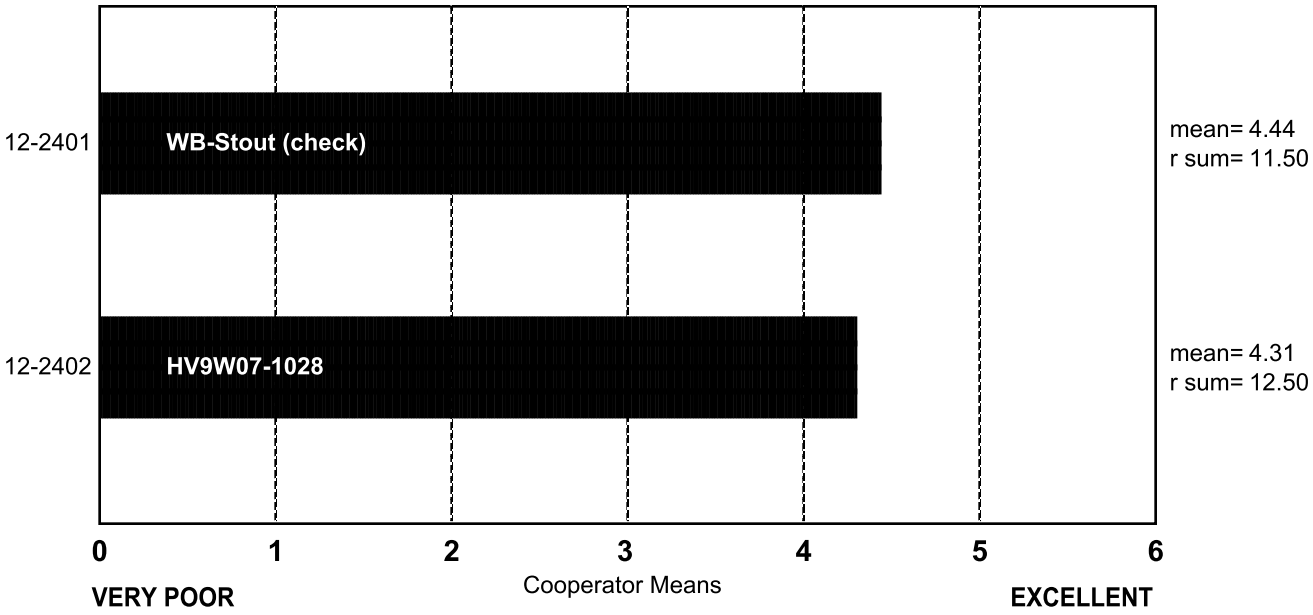
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2401	6506	137.4	3933	0.455	2.196	2.778	1.735	-17.10
2402	6523	134.9	4244	0.435	1.950	9.823	1.795	-16.55

SPONGE CHARACTERISTICS

(Small Scale) Westbred

ncoop= 8
chisq= 0.13
chisqc= 0.25
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

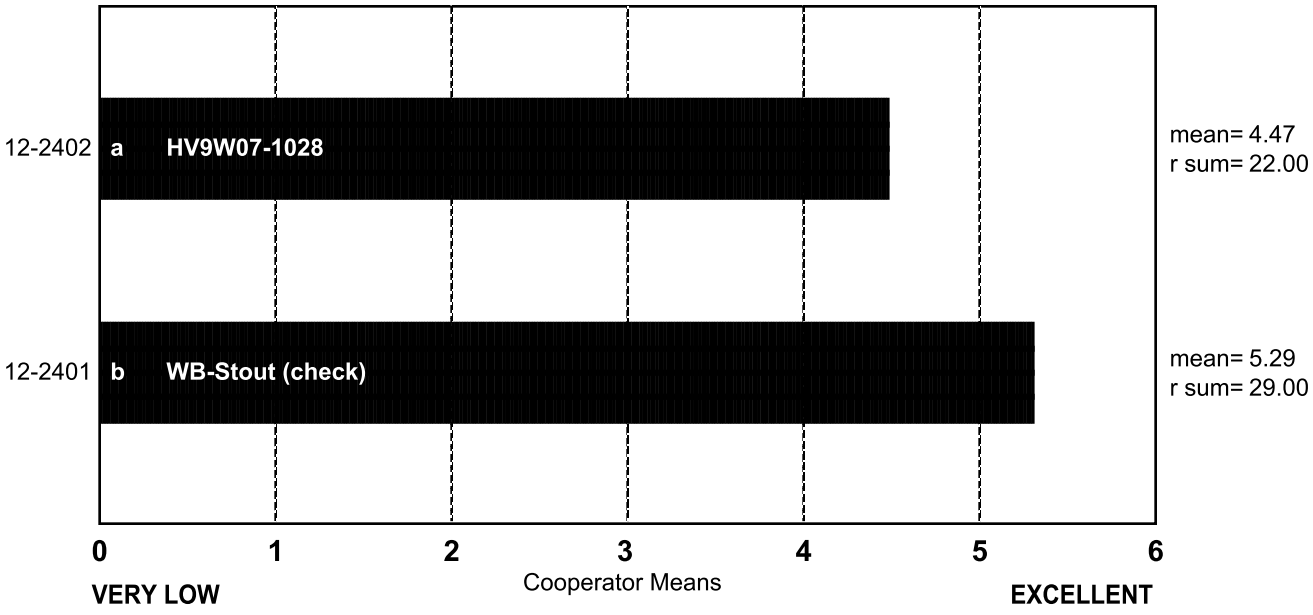


BAKE ABSORPTION

(Small Scale) Westbred

ncoop= 17
chisq= 2.88
chisqc= 4.45
cvchisq= 3.84
crdiff= 3.29

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Westbred

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2401 WB-Stout (check)	**68.1**	**65.0**	**64.7**	**64.1**	**67.5**	**59.0**	**67.3**	**70.7**	**66.0**	**67.8**	**62.5**	**64.5**	**67.3**	**65.0**	**63.0**	**66.6**	**65.5**
12-2402 HV9W07-1028	**66.1**	**63.0**	**64.7**	**64.1**	**62.0**	**59.0**	**62.1**	**65.6**	**61.0**	**67.8**	**57.3**	**64.5**	**62.1**	**67.0**	**63.0**	**63.4**	**63.0**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Westbred

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2401 WB-Stout (check)	**3.0**	**6.0**	**3.5**	**4.0**	**6.0**	**20.0**	**9.0**	**3.2**	**15.0**	**4.4**	**2.0**	**4.3**	**7.0**	**5.0**	**9.0**	**5.5**	**18.0**
12-2402 HV9W07-1028	**4.8**	**13.0**	**5.0**	**5.0**	**7.0**	**20.0**	**11.0**	**4.3**	**25.0**	**5.8**	**2.3**	**6.6**	**10.0**	**8.0**	**9.0**	**6.6**	**30.0**

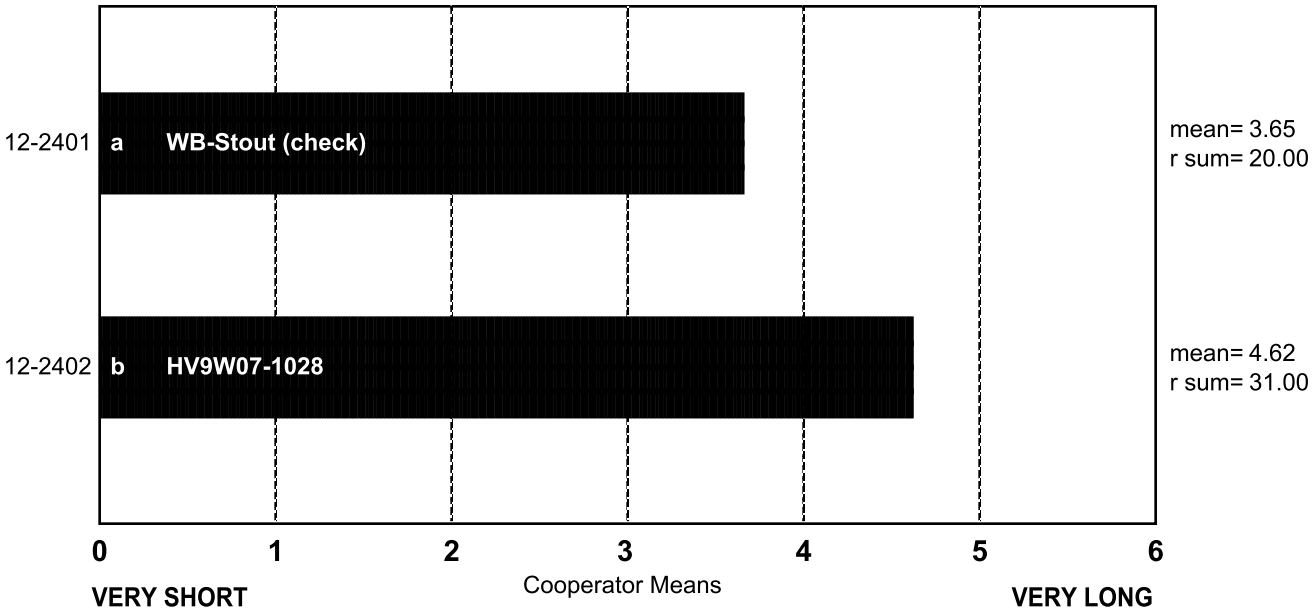
Raw Data

BAKE MIX TIME

(Small Scale) Westbred

ncoop= 17
chisq= 7.12
chisqc= 8.64
cvchisq= 3.84
crdiff= 2.80

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



mean= 3.65
r sum= 20.00

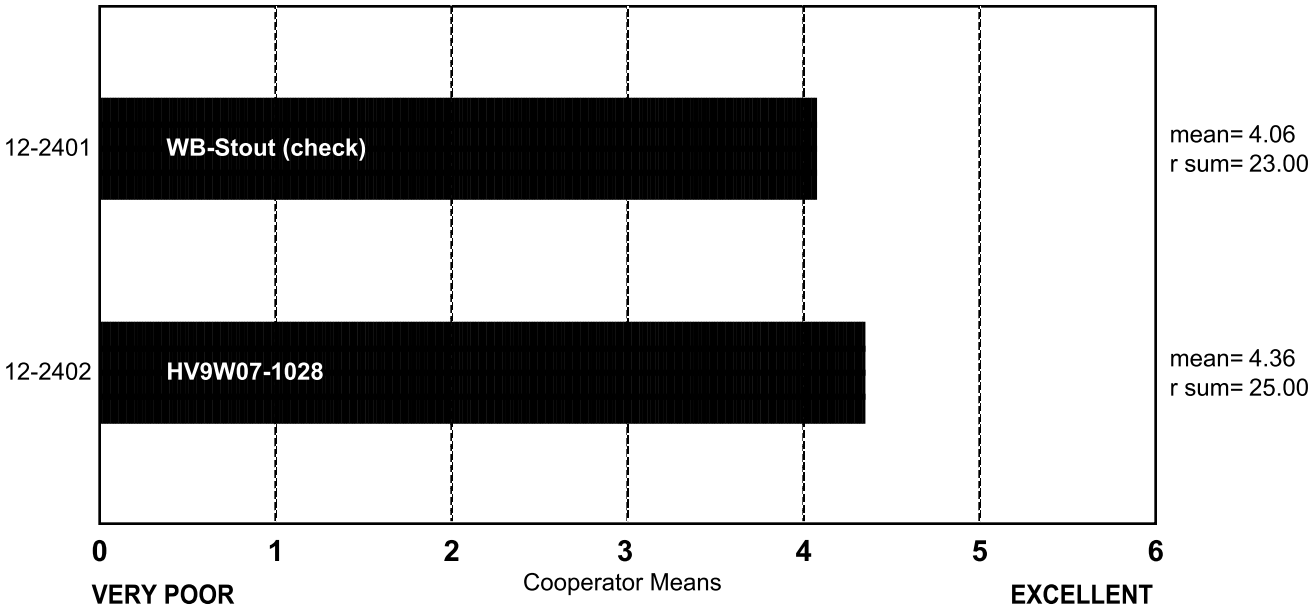
mean= 4.62
r sum= 31.00

MIXING TOLERANCE

(Small Scale) Westbred

ncoop= 16
chisq= 0.25
chisqc= 0.33
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



mean= 4.06
r sum= 23.00

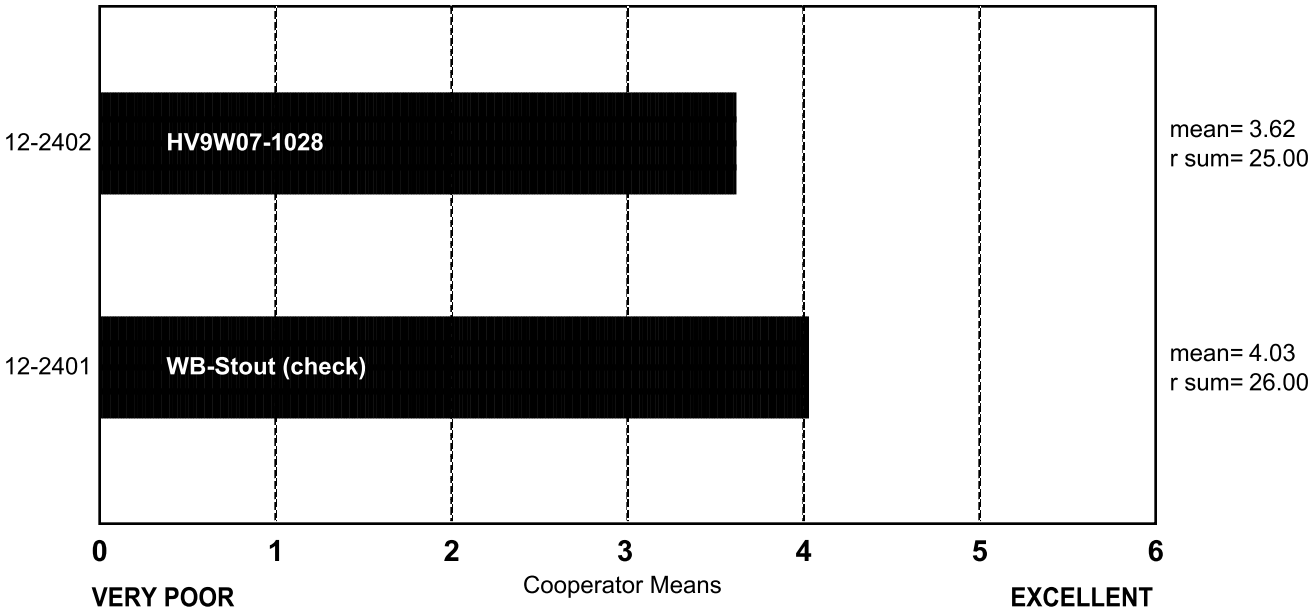
mean= 4.36
r sum= 25.00

DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Westbred

ncoop= 17
chisq= 0.06
chisqc= 0.09
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'OUT OF MIXER', DESCRIBED

(Small Scale) Westbred

	Sticky	Wet	Tough	Good	Excellent
12-2401 WB-Stout (check)	**3**	**1**	**5**	**7**	**1**
12-2402 HV9W07-1028	**0**	**1**	**9**	**6**	**1**

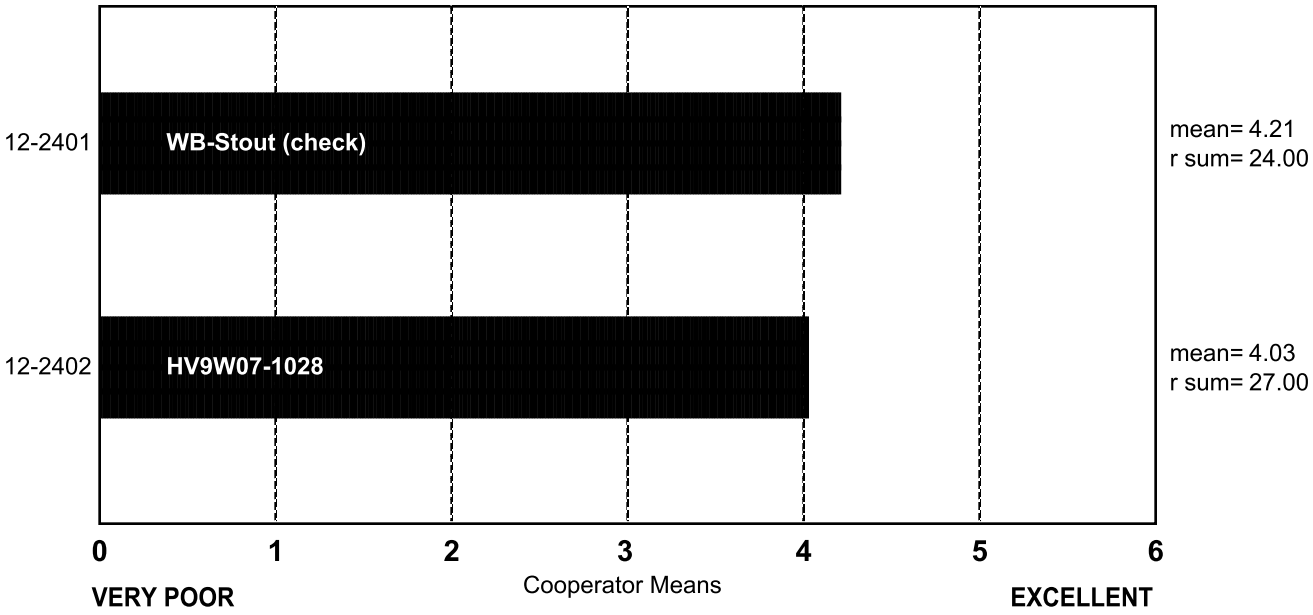
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Westbred

ncoop= 17
chisq= 0.53
chisqc= 0.82
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) Westbred

	Sticky	Wet	Tough	Good	Excellent
12-2401 WB-Stout (check)	**1**	**0**	**1**	**14**	**1**
12-2402 HV9W07-1028	**0**	**2**	**5**	**9**	**1**

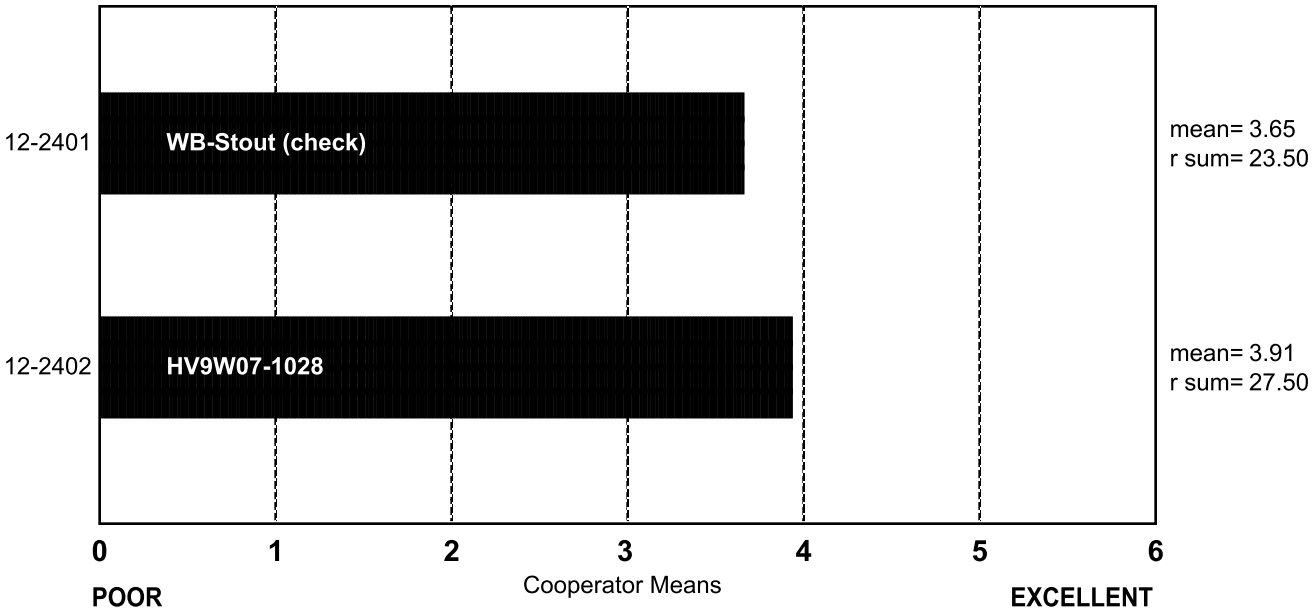
Frequency Table

CRUMB GRAIN

(Small Scale) Westbred

ncoop= 17
chisq= 0.94
chisqc= 1.00
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB GRAIN, DESCRIBED

(Small Scale) Westbred

	Open	Fine	Dense
12-2401 WB-Stout (check)	**9**	**8**	**0**
12-2402 HV9W07-1028	**8**	**8**	**1**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Westbred

	Round	Irregular	Elongated
12-2401 WB-Stout (check)	**6**	**7**	**4**
12-2402 HV9W07-1028	**4**	**4**	**9**

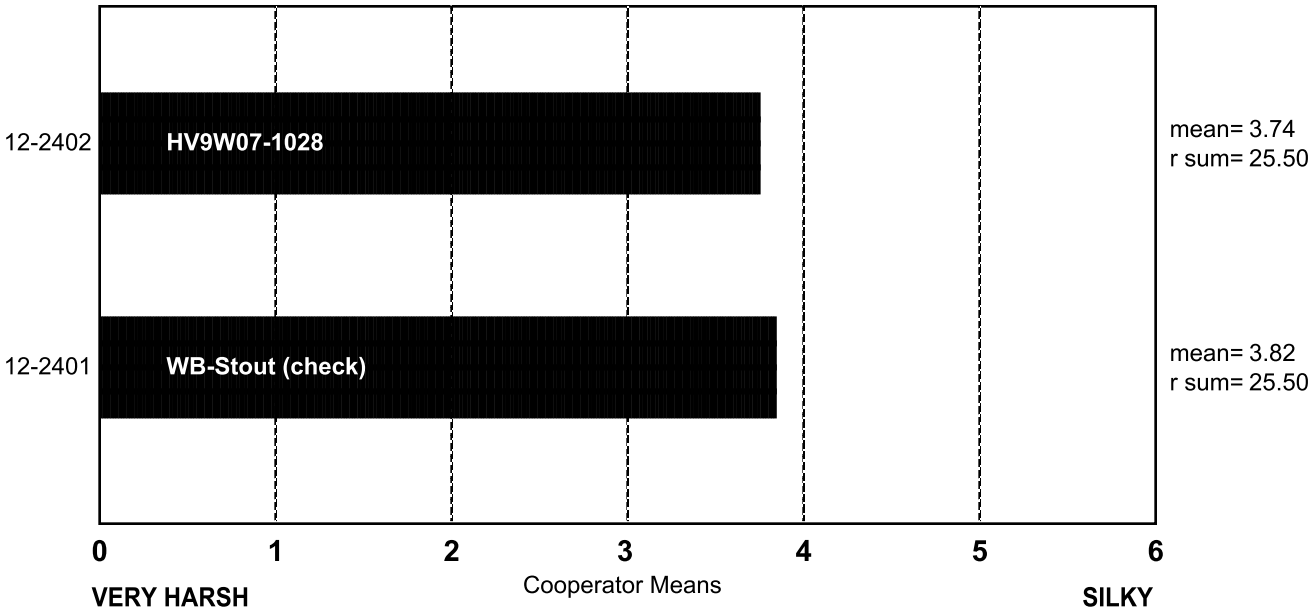
Frequency Table

CRUMB TEXTURE

(Small Scale) Westbred

ncoop= 17
chisq= 0.00
chisqc= 0.00
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB TEXTURE, DESCRIBED

(Small Scale) Westbred

	Harsh	Smooth	Silky
12-2401 WB-Stout (check)	**2**	**11**	**4**
12-2402 HV9W07-1028	**2**	**12**	**3**

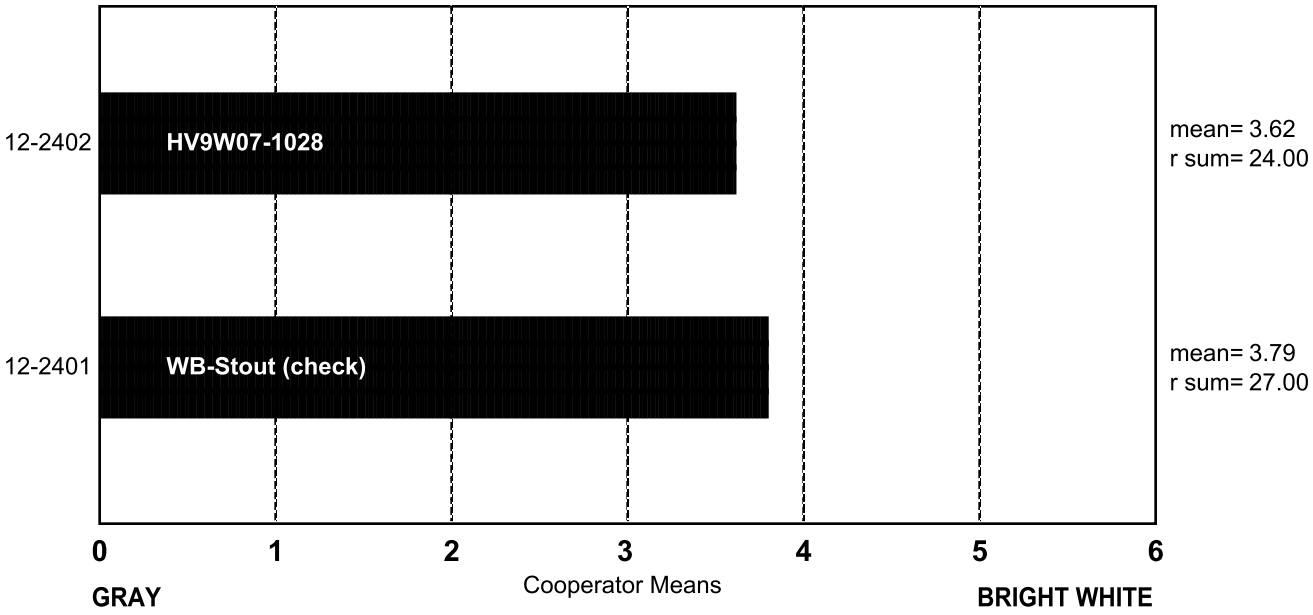
Frequency Table

CRUMB COLOR

(Small Scale) Westbred

ncoop= 17
chisq= 0.53
chisqc= 1.00
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB COLOR, DESCRIBED

(Small Scale) Westbred

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
12-2401 WB-Stout (check)	**0**	**1**	**1**	**3**	**9**	**3**	**0**
12-2402 HV9W07-1028	**0**	**1**	**0**	**6**	**8**	**2**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Westbred

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2401 WB-Stout (check)	**179.0**	**465.9**	**141.8**	**140.5**	**485.0**	**409.0**	**470.0**	**132.4**	**483.3**	**158.5**	**133.9**	**149.5**	**449.8**	**483.2**	**134.0**	**144.4**	**458.2**
12-2402 HV9W07-1028	**178.0**	**465.9**	**141.5**	**138.4**	**494.0**	**411.0**	**469.0**	**126.6**	**481.8**	**155.5**	**129.7**	**149.3**	**453.7**	**475.8**	**134.0**	**142.7**	**464.7**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Westbred

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2401 WB-Stout (check)	**838**	**2400**	**970**	**944**	**3150**	**3000**	**2325**	**940**	**3045**	**1042**	**880**	**920**	**2460**	**2338**	**995**	**955**	**2575**
12-2402 HV9W07-1028	**878**	**2550**	**1000**	**1033**	**2650**	**3100**	**2275**	**975**	**3104**	**1034**	**815**	**1000**	**2383**	**2425**	**1028**	**955**	**2725**

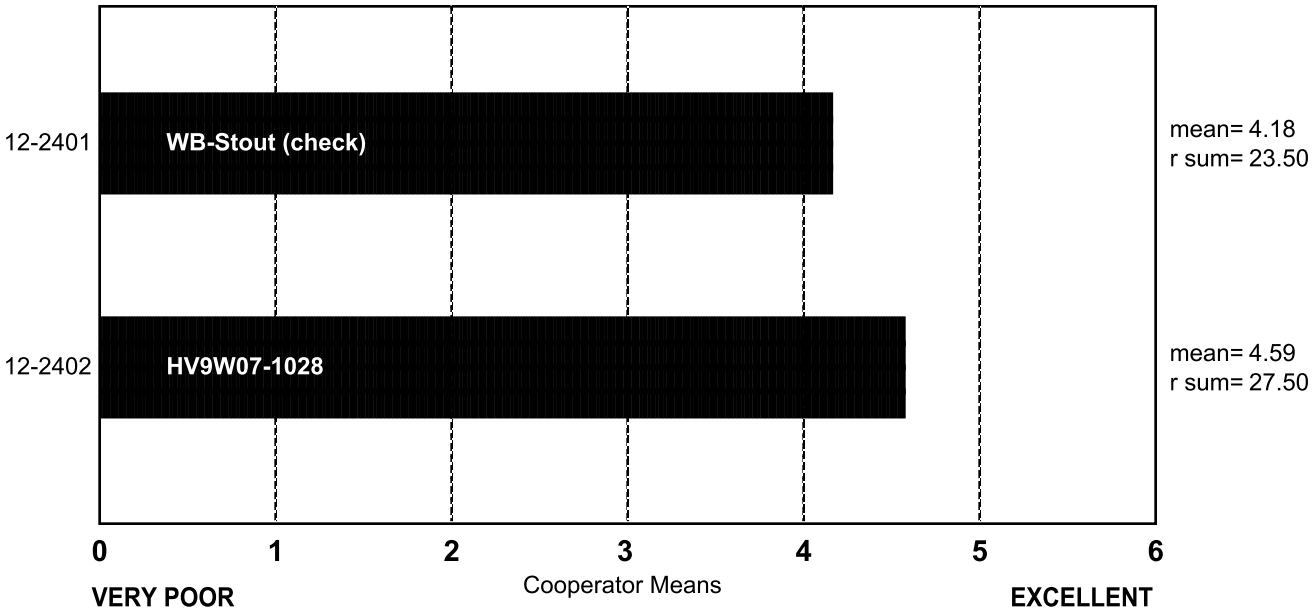
Raw Data

LOAF VOLUME

(Small Scale) Westbred

ncoop= 17
chisq= 0.94
chisqc= 1.14
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

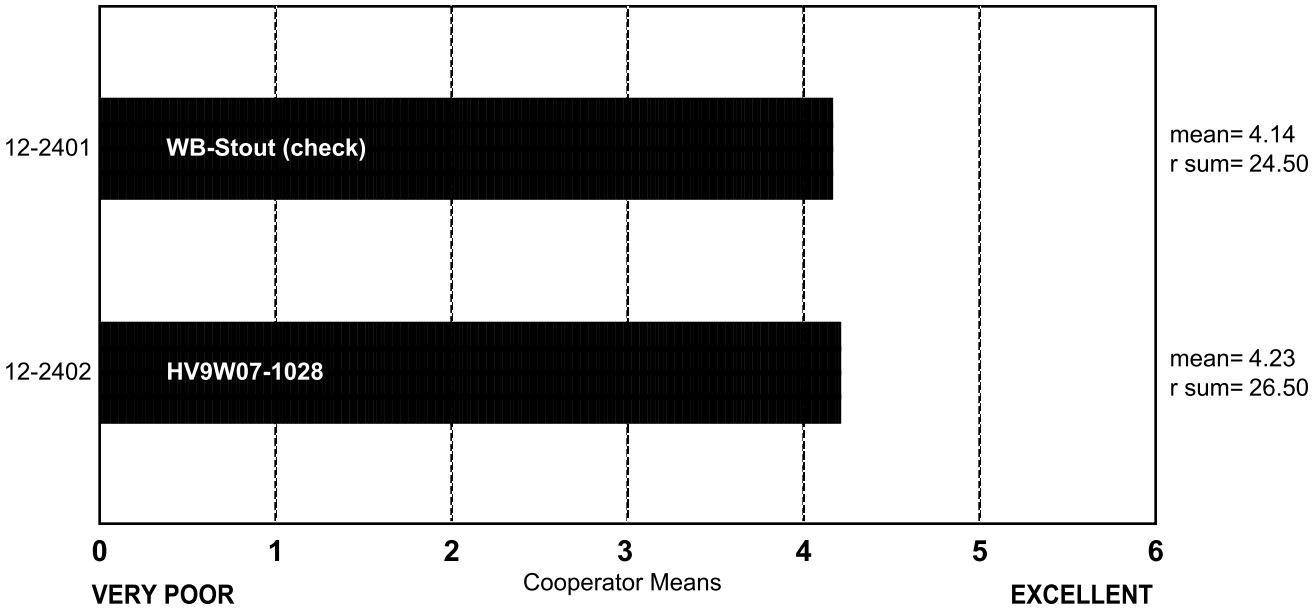


OVERALL BAKING QUALITY

(Small Scale) Westbred

ncoop= 17
chisq= 0.24
chisqc= 0.29
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) Westbred

COOP. 12-2401 WB-Stout (Check)

A. No comment.
B. High abs, avg. mix time, low volume, good color, open grain, flat.
C. Excellent externals.
D. No comment.
E. No comment.
F. Long mix, tough out of mixer, excellent volume, bright interior, sl. open grain.
G. No comment.
H. Good crumb and texture, high absorption.
I. Good absorption, average mixing strength, sl. above average grain and texture, very good volume.
J. Good dough properties and volume performance for protein level; crumb grain a little weak looking.
K. Good loaf volume; high bake absorption.
L. 12.5% flour protein, good absorption & MT, questionable/satisfactory crumb grain, dull color.
M. No comment.
N. High absorption, fine grain, creamy, good volume.
O. Good overall, slightly soft dough handling.
P. Normal Abs & MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, slight yellow.
Q. No comment.

COOP. 12-2402 HV9W07-1028

A. No comment.
B. Sl. above avg. abs, long mix time, below avg. volume, good color, sl. open grain, sl. flat.
C. Strong out of mixer, elastic, nice externals.
D. No comment.
E. No comment.
F. Long mix, tough out of mixer, creamy, sl. open grain.
G. No comment.
H. No comment.
I. Sl. above average absorption, fairly tight, consistent grain, excellent volume.
J. Good dough properties and volume performance for protein level.
K. No comment.
L. 12.8% flour protein, good mixing tolerance, long MT, crumb score & LV better than check, dull color, rated higher than the check.
M. No comment.
N. High absorption, good mix time, avg. grain, high volume.
O. Good overall.
P. Normal Abs and MT, slight sticky & strong dough, very Hi OS & volume, fine & elongated cells, white crumb, silky & resilient texture.
Q. No comment.

Notes: B, E, F, I, M, N, O and Q conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

Nebraska - Stephen Baenziger

Growing Conditions of Wheat Quality Samples:

The samples are a composite of approximately 1 bu each produced at Sidney, North Platte, and Mead NE. All the samples were grown under normal production practices for those regions. The 2011-2012 growing season had a good start with normal to above normal moisture. However, the season was exceptionally early (harvest one month earlier than normal and two weeks earlier than our previous earliest season) and finished under drought stress. Hence the samples were affected by drought stress and possibly heat stress (which tends to shorten the Mixograph mixing times and reduce Mixograph tolerance scores). The main diseases present were stripe rust (mainly at North Platte) and leaf and stripe rust at Mead. Sidney was relatively rust free.

Data from the State Variety Trial

Line	Mead	North Platte	Sidney
	bu/a	bu/a	bu/a
NE06607	68	52	36
NE06545	76	61	39
NW07505	70	45	30
Millennium	NT	46	33
Nursery Mean	**64**	**51**	**29**

Lines submitted for testing:

NE06607: The pedigree of NE06607 is **NE98466/Wesley** where the pedigree of NE98466 is KS89H50-4/3/Brule//Siouxland/Bennet. NE06607 is a medium early, medium height semi-dwarf wheat with good winter hardiness and average straw strength. It is resistant to wheat soilborne mosaic virus and stem rust (races QFCS and TPMK); moderately susceptible to moderately resistant yellow (stripe) rust; moderately susceptible to susceptible to leaf rust and; and susceptible to Russian wheat aphid, Hessian fly, and wheat streak mosaic virus. It was tested in the NRPN in 2010 and in the SRPN in 2011 (data available at http://www.ars.usda.gov/Research/docs.htm?docid=11932) and in the Nebraska State Variety Trials (data available at: http://cropwatch.unl.edu/web/varietytest/wheat). Based upon the data we have collected so far, NE06607 seems to be fairly narrowly adapted and best suited for production in southwest Nebraska. Based upon our end-use quality data to date, NE06607 would be similar to slightly better in end-use quality to McGill. Compared to Wesley (moderately susceptible to susceptible for scab reaction and susceptible for DON accumulation) and Overland (moderately resistance to scab

reaction and moderately resistant for DON accumulation), NE06607is considered as being moderately resistant for scab reaction and moderately resistant to DON accumulation.

NE06545: The pedigree of NE06545 is **KS92-946-B-15-1/ALLIANCE** where the pedigree of KS92-946-B-15-1 is ABI86*3414/Jagger//Karl 92. NE06545 is a medium early, medium height semi-dwarf wheat with good winter hardiness and average straw strength It is moderately resistant to resistant to wheat soilborne mosaic virus, stem rust and leaf rust; moderately susceptible to moderately resistant Hessian fly; moderately susceptible to susceptible to yellow (stripe) rust; and susceptible to Russian wheat aphid and wheat streak mosaic virus. It was tested in the SRPN in 2010 and in the NRPN in 2011 (data available at http://www.ars.usda.gov/Research/docs.htm?docid=11932) and in the Nebraska State Variety Trials (data available at: http://cropwatch.unl.edu/web/varietytest/wheat). Based upon the data we have collected so far, NE06545 seems to be fairly broadly adapted and best suited for production in virtually all parts of Nebraska and states north and west of Nebraska. Based upon our end-use quality data to date, NE06545 would be similar in end-use quality to McGill. This line has been recommended for release to certified seed producers in 2013. Compared to Wesley (moderately susceptible to susceptible for scab reaction and susceptible for DON accumulation) and Overland (moderately resistance to scab reaction and moderately resistant for DON accumulation), NE06545 is considered as being moderately susceptible for scab reaction and moderately susceptible for DON accumulation.

NW07505: The pedigree of NW07505 is **Trego/Thunderbolt**. NW07505 is a medium early, medium height semi-dwarf white wheat with acceptable winter hardiness (less than some Nebraska wheat cultivars) and average straw strength. It is moderately resistant to moderately susceptible to stem rust (race QFCS and in Kenya; but susceptible to race TMPKC), wheat soilborne mosaic virus, leaf rust, and Hessian fly; moderately susceptible to yellow (stripe) rust; and susceptible to Russian wheat aphid and wheat streak mosaic virus. It was tested in the NRPN in 2011 and in 2012 (data available at http://www.ars.usda.gov/Research/docs.htm?docid=11932) and in the Nebraska State Variety Trials (data available at: http://cropwatch.unl.edu/web/varietytest/wheat). Based upon the data we have collected so far, NW07505 seems to be fairly broadly adapted without being the best line in any of the major regions of Nebraska's wheat production. Based upon our end-use quality data to date, NW07505 would be similar to slightly lower in end-use quality to McGill. NW07505 is susceptible to sprouting (similar to some released cultivars) so individual locations may show greater variation in end-use quality than a tradition red wheat cultivar. Compared to Wesley (moderately susceptible to susceptible for scab reaction and susceptible for DON accumulation) and Overland (moderately resistance to scab reaction and moderately resistant for DON accumulation), NW07505 is considered as being moderately susceptible for scab reaction and moderately susceptible for DON accumulation.

Nebraska: 2012 (Small-Scale) Samples

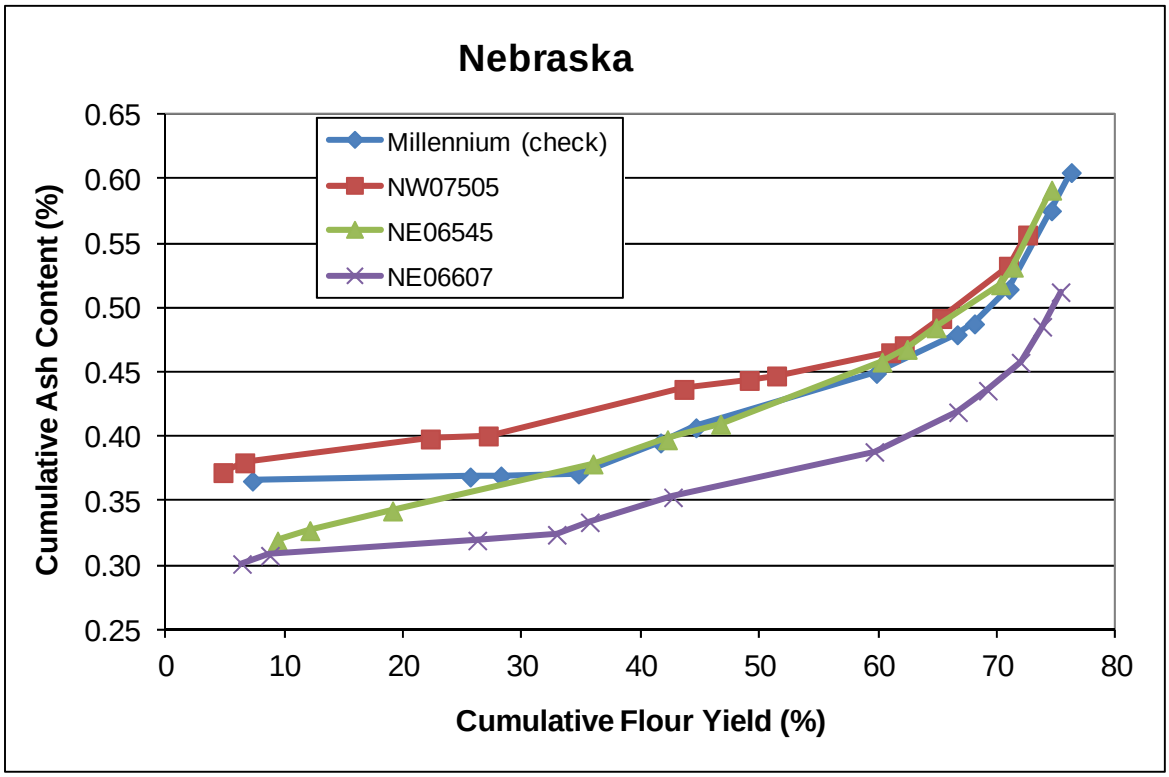
Test entry number	12-2403	12-2404	12-2405	12-2406
Sample identification	**Millennium (check)**	**NW07505**	**NE06545**	**NE06607**
Wheat Data				
GIPSA classification	1 HRW	3 HDWH	2 HRW	2 HRW
Test weight (lb/bu)	60.5	61.4	58.8	60.0
Hectoliter weight (kg/hl)	79.6	80.7	77.4	78.9
1000 kernel weight (gm)	26.9	27.3	28.0	28.1
Wheat kernel size (Rotap)				
Over 7 wire (%)	51.7	57.8	65.6	61.9
Over 9 wire (%)	46.9	39.8	32.9	36.9
Through 9 wire (%)	1.5	2.3	1.5	1.2
Single kernel (skcs)[a]				
Hardness (avg /s.d)	69.4/16.8	75.6/15.3	54.4/18.5	62.1/15.9
Weight (mg) (avg/s.d)	26.9/7.0	27.3/7.6	28.0/8.5	28.1/7.7
Diameter (mm)(avg/s.d)	2.51/0.30	2.58/0.35	2.58/0.36	2.59/0.32
Moisture (%) (avg/s.d)	10.8/0.9	10.3/0.8	10.5/0.8	10.5/0.8
SKCS distribution	02-06-20-72-01	01-02-12-85-01	15-16-27-42-03	04-12-24-60-01
Classification	Hard	Hard	Mixed	Hard
Wheat protein (12% mb)	12.8	12.7	12.2	11.7
Wheat ash (12% mb)	1.42	1.34	1.32	1.34
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	76.4	72.7	74.8	75.5
Quadrumat Sr. Mill	71.9	68.3	68.9	72.9
Flour moisture (%)	11.1	10.6	9.9	12.2
Flour protein (14% mb)	11.5	11.4	11.1	10.7
Flour ash (14% mb)	0.63	0.57	0.60	0.52
Rapid Visco-Analyser				
Peak time (min)	6.1	5.7	6.1	6.1
Peak viscosity (RVU)	180.9	149.1	224.3	239.3
Breakdown (RVU)	62.5	93.1	81.8	97.1
Final viscosity at 13 min (RVU)	227.3	119.5	262.4	242.6
Minolta color meter				
L*	91.1	92.0	91.3	92.0
a*	-0.69	-0.84	-0.90	-0.82
b*	9.00	8.89	9.46	8.49
PPO	0.669	0.541	0.590	0.644
Falling number (sec)	500	343	501	446
Damaged Starch				
(AI%)	96.88	97.19	96.24	95.83
(AACC76-31)	6.97	7.23	6.46	6.14

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

Nebraska: Physical Dough Tests and Gluten Analysis For 2012 (Small-Scale) Samples

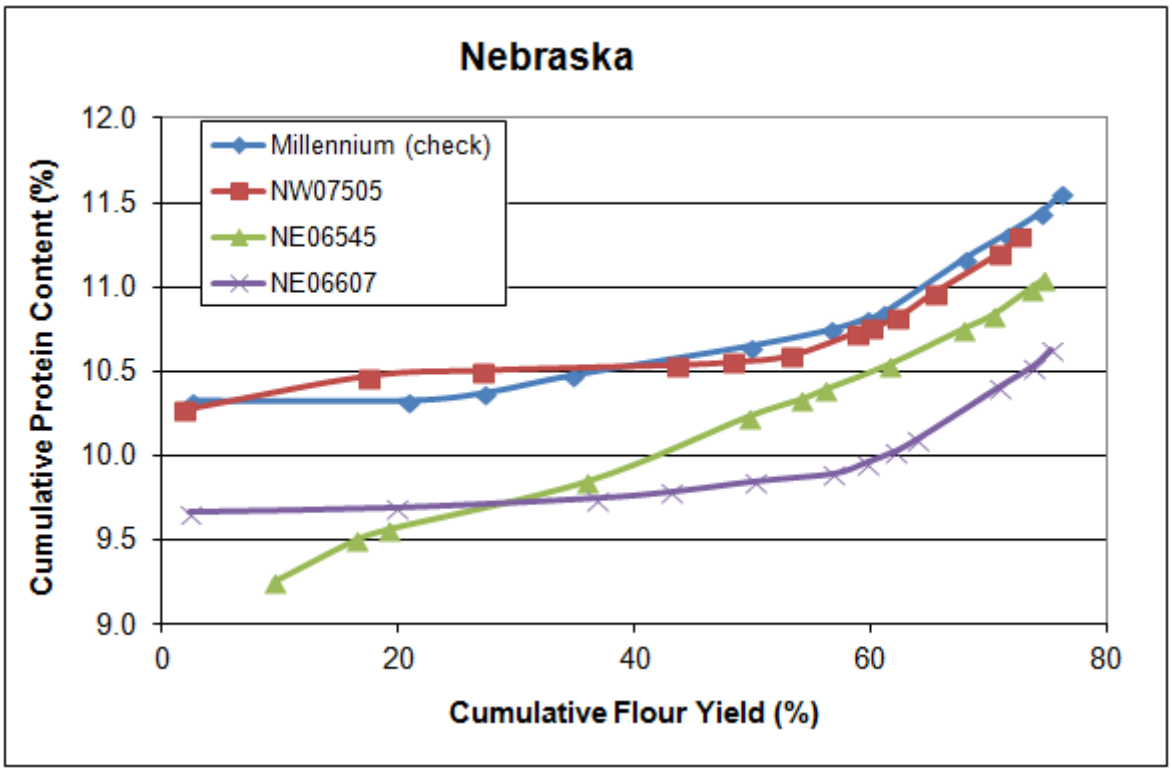
Test Entry Number	12-2403	12-2404	12-2405	12-2406
Sample Identification	Millennium (check)	NW07505	NE06545	NE06607
	MIXOGRAPH			
Flour Abs (% as-is)	65.3	65.6	64.5	62.3
Flour Abs (14% mb)	62.0	61.8	60.6	60.3
Mix Time (min)	3.1	5.0	3.5	3.8
Mix tolerance (0-6)	2	5	3	3
	FARINOGRAPH			
Flour Abs (% as-is)	63.5	65.0	61.6	61.5
Flour Abs (14% mb)	60.9	62.4	58.2	59.9
Development time (min)	5.5	5.2	5.5	6.5
Mix stability (min)	9.0	12.7	14.8	12.7
Mix Tolerance Index (FU)	39	25	28	27
Breakdown time (min)	9.1	11.6	10.6	12.0
	ALVEOGRAPH			
P(mm): Tenacity	77	114	75	87
L(mm): Extensibility	97	91	106	95
G(mm): Swelling index	21.9	21.2	22.9	21.7
W(10^{-4} J): strength (curve area)	211	372	236	280
P/L: curve configuration ratio	0.79	1.25	0.71	0.92
Ie(P_{200}/P): elasticity index	46.9	61.2	51.3	58.1
	EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	237/331/347	405/581/573	278/348/369	346/457/499
Extensibility (mm at 45/90/135 min)	165/155/161	156/162/159	159/176/166	159/159/145
Energy (cm^2 at 45/90/135 min)	70/89/103	122/183/176	82/119/122	104/139/132
Resist $_{max}$ (BU at 45/90/135min)	306/414/475	624/893/896	382/511/566	488/704/732
Ratio (at 45/90/135 min)	1.44/2.14/2.16	2.59/3.58/3.60	1.75/1.98/2.23	2.18/2.88/3.44
	PROTEIN ANALYSIS			
HMW-GS Composition	2*, 7+9, 5+10	2*, 7+8, 5+10	2*,7+9, 5+10	2*, 7+8, 5+10
%IPP	44.84	44.07	42.73	42.24
	SEDIMENTATION TEST			
Volume (ml)	41.6	54.8	50.1	42.1

Nebraska: Cumulative Ash Curves



Millennium (check)					NW057505					NE06545					NE06607				
Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash
1BK	7.3	0.37	7.3	0.37	1BK	4.8	0.37	4.8	0.37	1BK	9.4	0.32	9.4	0.32	1M	6.4	0.30	6.4	0.30
2M	18.3	0.37	25.6	0.37	1M Red	1.8	0.40	6.7	0.38	1M Red	2.7	0.36	12.1	0.33	1M Red	2.4	0.33	8.8	0.31
1M Red	2.6	0.38	28.2	0.37	2M	15.6	0.41	22.3	0.40	1M	7.0	0.37	19.1	0.34	2M	17.5	0.33	26.2	0.32
1M	6.5	0.38	34.8	0.37	1M	4.9	0.41	27.2	0.40	2M	16.9	0.42	36.0	0.38	1BK	6.7	0.34	32.9	0.32
2BK	6.9	0.52	41.7	0.40	3M	16.5	0.50	43.6	0.44	2BK	6.3	0.51	42.2	0.40	Grader	2.8	0.45	35.7	0.33
Grader	3.0	0.57	44.6	0.41	2BK	5.5	0.50	49.1	0.44	Grader	4.5	0.52	46.7	0.41	2BK	7.0	0.45	42.7	0.35
3M	15.2	0.57	59.8	0.45	Grader	2.3	0.52	51.4	0.45	3M	13.6	0.62	60.3	0.46	3M	17.0	0.48	59.7	0.39
4M	6.8	0.74	66.6	0.48	4M	9.6	0.56	61.0	0.47	FILTER FLR	2.1	0.75	62.4	0.47	4M	7.0	0.68	66.7	0.42
FILTER FLR	1.5	0.87	68.1	0.49	FILTER FLR	1.1	0.76	62.2	0.47	3BK	2.4	0.91	64.9	0.48	FILTER FLR	2.5	0.88	69.2	0.44
3BK	2.9	1.14	71.0	0.51	3BK	3.1	0.91	65.3	0.49	4M	5.4	0.92	70.3	0.52	3BK	2.8	1.01	72.0	0.46
5M	3.6	1.79	74.6	0.58	5M	5.6	1.01	70.9	0.53	BRAN FLR	1.1	1.43	71.4	0.53	5M	1.8	1.58	73.8	0.49
BRAN FLR	1.7	1.93	76.2	0.61	BRAN FLR	1.6	1.62	72.6	0.56	5M	3.2	1.91	74.6	0.59	BRAN FLR	1.5	1.80	75.3	0.51
Break Shorts	4.1	3.37	80.3	0.75	Break Shorts	4.5	2.64	77.1	0.68	Break Shorts	4.0	3.22	78.6	0.73	Break Shorts	3.4	3.12	78.7	0.62
Red Dog	2.7	3.49	83.0	0.84	Red Dog	3.3	3.04	80.5	0.78	Red Dog	1.8	3.24	80.4	0.78	Red Dog	2.7	3.00	81.5	0.70
Red Shorts	1.4	3.83	84.5	0.89	Red Shorts	1.2	3.57	81.6	0.82	Red Shorts	0.5	3.87	80.9	0.80	Red Shorts	0.4	3.79	81.9	0.72
Filter Bran	0.7	2.39	85.2	0.90	Filter Bran	0.7	2.20	82.3	0.83	Filter Bran	0.8	1.72	81.6	0.81	Filter Bran	0.7	2.46	82.6	0.74
Bran	14.8	4.42	100.0	1.42	Bran	17.7	3.89	100.0	1.37	Bran	18.4	3.26	100.0	1.26	Bran	17.4	4.35	100.0	1.37
Wheat		1.39			Wheat		1.31			Wheat		1.29			Wheat		1.31		
St. Grd. Fl.		0.63			St. Grd. Fl.		0.57			St. Grd. Fl.		0.60			St. Grd. Fl.		0.52		

Nebraska: Cumulative Protein Curves

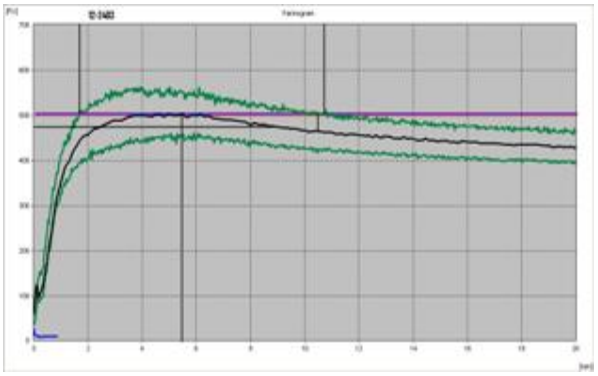


Millennium (check)					NW07505					NE06545					NE06607				
Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein
1M Red	2.6	10.3	2.6	10.3	1M Red	1.8	10.3	1.8	10.3	1BK	9.4	9.3	9.4	9.3	1M Red	2.4	9.7	2.4	9.7
2M	18.3	10.3	20.9	10.3	2M	15.6	10.5	17.5	10.5	1M	7.0	9.8	16.4	9.5	2M	17.5	9.7	19.8	9.7
1M	6.5	10.5	27.4	10.4	4M	9.6	10.6	27.0	10.5	1M Red	2.7	9.9	19.1	9.6	3M	17.0	9.8	36.8	9.7
1BK	7.3	10.9	34.8	10.5	3M	16.5	10.6	43.5	10.5	2M	16.9	10.2	36.0	9.8	1M	6.4	10.0	43.2	9.8
3M	15.2	11.1	49.9	10.6	1M	4.9	10.7	48.4	10.6	3M	13.6	11.2	49.6	10.2	4M	7.0	10.2	50.2	9.8
4M	6.8	11.5	56.7	10.7	1BK	4.8	11.0	53.2	10.6	Grader	4.5	11.5	54.0	10.3	1BK	6.7	10.2	56.9	9.9
Grader	3.0	12.1	59.7	10.8	5M	5.6	12.1	58.8	10.7	FILTER FLR	2.1	11.9	56.2	10.4	Grader	2.8	11.3	59.7	10.0
FILTER FLR	1.5	12.2	61.2	10.8	FILTER FLR	1.1	12.3	60.0	10.8	4M	5.4	12.1	61.6	10.5	FILTER FLR	2.5	11.7	62.2	10.0
2BK	6.9	14.0	68.1	11.2	Grader	2.3	12.4	62.3	10.8	2BK	6.3	12.8	67.9	10.8	5M	1.8	12.5	64.0	10.1
5M	3.6	14.1	71.6	11.3	3BK	3.1	13.9	65.4	11.0	3BK	2.4	13.1	70.3	10.8	2BK	7.0	13.3	71.0	10.4
3BK	2.9	14.6	74.6	11.4	2BK	5.5	14.0	70.9	11.2	5M	3.2	14.4	73.5	11.0	3BK	2.8	13.6	73.8	10.5
BRAN FLR	1.7	16.4	76.2	11.6	BRAN FLR	1.6	15.7	72.6	11.3	BRAN FLR	1.1	14.6	74.6	11.0	BRAN FLR	1.5	15.4	75.3	10.6
Break Shorts	4.1	15.0	80.3	11.7	Break Shorts	4.5	14.0	77.1	11.5	Break Shorts	4.0	14.5	78.6	11.2	Break Shorts	3.4	13.2	78.7	10.7
Red Dog	2.7	14.3	83.0	11.8	Red Dog	3.3	14.2	80.5	11.6	Red Dog	1.8	12.8	80.4	11.3	Red Dog	2.7	13.0	81.5	10.8
Red Shorts	1.4	13.9	84.5	11.8	Red Shorts	1.2	14.2	81.6	11.6	Red Shorts	0.5	13.7	80.9	11.3	Red Shorts	0.4	12.9	81.9	10.8
Filter Bran	0.7	12.8	85.2	11.9	Filter Bran	0.7	12.0	82.3	11.6	Filter Bran	0.8	11.6	81.6	11.3	Filter Bran	0.7	11.5	82.6	10.8
Bran	14.8	16.5	100.0	12.5	Bran	17.7	15.7	100.0	12.3	Bran	18.4	15.8	100.0	12.1	Bran	17.4	15.9	100.0	11.7
Wheat		12.5			Wheat		12.4			Wheat		11.93			Wheat		11.4		
St. Grd. Fl.		11.5			St. Grd. Fl.		11.4			St. Grd. Fl.		11.08			St. Grd. Fl.		10.7		

Physical Dough Tests

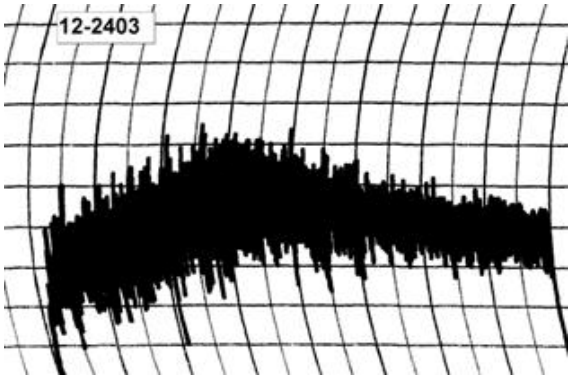
2012 (Small Scale) Samples - Nebraska

Farinograms



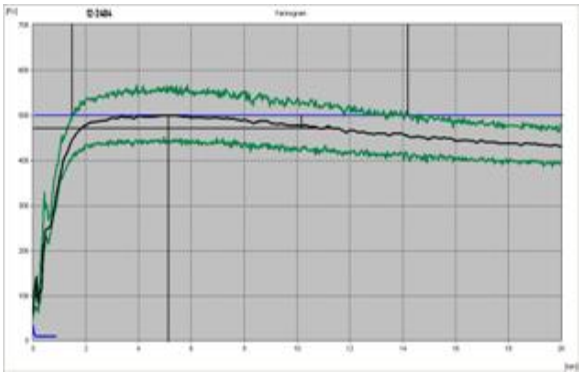
Water abs = 60.9%, Peak time = 5.5 min,
Mix stab = 9.0 min, MTI = 39 FU

Mixograms

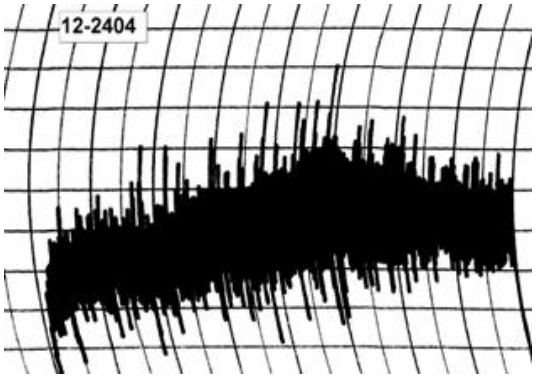


Water abs = 62.0%
Mix time = 3.1 min

12-2403, Millennium (check)



Water abs = 62.4%, Peak time = 5.2 min,
Mix stab = 12.7 min, MTI = 25 FU



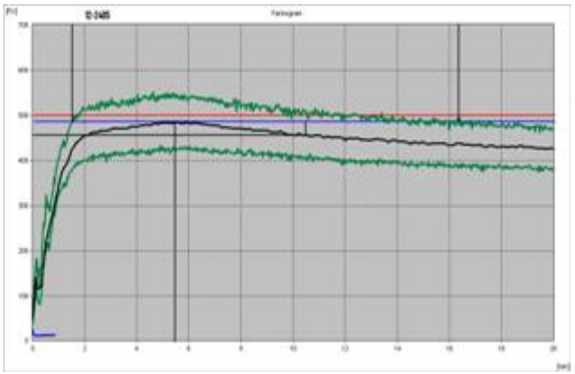
Water abs = 61.8%
Mix time = 5.0 min

12-2404, NW07505

Physical Dough Tests

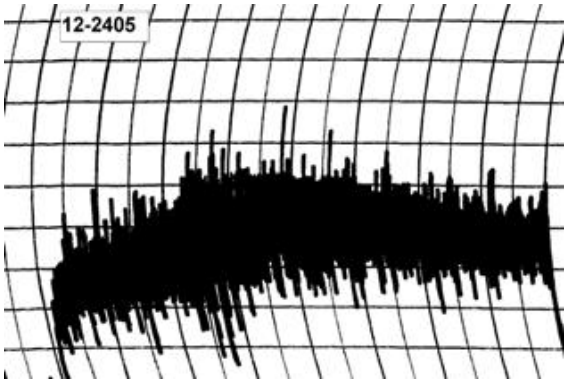
2012 (Small Scale) Samples - Nebraska (continued)

Farinograms



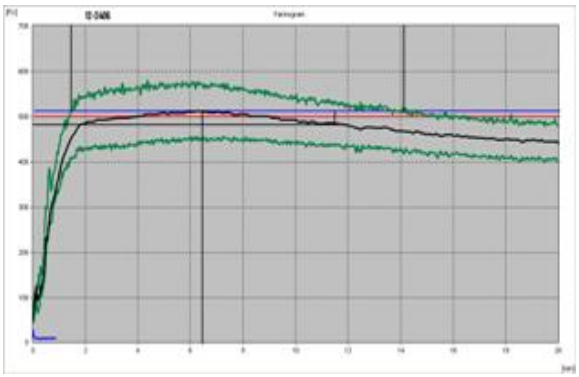
Water abs= 58.2%, Peak time = 5.5 min,
Mix stab = 14.8 min, MTI = 28 FU

Mixograms

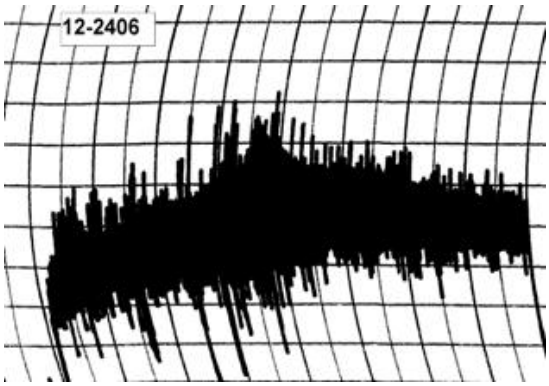


Water abs = 60.0%
Mix time = 3.5 min

12-2405, NE06545



Water abs= 59.9%, Peak time = 6.5 min,
Mix stab = 12.7 min, MTI = 27 FU

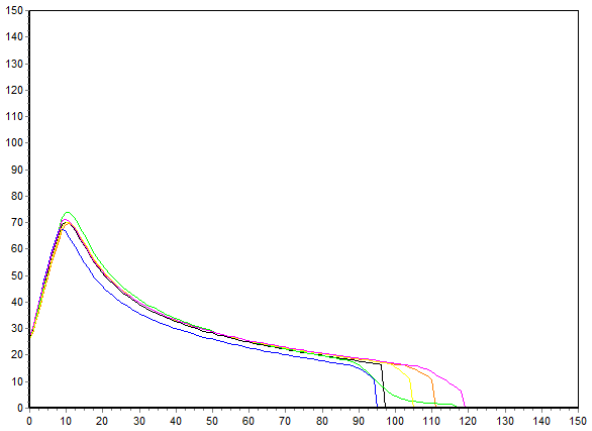


Water abs = 60.3%
Mix time = 3.8 min

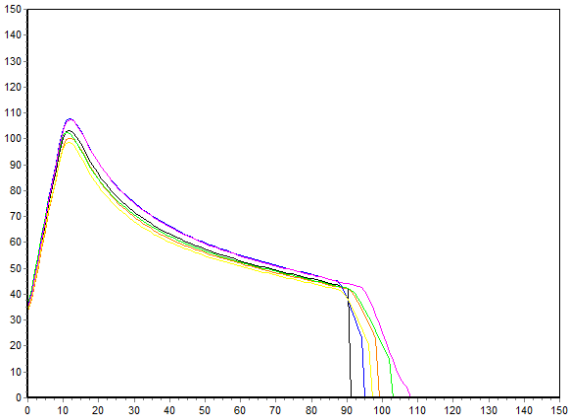
12-2406, NE06607

Physical Dough Tests - Alveograph

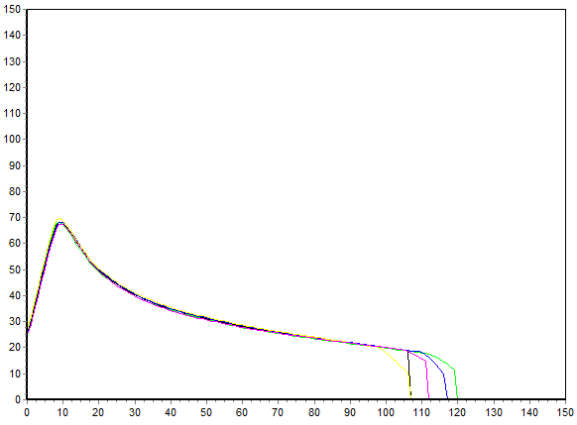
2012 (Small Scale) Samples – Nebraska



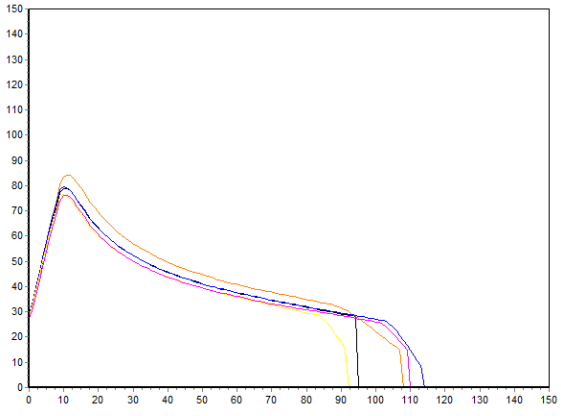
12-2403, Millennium (check)
P(mm H_20)=77, L(mm)=97, W($10E^{-4}$ J)=211



12-2404, NW07506
P(mm H_20)=114, L(mm)=91, W($10E^{-4}$ J)=372



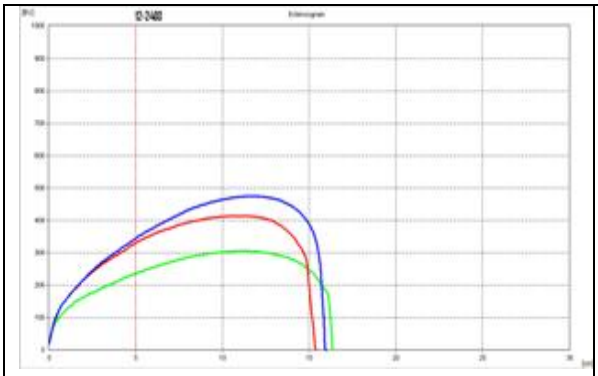
12-2405 NE06545
P(mm H_20)=75, L(mm)=106, W($10E^{-4}$ J)=236



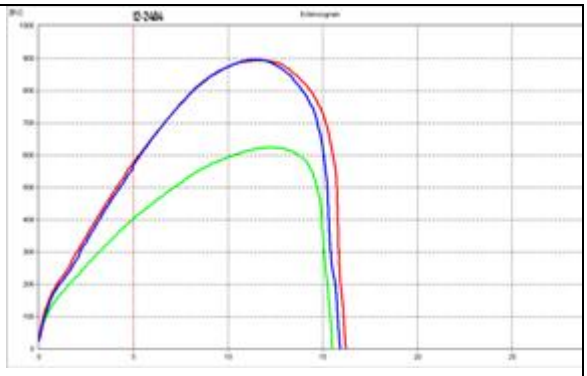
12-2406, NE06607
P(mm H_20)=87, L(mm)=95, W($10E^{-4}$ J)=280

Physical Dough Tests - Extensigraph

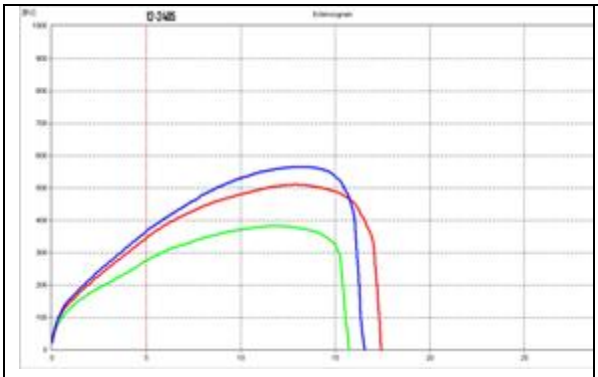
2012 (Small Scale) Samples – Nebraska



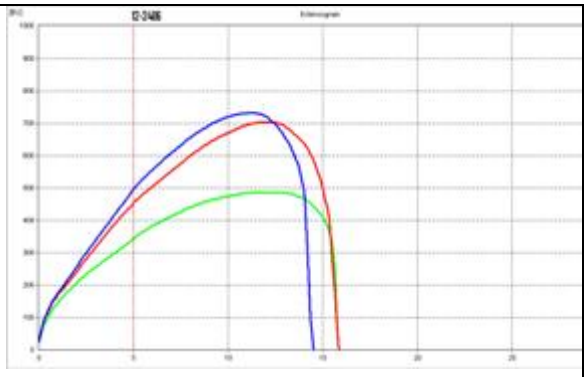
Millennium (check) -2403
R (BU) = 331, E (mm) =155, W (cm^2) = 89
Rmax (BU) = 414, Ratio = 2.14 at 90 min



NW07505 - 2404
R (BU) = 581, E (mm) =162, W (cm^2) = 183
Rmax (BU) = 893, Ratio = 3.58 at 90 min



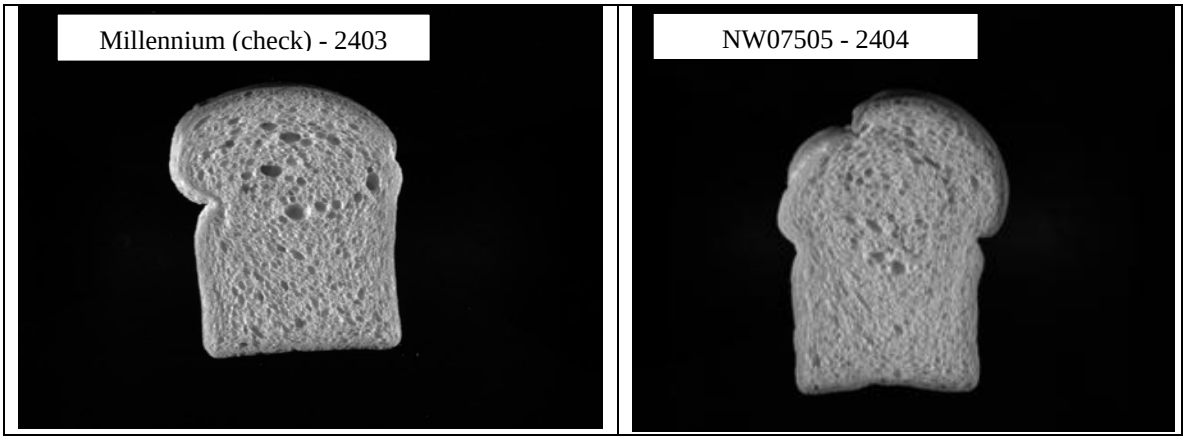
NE06545 - 2405
R (BU) = 348, E (mm) =176, W (cm^2) = 119
Rmax (BU) = 511, Ratio = 1.98 at 90 min



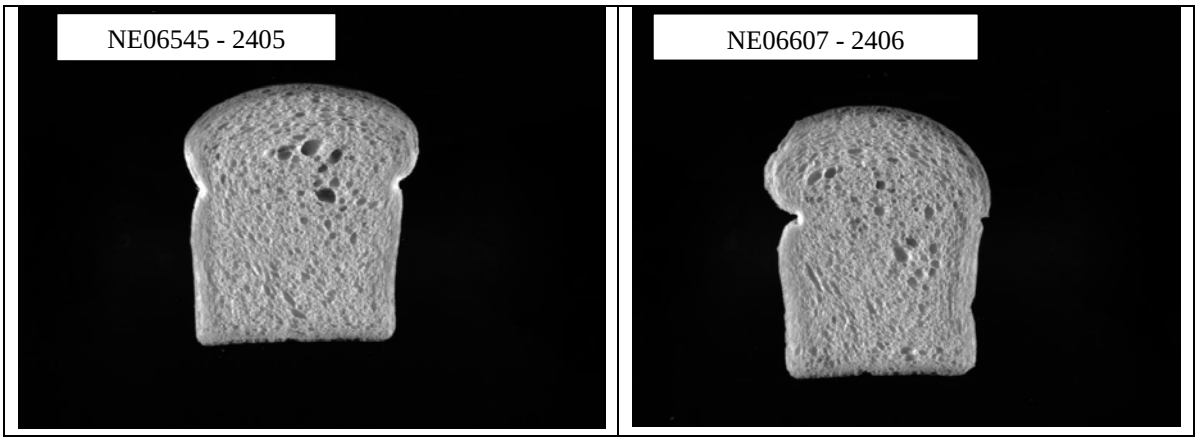
NE06607 - 2406
R (BU) = 457, E (mm) =159, W (cm^2) = 139
Rmax (BU) = 704, Ratio = 2.88 at 90 min

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.

Nebraska: C-Cell Bread Images and Analysis for 2012 (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})
2403	5720	136.7	4085	0.423	1.716	1.266	1.700	-9.30
2404	6347	139.5	3796	0.451	2.109	7.961	1.770	6.90



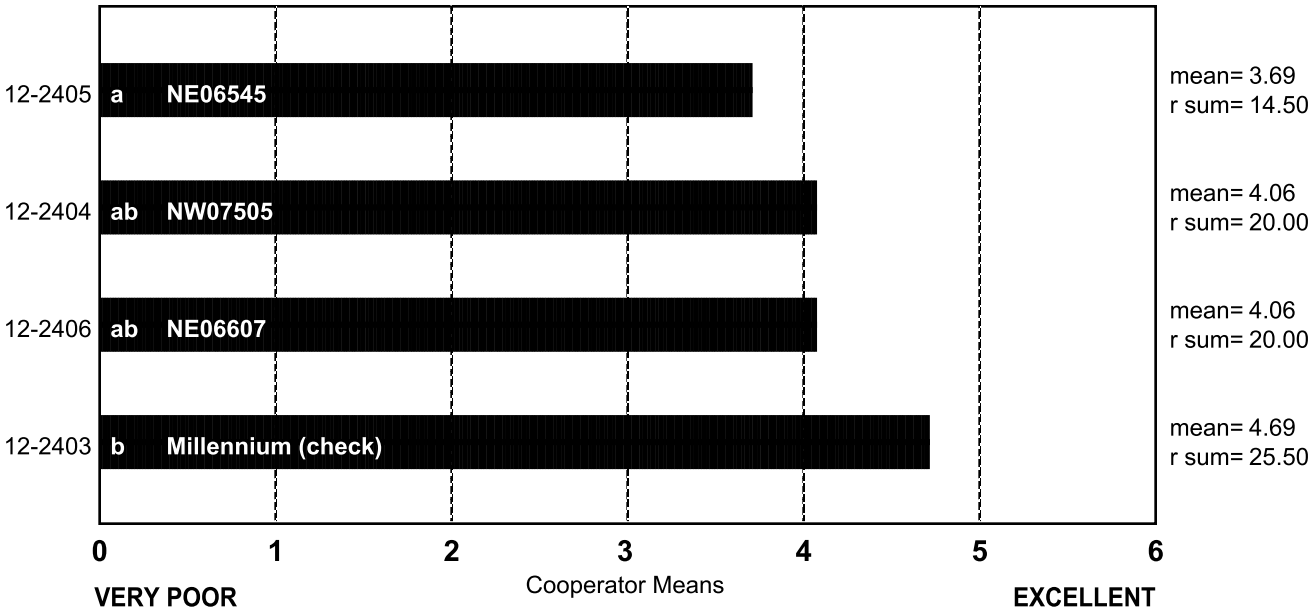
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2405	5762	137.6	4228	0.422	1.672	1.174	1.695	-7.55
2406	5678	138.1	3715	0.437	1.856	8.259	1.715	-14.90

SPONGE CHARACTERISTICS

(Small Scale) Nebraska

ncoop= 8
chisq= 4.54
chisqc= 8.25
cvchisq= 7.82
crdiff= 6.90

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

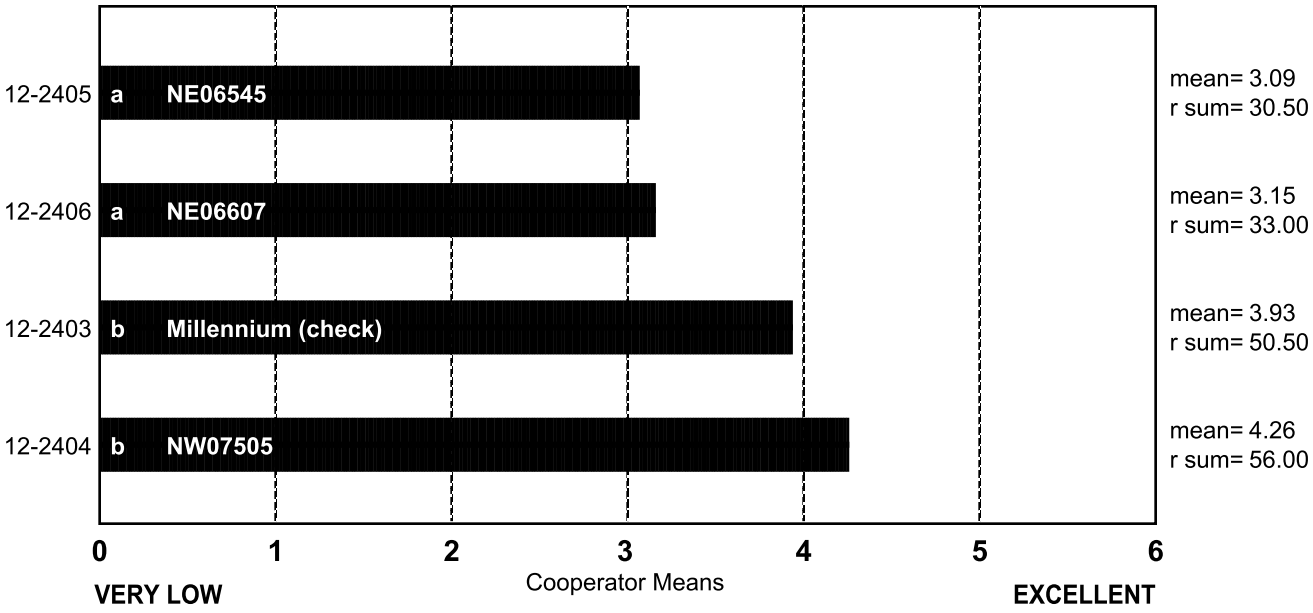


BAKE ABSORPTION

(Small Scale) Nebraska

ncoop= 17
chisq= 16.96
chisqc= 23.06
cvchisq= 7.82
crdiff= 9.90

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Nebraska

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2403 Millennium (check)	**66.1**	**62.0**	**61.7**	**63.0**	**61.0**	**58.0**	**60.9**	**64.7**	**61.0**	**63.8**	**56.6**	**60.4**	**60.9**	**64.0**	**61.0**	**63.5**	**60.0**
12-2404 NW07505	**66.1**	**64.0**	**62.2**	**62.9**	**62.5**	**58.0**	**62.4**	**66.3**	**61.0**	**63.2**	**57.6**	**61.9**	**62.4**	**62.0**	**61.0**	**63.5**	**62.0**
12-2405 NE06545	**64.1**	**61.0**	**61.4**	**61.8**	**58.0**	**57.0**	**58.2**	**62.0**	**59.0**	**65.9**	**53.1**	**60.2**	**58.2**	**62.0**	**60.0**	**62.4**	**59.5**
12-2406 NE06607	**64.1**	**60.0**	**59.9**	**61.8**	**60.0**	**57.0**	**59.9**	**64.1**	**60.0**	**62.1**	**56.8**	**61.7**	**59.9**	**62.0**	**60.0**	**63.4**	**58.5**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Nebraska

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2403 Millennium (check)	**2.8**	**5.0**	**4.0**	**3.3**	**5.5**	**11.0**	**7.5**	**3.2**	**16.0**	**3.4**	**2.0**	**4.0**	**5.0**	**4.0**	**3.0**	**6.5**	**10.0**
12-2404 NW07505	**5.3**	**8.0**	**5.8**	**5.2**	**5.0**	**20.0**	**8.0**	**5.0**	**25.0**	**5.9**	**2.3**	**8.4**	**8.0**	**7.0**	**9.0**	**9.3**	**30.0**
12-2405 NE06545	**3.8**	**6.0**	**5.0**	**3.8**	**5.5**	**20.0**	**8.0**	**4.2**	**25.0**	**4.7**	**2.3**	**6.9**	**7.0**	**4.0**	**6.0**	**7.2**	**23.0**
12-2406 NE06607	**4.0**	**6.0**	**5.0**	**4.0**	**6.5**	**14.0**	**8.0**	**4.3**	**25.0**	**5.0**	**2.0**	**7.1**	**6.0**	**6.0**	**6.0**	**7.1**	**13.0**

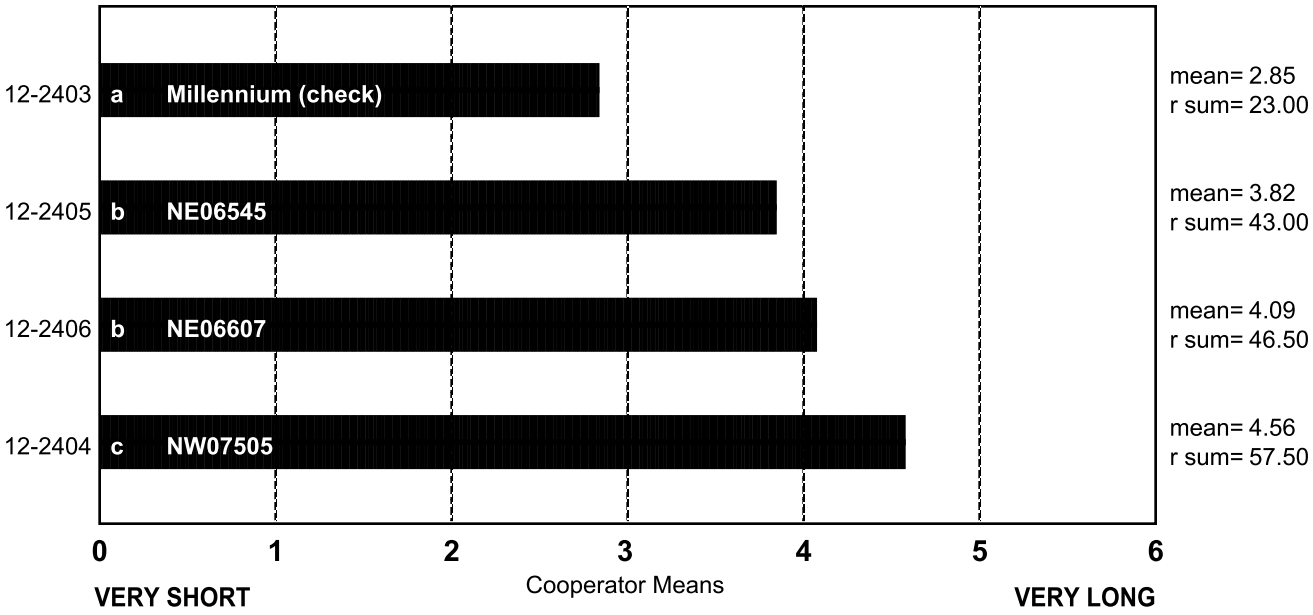
Raw Data

BAKE MIX TIME

(Small Scale) Nebraska

ncoop= 17
chisq= 21.94
chisqc= 28.25
cvchisq= 7.82
crdiff= 9.18

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

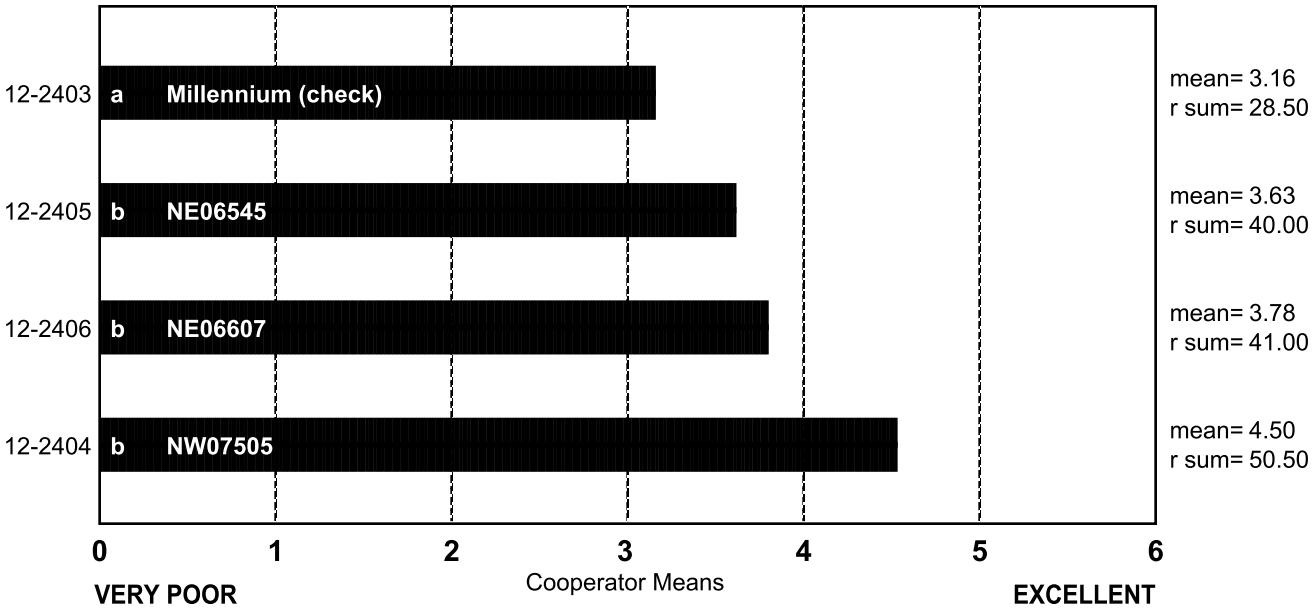


MIXING TOLERANCE

(Small Scale) Nebraska

ncoop= 16
chisq= 9.13
chisqc= 12.07
cvchisq= 7.82
crdiff= 11.43

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

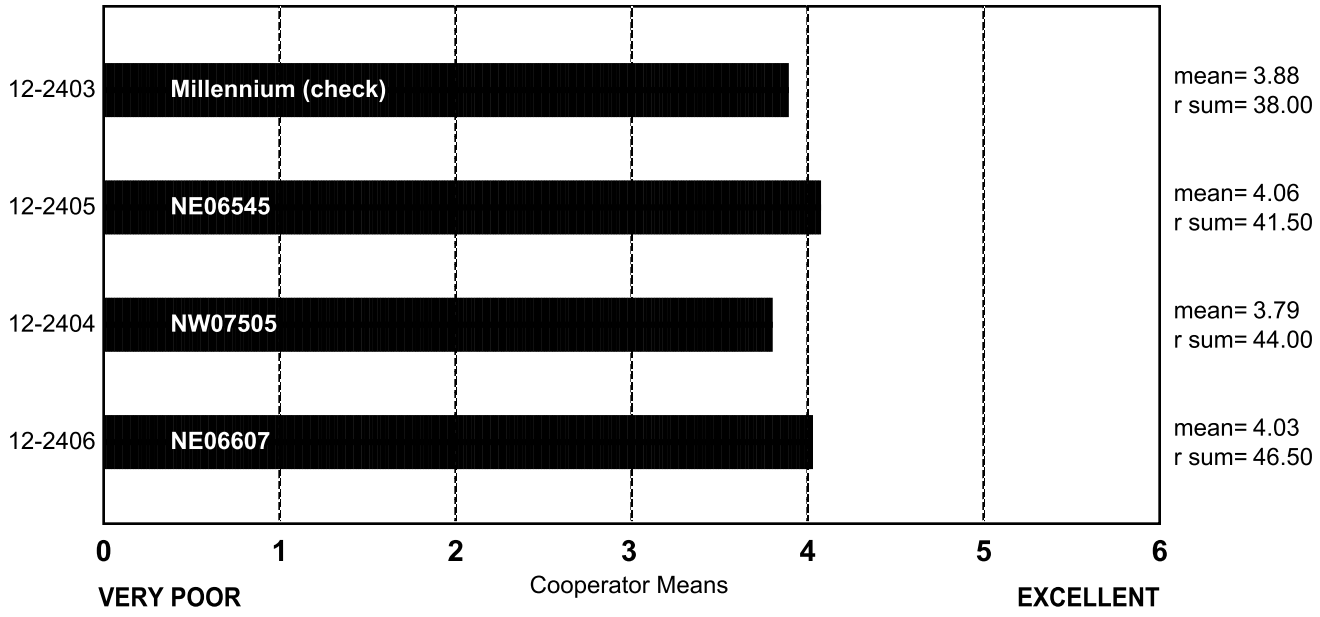


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Nebraska

ncoop= 17
chisq= 1.39
chisqc= 1.93
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'OUT OF MIXER', DESCRIBED

(Small Scale) Nebraska

	Sticky	Wet	Tough	Good	Excellent
12-2403 Millennium (check)	**5**	**2**	**1**	**9**	**0**
12-2404 NW07505	**1**	**0**	**7**	**9**	**0**
12-2405 NE06545	**2**	**2**	**5**	**7**	**1**
12-2406 NE06607	**1**	**0**	**4**	**11**	**1**

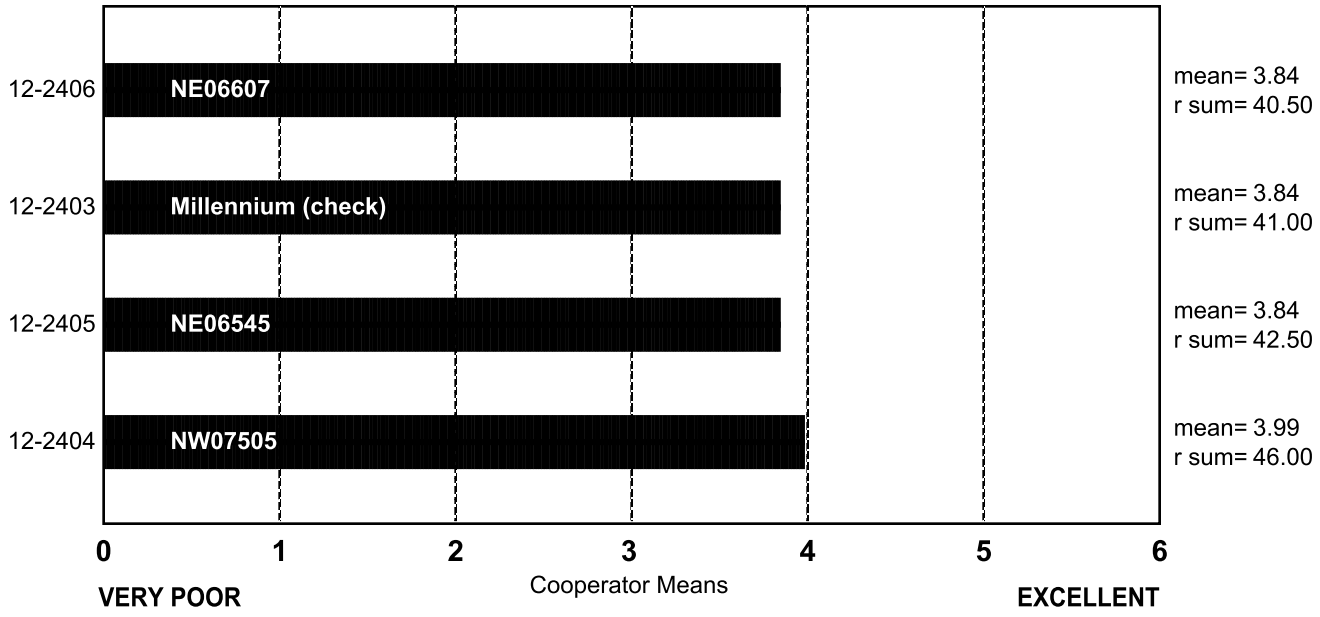
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Nebraska

ncoop= 17
chisq= 0.65
chisqc= 0.94
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) Nebraska

	Sticky	Wet	Tough	Good	Excellent
12-2403 Millennium (check)	**3**	**2**	**2**	**10**	**0**
12-2404 NW07505	**2**	**0**	**6**	**8**	**1**
12-2405 NE06545	**3**	**3**	**3**	**6**	**2**
12-2406 NE06607	**1**	**1**	**6**	**8**	**1**

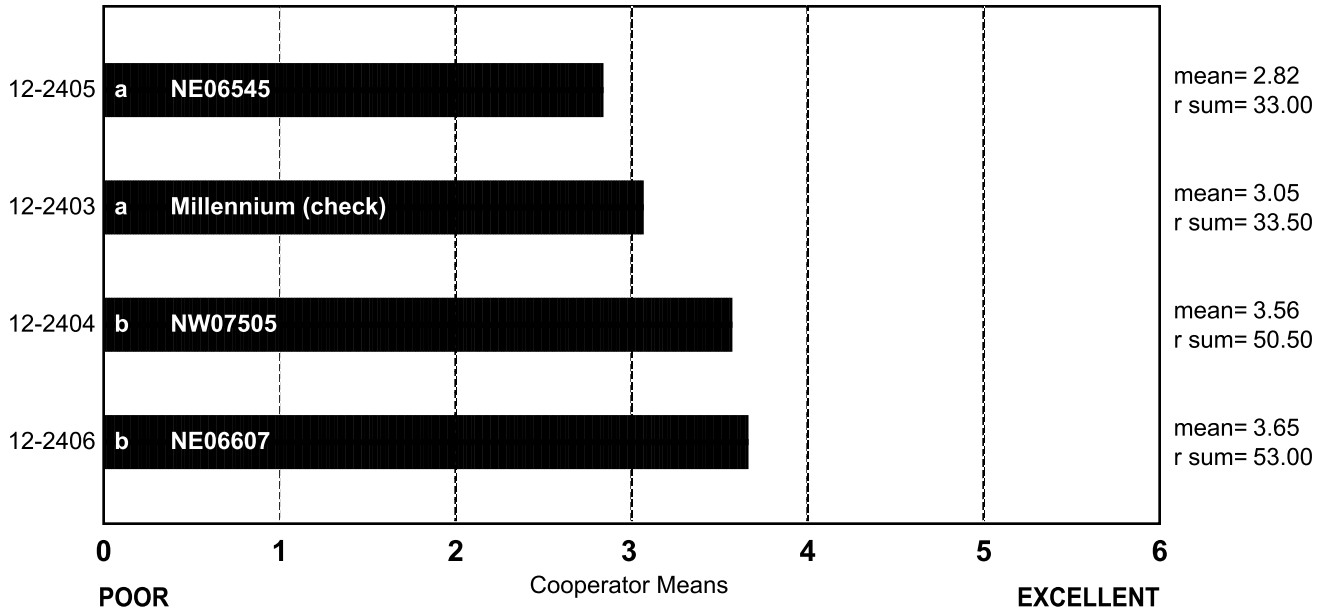
Frequency Table

CRUMB GRAIN

(Small Scale) Nebraska

ncoop= 17
chisq= 12.19
chisqc= 14.40
cvchisq= 7.82
crdiff= 12.17

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB GRAIN, DESCRIBED

(Small Scale) Nebraska

	Open	Fine	Dense
12-2403 Millennium (check)	**10**	**4**	**3**
12-2404 NW07505	**10**	**6**	**1**
12-2405 NE06545	**5**	**4**	**8**
12-2406 NE06607	**8**	**7**	**2**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Nebraska

	Round	Irregular	Elongated
12-2403 Millennium (check)	**9**	**7**	**1**
12-2404 NW07505	**3**	**7**	**7**
12-2405 NE06545	**6**	**10**	**1**
12-2406 NE06607	**1**	**11**	**5**

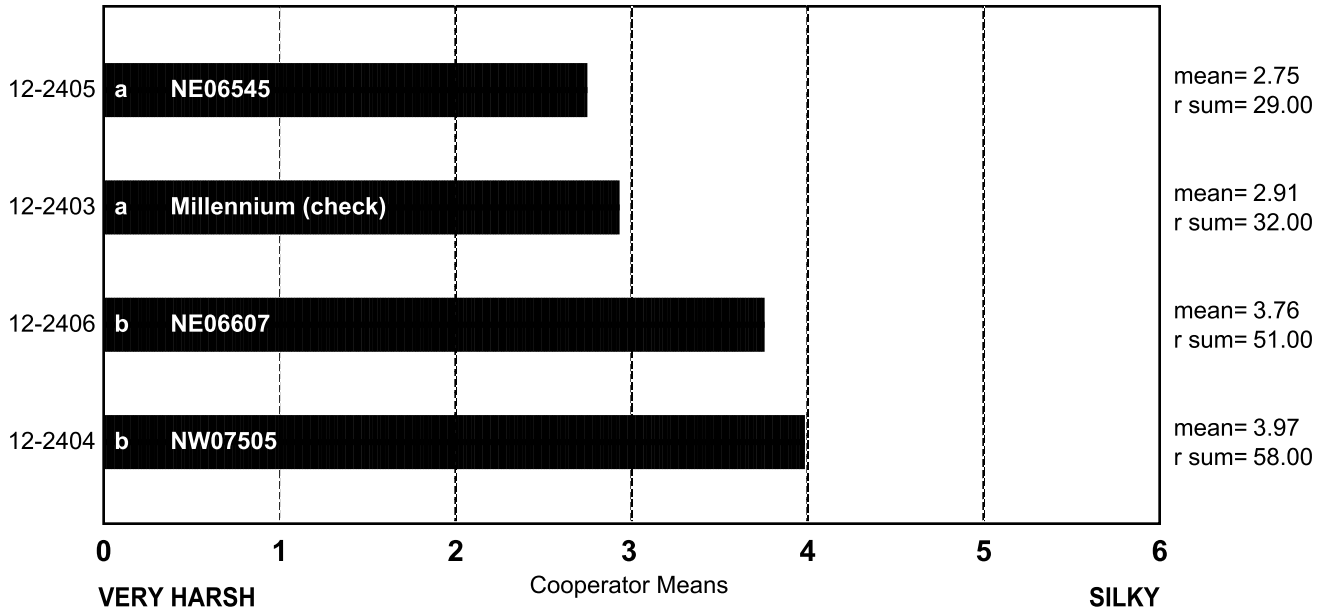
Frequency Table

CRUMB TEXTURE

(Small Scale) Nebraska

ncoop= 17
chisq= 21.35
chisqc= 27.09
cvchisq= 7.82
crdiff= 9.49

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB TEXTURE, DESCRIBED

(Small Scale) Nebraska

	Harsh	Smooth	Silky
12-2403 Millennium (check)	**11**	**5**	**1**
12-2404 NW07505	**1**	**12**	**4**
12-2405 NE06545	**12**	**5**	**0**
12-2406 NE06607	**3**	**10**	**4**

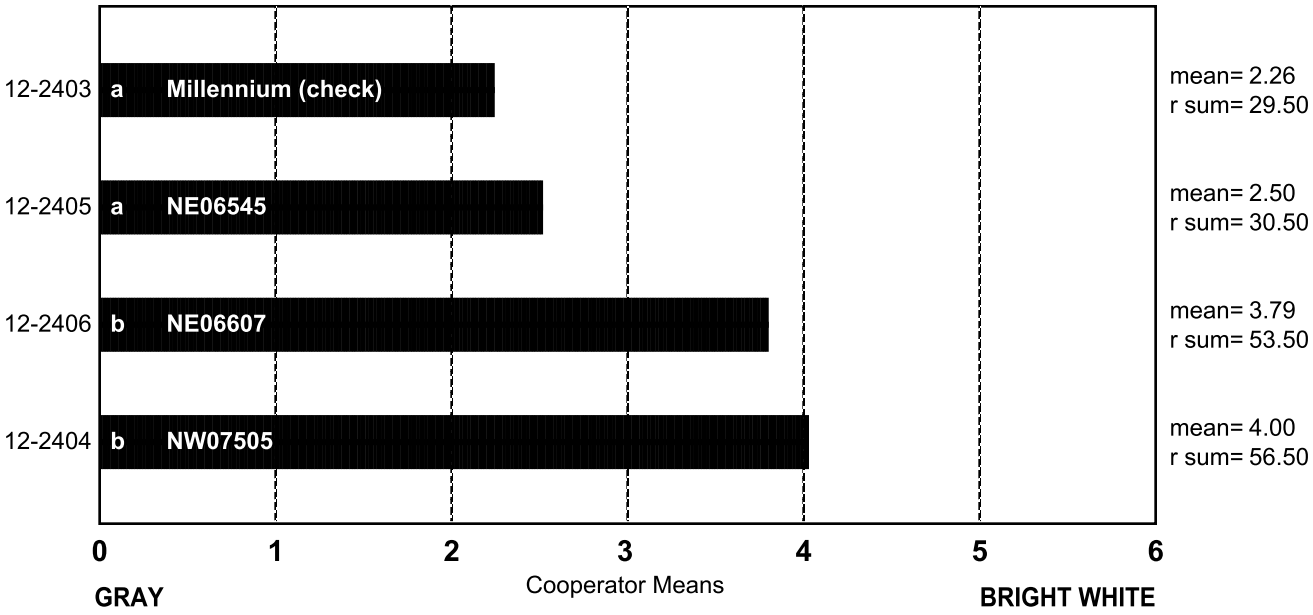
Frequency Table

CRUMB COLOR

(Small Scale) Nebraska

ncoop= 17
chisq= 22.24
chisqc= 26.81
cvchisq= 7.82
crdiff= 9.79

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB COLOR, DESCRIBED

(Small Scale) Nebraska

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
12-2403 Millennium (check)	**3**	**1**	**1**	**9**	**3**	**0**	**0**
12-2404 NW07505	**0**	**1**	**2**	**3**	**6**	**5**	**0**
12-2405 NE06545	**1**	**1**	**3**	**10**	**2**	**0**	**0**
12-2406 NE06607	**1**	**0**	**1**	**3**	**7**	**5**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Nebraska

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2403 Millennium (check)	**178.0**	**465.3**	**140.9**	**141.4**	**497.5**	**415.0**	**476.0**	**129.4**	**492.4**	**152.2**	**131.4**	**148.7**	**454.2**	**486.0**	**134.0**	**141.0**	**459.5**
12-2404 NW07505	**178.0**	**463.9**	**138.2**	**139.2**	**491.5**	**412.0**	**474.0**	**129.0**	**480.9**	**155.1**	**130.7**	**148.0**	**448.2**	**487.0**	**134.0**	**139.8**	**460.4**
12-2405 NE06545	**177.0**	**465.4**	**142.4**	**136.9**	**498.0**	**415.0**	**477.0**	**125.6**	**497.4**	**152.3**	**128.2**	**145.8**	**456.5**	**486.0**	**134.0**	**141.0**	**467.7**
12-2406 NE06607	**177.0**	**466.9**	**138.2**	**142.4**	**486.5**	**410.0**	**474.0**	**126.2**	**496.0**	**148.8**	**131.1**	**148.7**	**453.5**	**480.0**	**134.0**	**141.3**	**461.8**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Nebraska

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2403 Millennium (check)	**713**	**2325**	**795**	**837**	**2350**	**2700**	**2000**	**785**	**2986**	**956**	**700**	**810**	**2433**	**2263**	**843**	**830**	**2475**
12-2404 NW07505	**828**	**2563**	**1025**	**914**	**2700**	**2975**	**2150**	**940**	**3104**	**1061**	**740**	**910**	**2567**	**2313**	**955**	**815**	**2750**
12-2405 NE06545	**790**	**2325**	**875**	**811**	**2300**	**2500**	**1900**	**750**	**2986**	**1039**	**635**	**785**	**2408**	**2100**	**858**	**803**	**2500**
12-2406 NE06607	**750**	**2475**	**980**	**799**	**2900**	**3000**	**2050**	**835**	**3074**	**1025**	**675**	**755**	**2417**	**2463**	**933**	**868**	**2600**

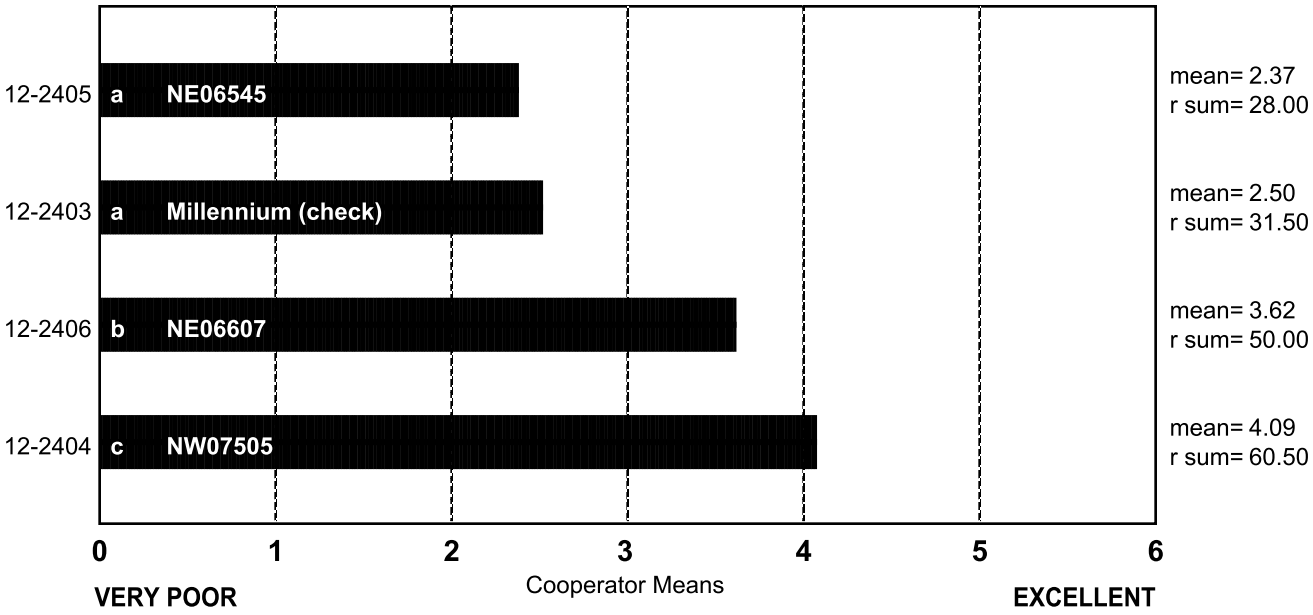
Raw Data

LOAF VOLUME

(Small Scale) Nebraska

ncoop= 17
chisq= 25.11
chisqc= 30.28
cvchisq= 7.82
crdiff= 9.06

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

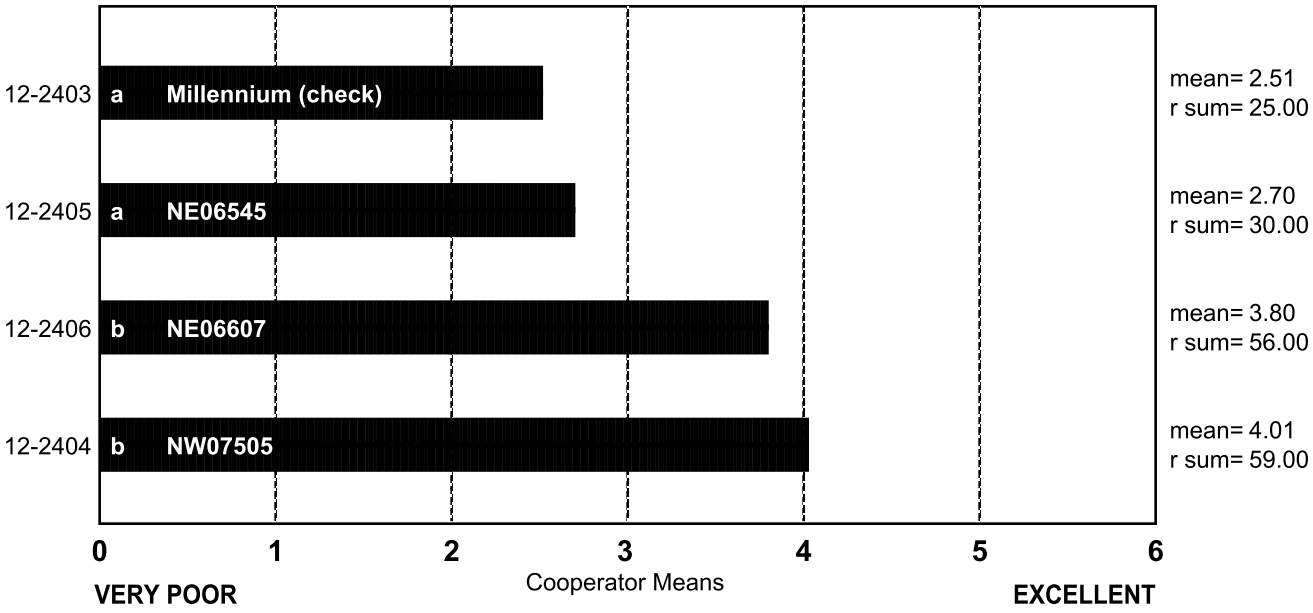


OVERALL BAKING QUALITY

(Small Scale) Nebraska

ncoop= 17
chisq= 32.36
chisqc= 37.18
cvchisq= 7.82
crdiff= 7.58

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) Nebraska

COOP. **12-2403 Millennium (Check)**

A. No comment.
B. Avg. abs, sl. short mix time, low volume, tan crumb, open grain, harsh texture, very flat.
C. Sticky out of mixer, slack at pan, slight cap.
D. No comment.
E. No comment.
F. Nice grain, avg. volume for protein, good dough, sl. creamy.
G. No comment.
H. Good color but poor texture and dense crumb grain.
I. Gray crumb color, open, thick cell walls, coarse texture, good volume.
J. Good performance.
K. Low loaf volume.
L. 11.4% flour protein, good bake MT, questionable crumb grain, dull color.
M. Lower mix time, good volume and grain rating, dull in color, harsh grain texture.
N. High absorption, short mix time, poor tolerance, sticky and wet dough, dense grain, avg. volume.
O. Poor bake quality, poor mix tolerance and grain, soft dough handling.
P. Normal Abs and MT, slight sticky & strong dough, med. Hi OS & volume, open & round cells, dull yellow crumb, slight harsh & tight texture.
Q. No comment.

COOP. **12-2404 NW07505**

A. No comment.
B. High abs, avg. mix time, below avg. volume, good color, open grain, sl. flat.
C. Slightly dry out of mixer, rough break.
D. No comment.
E. No comment.
F. Lower protein, good volume, long mix time, tough & bucky, very open grain.
G. No comment.
H. No comment.
I. Strong mixing dough, sl. open, streaky grain, excellent volume.
J. Very nice mixing properties and volume performance for protein level.
K. Low loaf volume.
L. Excellent mixograph tolerance, long bake MT, crumb grain & LV better than the check, dull color, rated higher than the check.
M. Good mix time, excellent volume, dense grain rating, white in color.
N. Good absorption, good mix time, fine grain, creamy, good volume.
O. Good overall, stiff dough handling - could take more water.
P. Normal Abs, much longer MT, slight sticky & strong dough, med. Hi OS & volume, fine & elongated cells, slight yellow crumb, smooth & resilient texture.
Q. No comment.

COOP. 12-2405 NE06545

A. No comment.
B. Avg. abs, avg. mix time, low volume, tan crumb, open grain, harsh texture, very flat.
C. Wet, slack out of mixer and at pan.
D. No comment.
E. No comment.
F. Lower protein, low volume, dull crumb color, tough dough.
G. No comment.
H. Poor color, texture, and crumb grain; low volume.
I. Below average absorption, good mixing strength, dull crumb color, good volume.
J. Very nice mixing properties and volume performance for protein level.
K. Low loaf volume, dark yellow crumb color.
L. 10.8% flour protein, long MT, good at make-up, LV lower than the check, crumb grain questionable-satisfactory, dull color, rated slightly higher than the check.
M. Lower abs, dull color, average volume, open grain.
N. Good absorption, short mix time, sticky and wet at make-up, dense grain, low volume.
O. Poor bake quality, small volumes and poor mix tolerance.
P. Normal Abs, longer MT, slight sticky & strong dough, med Hi OS & volume, open & irregular cells, yellow crumb, slight harsh & tight texture.
Q. No comment.

COOP. 12-2406 NE06607

A. No comment.
B. Avg. abs, avg. mix time, low volume, white crumb, sl. open crumb, sl. flat.
C. Excellent externals.
D. No comment.
E. No comment.
F. Lower protein, good volume, good mix, very good dough, open grain.
G. No comment.
H. White color.
I. Average absorption, strong mixing dough, fairly tight grain, excellent volume.
J. Very nice mixing properties and volume performance for protein level.
K. Low loaf volume.
L. Long MT, good at make-up, crumb grain rated satisfactory-higher than the check.
M. Average volume, good mix time, creamy white color, lower abs.
N. Good absorption, good dough, fine grain, creamy, high volume.
O. Acceptable bake quality, soft dough handling.
P. Normal Abs, longer MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, creamy crumb, silky & resilient texture.
Q. No comment.

Notes: **B, E, F, I, M, N, O and Q** conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

Colorado - 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, and adjacent breeding and extension trials, was fertilized with a pre-plant application of 40 lbs N (applied as 46-0-0). The planting date was 9/20/11 and the harvest date was 6/25/12.

Growing conditions included: timely planting into excellent soil moisture, excellent fall stands and growth, excellent fall precipitation and subsoil moisture going into the winter, adequate winter precipitation, no visible moisture stress at spring green-up, good mid-spring soil moisture conditions, extremely dry throughout May with significant drought stress apparent by mid- to late-May, very early heading due to warm spring temperatures, very early harvest (2+ weeks earlier than normal) with significant terminal drought stress during grain filling. Stripe rust was present at very low levels and no other significant disease or insect problems were observed. No rain was received after maturity and prior to harvest.

Grain yields of the adjacent state variety extension trial (UVPT) were quite good (despite the tough conditions), averaging 51.2 bu/a (34.7-58.6 bu/a range) with an average test weight of 61.6 lb/bu (58.9-63.5 lb/bu range). Average grain protein content (12% moisture basis) from the group of five strips harvested for the WQC was 14.6%.

Byrd (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. Byrd was chosen as our HRW check, replacing our long-term check Hatcher, because it has shown good milling and baking quality characteristics and will likely soon displace Hatcher in Colorado. Byrd is marketed by the Colorado Wheat Research Foundation (CWRF) under the PlainsGold Brand.

Snowmass (check)

Snowmass is a hard white winter wheat (HWW) that was released by Colorado State University in 2009. Snowmass was tested in the 2007 and 2008 WQC sample sets under its experimental number CO03W054. Snowmass was chosen as our HWW check this year as it has shown good milling and baking quality characteristics and it is the most widely grown HWW variety in Colorado. Snowmass is marketed by the Colorado Wheat Research Foundation (CWRF) under the PlainsGold Brand.

CO07W245 (Antero)

CO07W245 is a hard white winter wheat from the cross KS01HW152-1/TAM 111 made in 2003. KS01HW152-1 is an unreleased experimental line from Kansas State University with the pedigree Trego/Betty Sib and TAM 111 is a hard red winter wheat cultivar released by Texas A&M University in 2002. CO07W245 is medium height and medium maturing, and has a medium-length coleoptile, good straw strength, and excellent test weight. Pre-harvest sprouting tolerance of CO07W245 is similar to Snowmass (which is similar to Hatcher HRW). CO07W245 is resistant to stripe rust, moderately resistant to stem rust and wheat soilborne/wheat spindle streak mosaic virus, moderately susceptible to barley yellow dwarf and wheat streak mosaic viruses, and susceptible to leaf rust and all biotypes of Russian wheat aphid. CO07W245 is heterogeneous for resistance to Hessian fly and its reaction to Fusarium head blight is unknown. In two years of testing (2011-2012) in the dryland CSU Uniform Variety Performance Trial (UVPT), CO07W245 was the second highest yielding entry in the trial (similar to Byrd). CO07W245 has shown excellent overall milling properties and good overall baking properties in tests conducted in the CSU Wheat Quality Lab.

CO07W245 was formally released in fall 2012 by Colorado State University and will be marketed as 'Antero' by the Colorado Wheat Research Foundation under the PlainsGold Brand.

CO07W722-F5

CO07W722-F5 is a hard white winter wheat from the cross KS02HW89-1/BC97ROM-41W made by Kansas State University in 2004. KS02HW89-1 is an unreleased HWW experimental line from Kansas State with the pedigree Trego*2/Jagger 8W and BC97ROM-41W is an unreleased HWW experimental line from Agripro-Syngenta. CO07W722 was selected at Fort Collins, CO, in 2007, and CO07W722-F5 is a single plant re-selection made from CO07W722 in 2009. CO07W722-F5 is medium height and medium maturing, and has a medium-short coleoptile, good straw strength, and good test weight. Pre-harvest sprouting tolerance of CO07W722-F5 is less than Antero and Snowmass and greater than TAM 112. CO07W722-F5 is resistant to stripe rust (*Yr17*-virulent races) and wheat soilborne/wheat spindle streak mosaic virus, moderately resistant to stem rust, moderately susceptible to leaf rust and barley yellow dwarf virus, and susceptible to all biotypes of Russian wheat aphid. Reaction of CO07W722-F5 to Fusarium head blight is unknown. In its first year of testing (2012) in the dryland 2012 CSU Uniform Variety Performance Trial (UVPT), CO07W722-F5 was the third highest yielding entry in the trial, slightly lower than Byrd and Antero and greater than Snowmass. In irrigated state variety trials, CO07W722-F5 has also done quite well, showing high yield and very good straw strength under high input irrigated conditions. CO07W722-F5 has shown good overall milling and baking properties in tests conducted in the CSU Wheat Quality Lab. Dough mixing and break baking properties of CO07W722-F5 have been slightly inferior to Antero, though CO07W722-F5 has shown low polyphenol oxidase content. CO07W722-F5 is on breeder seed increase in 2013 with earliest possible release in fall 2014, pending outcome of trials in 2013.

Colorado: 2012 (Small-Scale) Samples

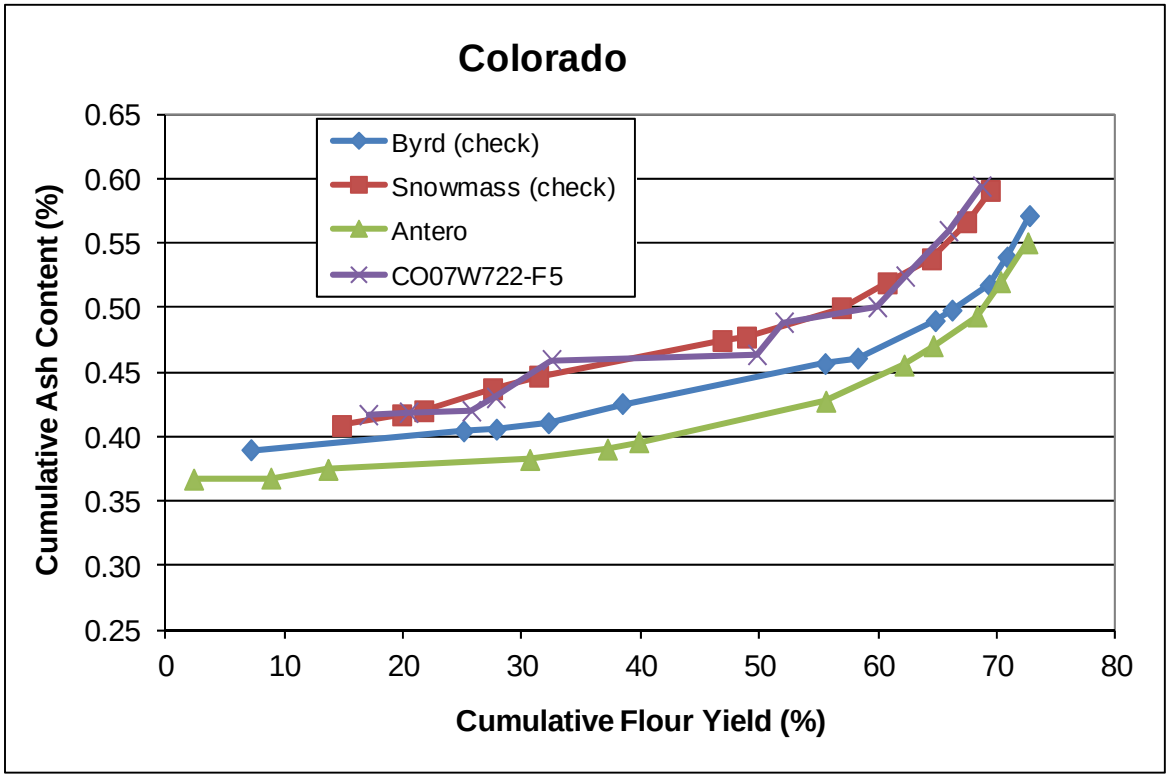
Test entry number	12-2407	12-2408	12-2409	12-2410
Sample identification	**Byrd (check)**	**Snowmass (check)**	**Antero**	**CO07W722-F5**
Wheat Data				
GIPSA classification	2 HRW	1 HDWH	4 HDWH	2 HDWH
Test weight (lb/bu)	59.4	60.0	61.7	59.7
Hectoliter weight (kg/hl)	78.2	78.9	81.1	78.6
1000 kernel weight (gm)	20.6	24.4	25.9	22.3
Wheat kernel size (Rotap)				
Over 7 wire (%)	7.5	18.7	33.1	15.2
Over 9 wire (%)	83.2	78.5	65.6	81.5
Through 9 wire (%)	9.3	2.8	1.3	3.3
Single kernel (skcs)[a]				
Hardness (avg /s.d)	78.9/15.0	85.8/16.2	76.5/13.5	91.8/14.7
Weight (mg) (avg/s.d)	20.6/5.9	24.4/7.3	25.9/6.4	22.3/5.8
Diameter (mm)(avg/s.d)	2.31/0.25	2.47/0.26	2.53/0.29	2.40/0.27
Moisture (%) (avg/s.d)	7.3/0.67	6.7/0.53	6.8/0.59	6.8/0.61
SKCS distribution	01-02-08-89-01	00-02-05-93-01	00-01-07-92-01	00-00-02-98-01
Classification	Hard	Hard	Hard	Hard
Wheat protein (12% mb)	14.6	14.4	13.9	13.9
Wheat ash (12% mb)	1.44	1.49	1.44	1.51
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	72.8	69.4	72.6	70.8
Quadrumat Sr. Mill	67.0	62.1	65.9	62.6
Flour moisture (%)	11.3	11.2	11.9	11.6
Flour protein (14% mb)	13.7	13.6	12.7	12.8
Flour ash (14% mb)	0.59	0.62	0.57	0.61
Rapid Visco-Analyser				
Peak time (min)	6.1	6.4	6.5	6.3
Peak viscosity (RVU)	218.1	196.6	231.8	177.4
Breakdown (RVU)	65.1	49.1	62.9	41.4
Final viscosity at 13 min (RVU)	283.8	264.5	271.5	255.3
Minolta color meter				
L*	91.9	92.1	92.33	92.0
a*	-1.22	-1.38	-1.33	-1.04
b*	10.72	10.52	10.44	10.26
PPO	0.590	0.693	0.569	0.195
Falling number (sec)	610	639	563	595
Damaged Starch				
(AI%)	96.74	97.47	96.54	97.92
(AACC76-31)	6.86	7.47	6.70	7.85

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

Colorado: Physical Dough Tests and Gluten Analysis For 2012 (Small-Scale) Samples

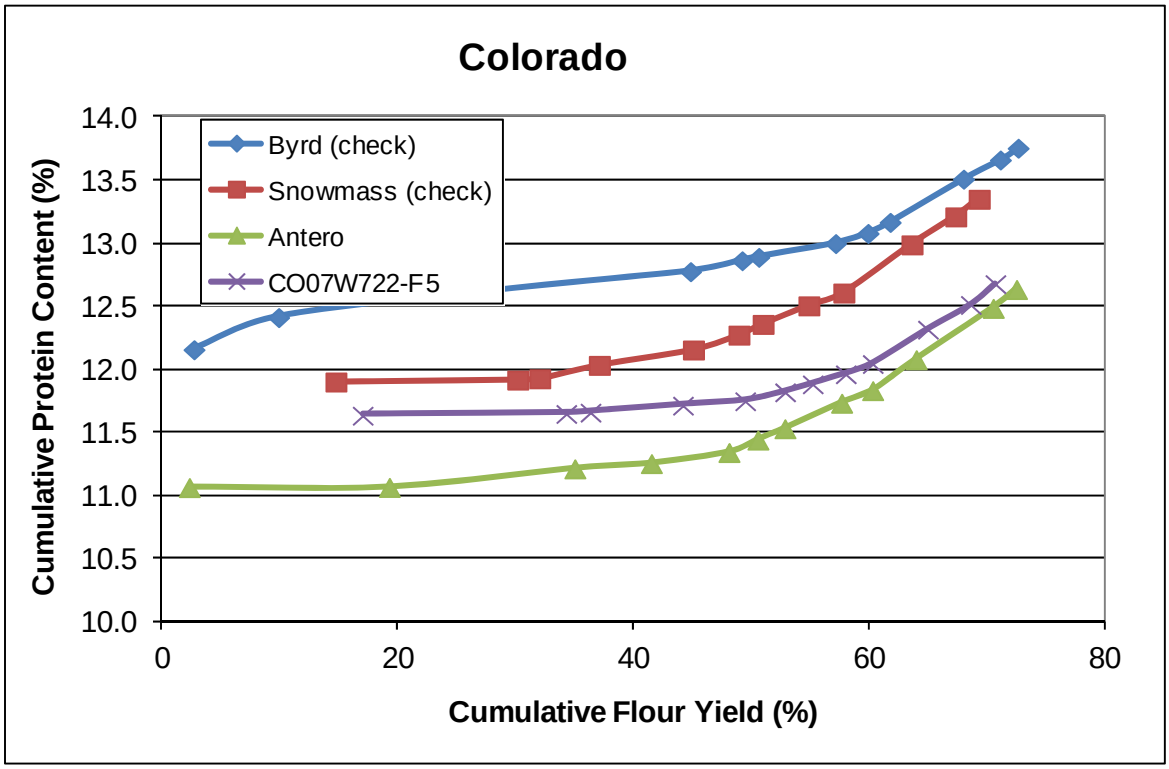
Test Entry Number	12-2407	12-2408	12-2409	12-2410
Sample Identification	Byrd (check)	Snowmass (check)	Antero	CO07W722-F5
	MIXOGRAPH			
Flour Abs (% as-is)	67.8	69.5	65.2	66.9
Flour Abs (14% mb)	64.7	66.3	62.8	64.2
Mix Time (min)	4.9	7.6	3.0	4.3
Mix tolerance (0-6)	5	5	2	4
	FARINOGRAPH			
Flour Abs (% as-is)	61.6	68.3	65.1	67.8
Flour Abs (14% mb)	59.5	66.1	63.3	64.4
Development time (min)	7.8	37.9	8.0	6.9
Mix stability (min)	28.5	42.9	15.9	18.1
Mix Tolerance Index (FU)	14	16	16	14
Breakdown time (min)	17.2	46.0	17.4	16.6
	ALVEOGRAPH			
P(mm): Tenacity	81	147	102	125
L(mm): Extensibility	123	71	91	77
G(mm): Swelling index	24.7	18.8	21.2	19.5
W(10^{-4} J): strength (curve area)	366	457	311	349
P/L: curve configuration ratio	0.66	2.07	1.12	1.62
Ie(P_{200}/P): elasticity index	66.8	73.5	56.6	58.0
	EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	474/742/816	734/988/997	307/417/478	332/443/426
Extensibility (mm at 45/90/135 min)	156/159/137	157/127/94.0	146/138/146	142/132/122
Energy (cm^2 at 45/90/135 min)	136/213/183	212/176/134	79/95/127	83/98/82
Resist $_{max}$ (BU at 45/90/135min)	694/999/999	994/988/997	400/538/692	443/584/544
Ratio (at 45/90/135 min)	3.03/4.66/5.97	4.68/7.76/10.61	2.11/3.02/3.28	2.33/3.37/3.48
	PROTEIN ANALYSIS			
HMW-GS Composition	2^{*}, 7+8, 5+10	2*, 7^{OE}+8, 5+10	2*, 7+9, 5+10	2*, 7+9, 5+10
%IPP	46.43	51.48	37.97	42.86
	SEDIMENTATION TEST			
Volume (ml)	65.9	66.8	44.4	40.4

Colorado: Cumulative Ash Curves



Byrd (check)					Snowmass (check)					Antero					CO07W722-F5				
Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash
1M	7.2	0.39	7.2	0.39	2M	14.8	0.41	14.8	0.41	1M Red	2.4	0.37	2.4	0.37	2M	17.1	0.42	17.1	0.42
2M	17.9	0.41	25.1	0.40	1M	5.1	0.44	19.9	0.42	1M	6.5	0.37	8.9	0.37	1BK	3.4	0.42	20.5	0.42
1M Red	2.8	0.42	27.8	0.41	1M Red	1.9	0.45	21.7	0.42	1BK	4.8	0.39	13.7	0.37	1M	5.3	0.43	25.7	0.42
1BK	4.4	0.44	32.2	0.41	2BK	5.8	0.50	27.5	0.44	2M	17.0	0.39	30.7	0.38	1M Red	2.1	0.43	27.8	0.42
2BK	6.2	0.50	38.4	0.43	1BK	3.9	0.52	31.4	0.45	2BK	6.5	0.43	37.2	0.39	2BK	4.7	0.49	32.5	0.43
3M	17.1	0.53	55.5	0.46	3M	15.4	0.53	46.8	0.47	Grader	2.6	0.48	39.8	0.40	3M	17.3	0.51	49.8	0.46
Grader	2.7	0.55	58.3	0.46	Grader	2.1	0.54	48.9	0.48	3M	15.7	0.51	55.6	0.43	Grader	2.3	0.55	52.1	0.46
4M	6.5	0.75	64.8	0.49	4M	8.0	0.64	56.9	0.50	4M	6.6	0.69	62.2	0.46	4M	7.8	0.65	59.9	0.49
FILTER FLR	1.4	0.87	66.2	0.50	FILTER FLR	3.9	0.80	60.7	0.52	FILTER FLR	2.5	0.85	64.6	0.47	FILTER FLR	2.3	0.81	62.3	0.50
3BK	3.1	0.93	69.3	0.52	3BK	3.7	0.84	64.5	0.54	3BK	3.7	0.90	68.3	0.49	3BK	3.6	0.93	65.9	0.52
BRAN FLR	1.5	1.54	70.8	0.54	5M	3.0	1.19	67.4	0.57	BRAN FLR	2.0	1.44	70.3	0.52	5M	2.8	1.39	68.7	0.56
5M	1.9	1.78	72.7	0.57	BRAN FLR	2.0	1.41	69.4	0.59	5M	2.3	1.47	72.6	0.55	BRAN FLR	2.1	1.73	70.8	0.59
Break Shorts	3.8	3.25	76.6	0.71	Break Shorts	4.7	2.98	74.1	0.74	Break Shorts	4.0	3.07	76.6	0.68	Break Shorts	4.6	3.15	75.4	0.75
Red Dog	3.3	2.98	79.9	0.80	Red Dog	4.1	2.66	78.2	0.84	Red Dog	3.4	2.94	79.9	0.78	Red Dog	3.7	2.95	79.0	0.85
Red Shorts	0.6	3.78	80.5	0.82	Red Shorts	0.9	3.76	79.1	0.87	Red Shorts	0.6	4.04	80.6	0.80	Red Shorts	0.7	3.78	79.7	0.88
Filter Bran	0.5	2.22	81.0	0.83	Filter Bran	1.4	1.79	80.5	0.89	Filter Bran	0.8	1.99	81.4	0.81	Filter Bran	0.8	1.76	80.6	0.89
Bran	19.0	3.71	100.0	1.38	Bran	19.5	3.68	100.0	1.43	Bran	18.6	4.30	100.0	1.46	Bran	19.4	3.86	100.0	1.46
Wheat		1.41			Wheat		1.46			Wheat		1.41			Wheat		1.48		
St. Grd. Fl.		0.59			St. Grd. Fl.		0.62			St. Grd. Fl.		0.57			St. Grd. Fl.		0.61		

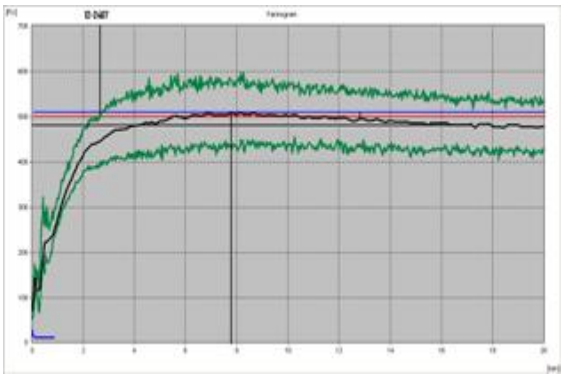
Colorado: Cumulative Protein Curves



Byrd (check)					Snowmass (check)					Antero					CO07W722-F5				
Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein
1M Red	2.8	12.2	2.8	12.2	2M	14.8	11.9	14.8	11.9	1M Red	2.4	11.1	2.4	11.1	2M	17.1	11.6	17.1	11.6
1M	7.2	12.5	9.9	12.4	3M	15.4	11.9	30.2	11.9	2M	17.0	11.1	19.3	11.1	3M	17.3	11.7	34.4	11.7
2M	17.9	12.7	27.8	12.6	1M Red	1.9	12.1	32.1	11.9	3M	15.7	11.4	35.1	11.2	1M Red	2.1	11.8	36.4	11.7
3M	17.1	13.0	44.9	12.8	1M	5.1	12.7	37.2	12.0	1M	6.5	11.5	41.6	11.3	4M	7.8	12.0	44.3	11.7
1BK	4.4	13.8	49.3	12.9	4M	8.0	12.7	45.2	12.2	4M	6.6	11.9	48.2	11.3	1M	5.3	12.0	49.5	11.8
FILTER FLR	1.4	13.8	50.7	12.9	FILTER FLR	3.9	13.7	49.0	12.3	FILTER FLR	2.5	13.4	50.6	11.4	1BK	3.4	12.9	52.9	11.8
4M	6.5	13.9	57.2	13.0	Grader	2.1	14.4	51.1	12.4	5M	2.3	13.5	52.9	11.5	FILTER FLR	2.3	13.3	55.3	11.9
Grader	2.7	14.8	60.0	13.1	1BK	3.9	14.4	55.0	12.5	1BK	4.8	14.0	57.7	11.7	5M	2.8	13.5	58.1	12.0
5M	1.9	16.0	61.9	13.2	5M	3.0	14.5	57.9	12.6	Grader	2.6	14.0	60.4	11.8	Grader	2.3	14.1	60.4	12.0
2BK	6.2	16.9	68.1	13.5	2BK	5.8	16.8	63.7	13.0	3BK	3.7	16.1	64.1	12.1	2BK	4.7	15.8	65.1	12.3
3BK	3.1	17.0	71.2	13.7	3BK	3.7	17.0	67.4	13.2	2BK	6.5	16.5	70.6	12.5	3BK	3.6	16.0	68.7	12.5
BRAN FLR	1.5	18.2	72.7	13.8	BRAN FLR	2.0	18.1	69.4	13.4	BRAN FLR	2.0	18.0	72.6	12.6	BRAN FLR	2.1	18.1	70.8	12.7
Break Shorts	3.8	15.8	76.6	13.9	Break Shorts	4.7	15.5	74.1	13.5	Break Shorts	4.0	14.7	76.6	12.7	Break Shorts	4.6	15.4	75.4	12.8
Red Dog	3.3	15.0	79.9	13.9	Red Dog	4.1	15.1	78.2	13.6	Red Dog	3.4	14.7	79.9	12.8	Red Dog	3.7	14.6	79.0	12.9
Red Shorts	0.6	14.3	80.5	13.9	Red Shorts	0.9	14.5	79.1	13.6	Red Shorts	0.6	14.4	80.6	12.8	Red Shorts	0.7	14.5	79.7	12.9
Filter Bran	0.5	13.5	81.0	13.9	Filter Bran	1.4	12.6	80.5	13.6	Filter Bran	0.8	12.2	81.4	12.8	Filter Bran	0.8	12.5	80.6	12.9
Bran	19.0	17.7	100.0	14.6	Bran	19.5	17.8	100.0	14.4	Bran	18.6	18.3	100.0	13.9	Bran	19.4	17.7	100.0	13.9
Wheat		14.3			Wheat		14.02			Wheat		13.54			Wheat		13.6		
St. Grd. Fl.		13.7			St. Grd. Fl.		13.64			St. Grd. Fl.		12.69			St. Grd. Fl.		12.8		

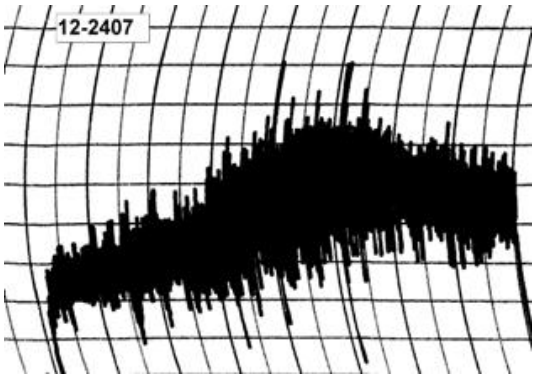
Physical Dough Tests
2012 (Small Scale) Samples - Colorado

Farinograms



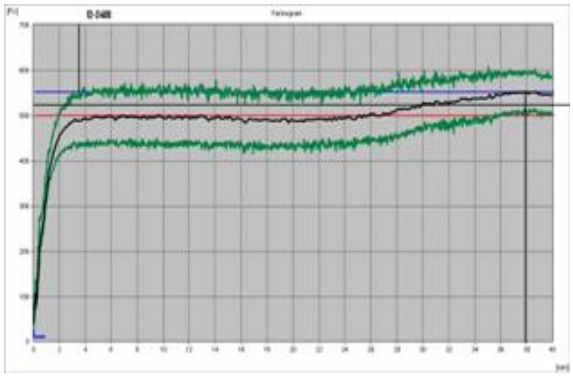
Water abs = 9.5%, Peak time = 7.8 min,
Mix stab = 28.5 min, MTI = 14 FU

Mixograms

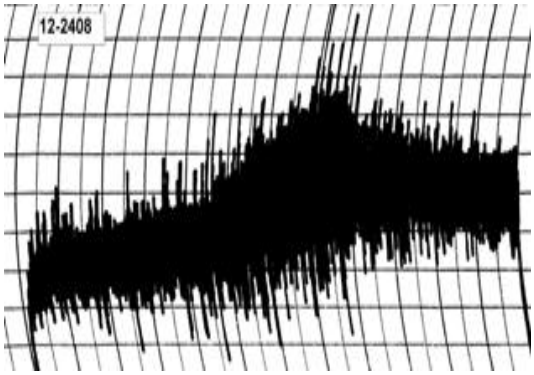


Water abs = 64.7%
Mix time = 4.9 min

12-2407, Byrd (check)



Water abs = 66.1%, Peak time = 37.9 min,
Mix stab = 42.9 min, MTI = 16 FU



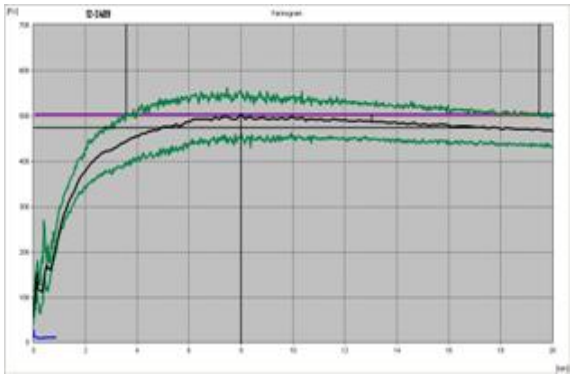
Water abs = 66.3%
Mix time = 7.6 min

12-2408, Snowmass (check)

Physical Dough Tests

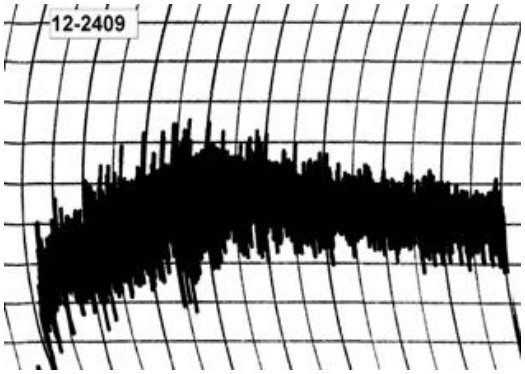
2012 (Small Scale) Samples - Colorado (continued)

Farinograms



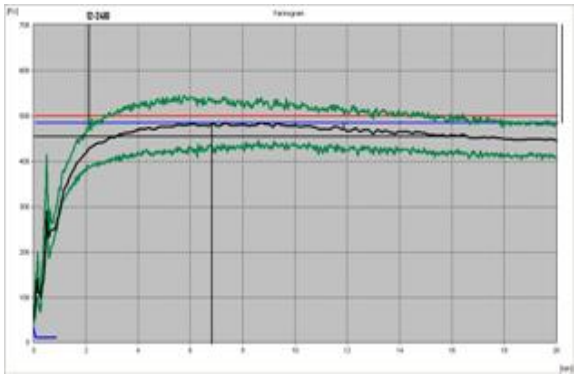
Water abs= 63.3%, Peak time = 8.0 min,
Mix stab = 15.9 min, MTI = 16 FU

Mixograms

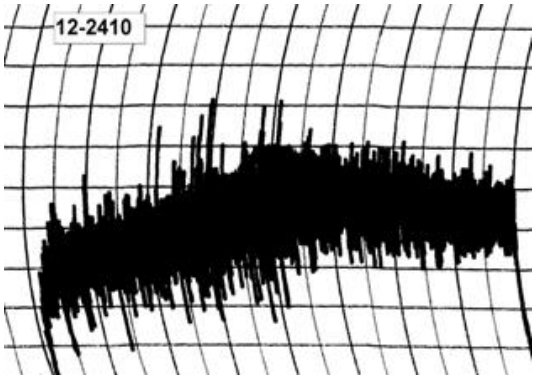


Water abs = 62.8%
Mix time = 3.0 min

12-2409, Antero (CO07W245)



Water abs= 64.4%, Peak time = 6.9 min,
Mix stab = 18.1 min, MTI = 14 FU

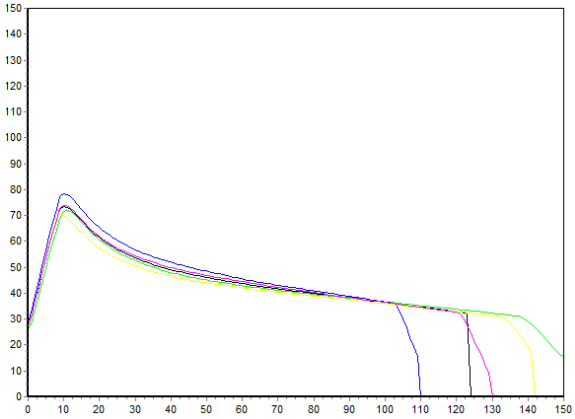


Water abs = 64.2%
Mix time = 4.3 min

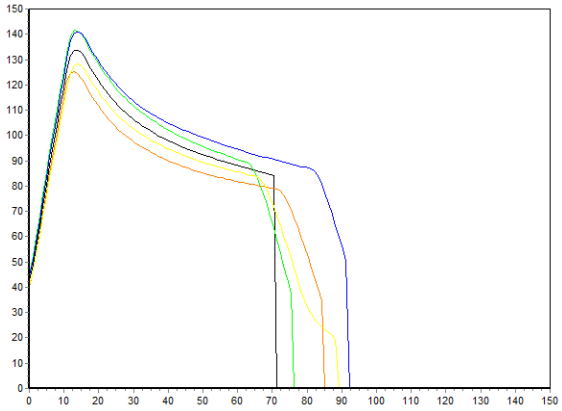
12-2410, CO07W722-F5

Physical Dough Tests - Alveograph

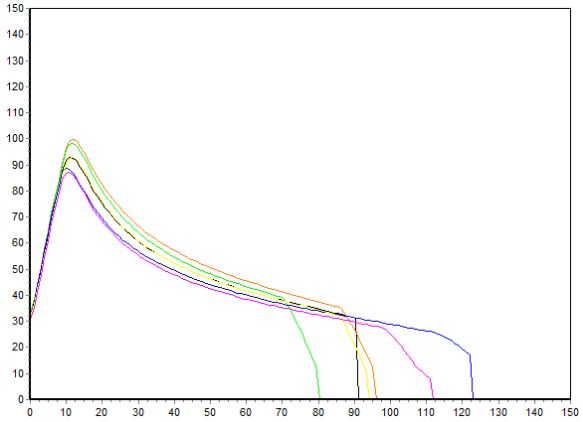
2012 (Small Scale) Samples – Colorado



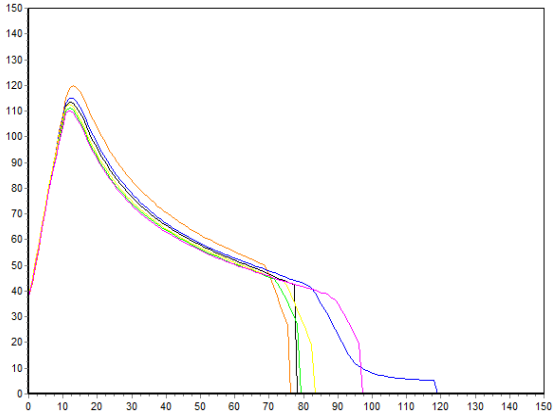
12-2407, Byrd (check)
P(mm H_20)=81, L(mm)=123, W(10E^{-4} J)=366



12-2408, Snowmass (check)
P(mm H_20)=147, L(mm)=71, W(10E^{-4} J)=457



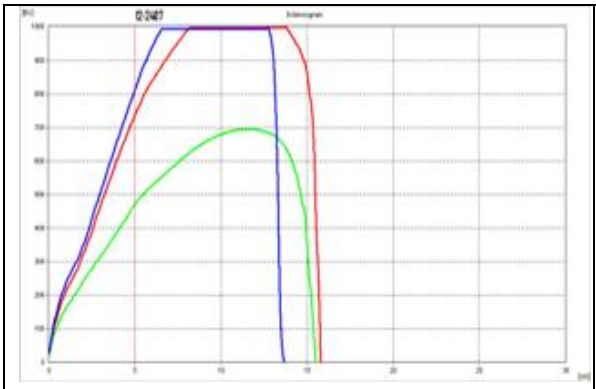
12-2409, Antero (CO07W245)
P(mm H_20)=102, L(mm)=91, W(10E^{-4} J)=311



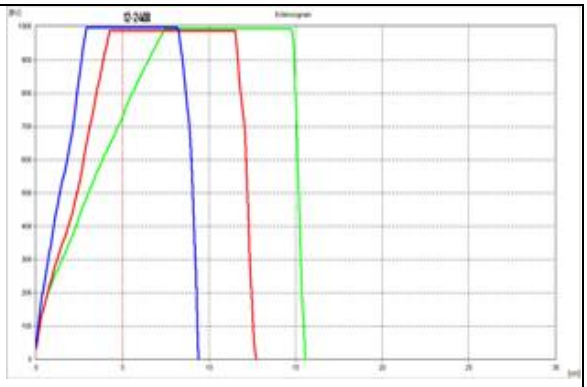
12-2410, CO07W722-F5
P(mm H_20)=125, L(mm)=77, W(10E^{-4} J)=349

Physical Dough Tests - Extensigraph

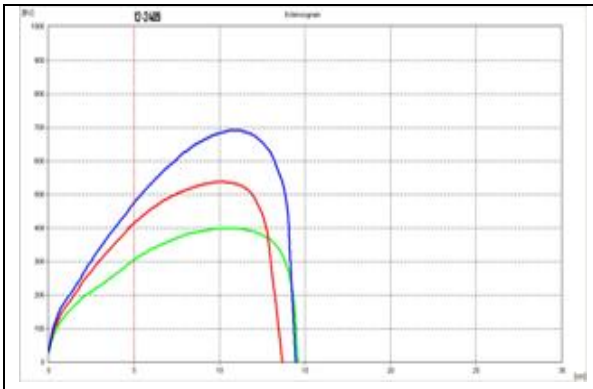
2012 (Small Scale) Samples – Colorado



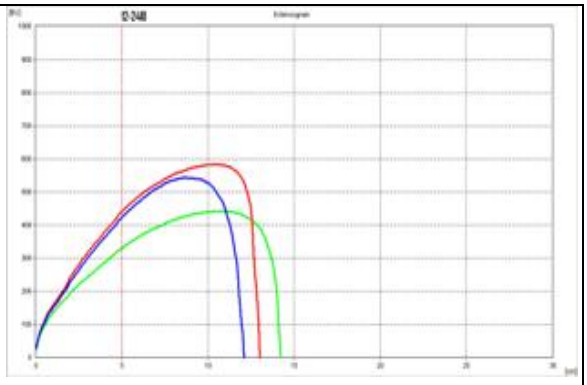
Byrd (check) -2407
R (BU) = 742, E (mm) =159, W (cm^2) = 213
Rmax (BU) = 999, Ratio = 4.7 at 90 min



Snowmass (check) - 2408
R (BU) = 988, E (mm) =127, W (cm^2) = 176
Rmax (BU) = 988, Ratio = 7.8 at 90 min



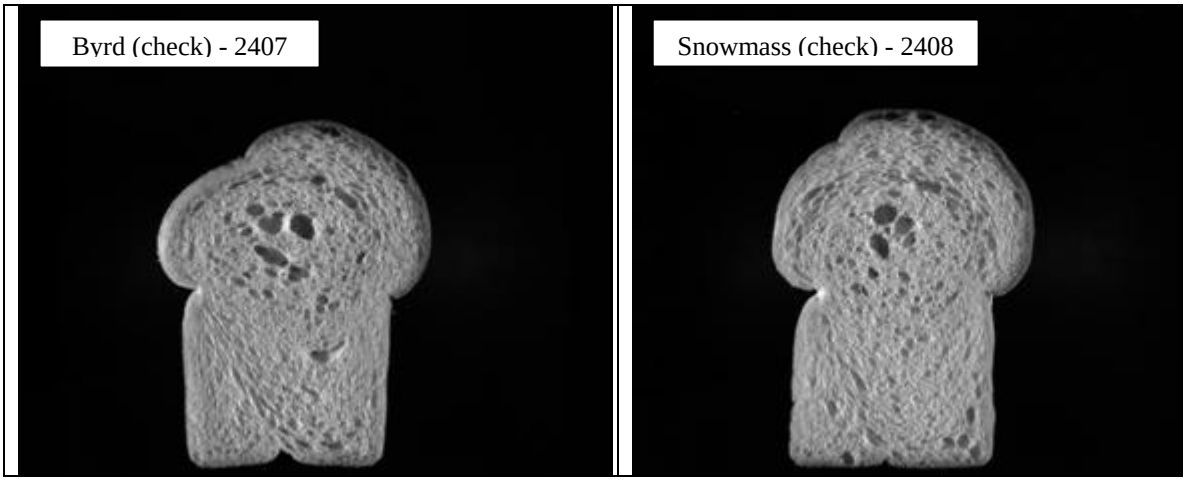
Antero (CO07W245) - 2409
R (BU) = 4175, E (mm) =138, W (cm^2) = 95
Rmax (BU) = 538, Ratio = 3.0 at 90 min



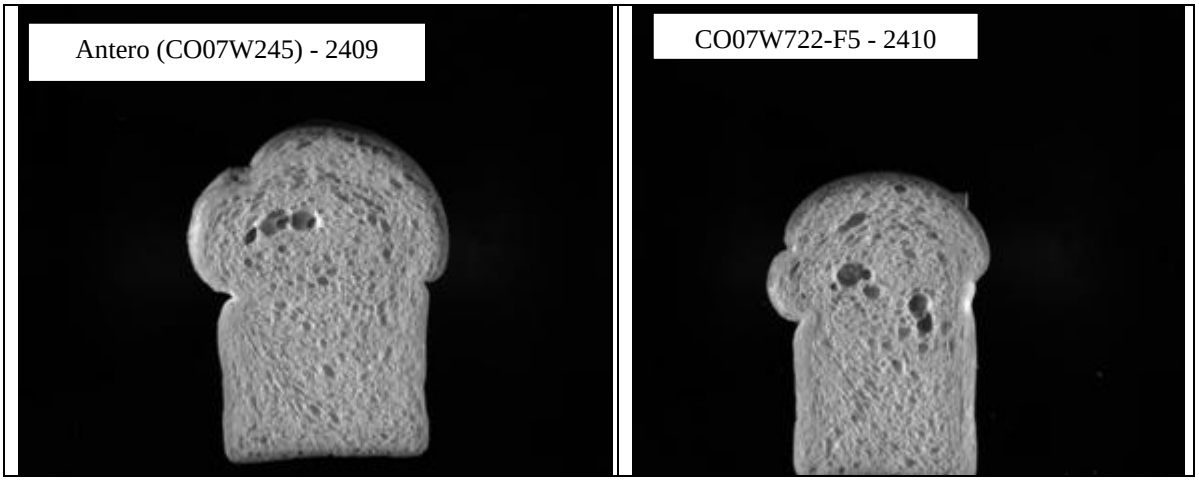
CO07W722-F5 - 2410
R (BU) = 443, E (mm) =132, W (cm^2) = 98
Rmax (BU) = 584, Ratio = 3.4 at 90 min

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 for 2012 (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})
2407	6681	129.6	4047	0.443	2.071	2.672	1.740	-12.10
2408	7133	135.2	4010	0.450	2.155	1.513	1.775	6.05



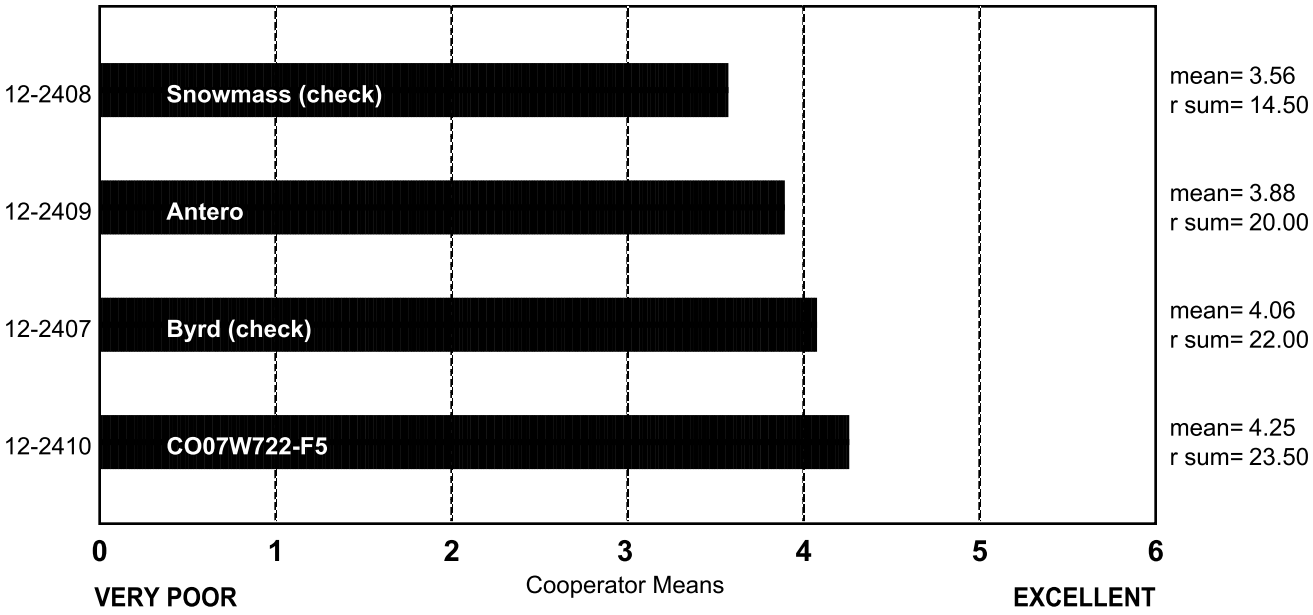
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2409	5945	139.8	3737	0.446	1.969	4.279	1.735	7.00
2410	5681	140.2	3667	0.439	1.883	3.140	1.740	-9.40

SPONGE CHARACTERISTICS

(Small Scale) Colorado

ncoop= 8
chisq= 3.49
chisqc= 5.07
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

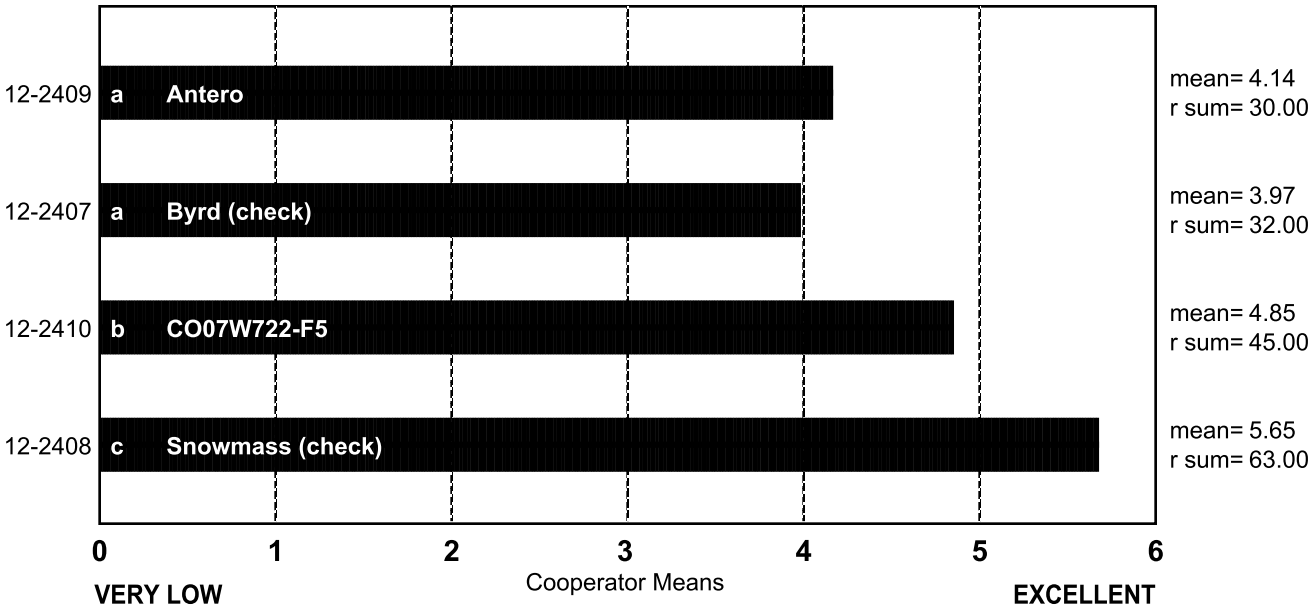


BAKE ABSORPTION

(Small Scale) Colorado

ncoop= 17
chisq= 24.46
chisqc= 30.13
cvchisq= 7.82
crdiff= 8.99

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Colorado

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2407 Byrd (check)	**67.1**	**63.0**	**66.0**	**64.5**	**59.5**	**60.0**	**59.5**	**62.1**	**60.0**	**67.1**	**56.0**	**62.6**	**59.5**	**63.0**	**64.0**	**62.9**	**61.0**
12-2408 Snowmass (check)	**70.1**	**70.0**	**66.8**	**66.1**	**66.0**	**60.0**	**66.1**	**69.0**	**66.0**	**70.9**	**62.9**	**65.5**	**66.1**	**66.0**	**64.0**	**66.3**	**64.5**
12-2409 Antero	**65.1**	**63.0**	**62.6**	**63.0**	**63.5**	**59.0**	**63.3**	**66.9**	**63.0**	**64.8**	**59.9**	**60.3**	**63.3**	**64.0**	**63.0**	**63.8**	**62.0**
12-2410 CO07W722-F5	**66.1**	**64.0**	**64.3**	**64.2**	**64.5**	**59.0**	**64.4**	**67.8**	**65.0**	**66.4**	**61.2**	**64.0**	**64.4**	**64.0**	**63.0**	**65.3**	**62.0**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Colorado

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2407 Byrd (check)	**5.8**	**14.0**	**5.8**	**5.8**	**8.0**	**20.0**	**8.0**	**4.3**	**25.0**	**6.5**	**2.3**	**8.3**	**17.0**	**14.0**	**9.0**	**7.1**	**30.0**
12-2408 Snowmass (check)	**8.0**	**18.0**	**9.0**	**8.3**	**8.0**	**20.0**	**11.0**	**7.3**	**25.0**	**10.7**	**5.0**	**11.6**	**19.0**	**28.0**	**9.0**	**11.7**	**30.0**
12-2409 Antero	**2.8**	**6.0**	**3.5**	**3.0**	**8.0**	**8.0**	**13.0**	**3.2**	**15.0**	**3.1**	**2.3**	**4.0**	**9.0**	**4.0**	**3.0**	**4.2**	**10.0**
12-2410 CO07W722-F5	**4.3**	**6.0**	**4.5**	**4.3**	**7.0**	**16.0**	**8.0**	**4.0**	**20.0**	**4.8**	**3.0**	**5.5**	**9.0**	**4.0**	**6.0**	**5.2**	**18.0**

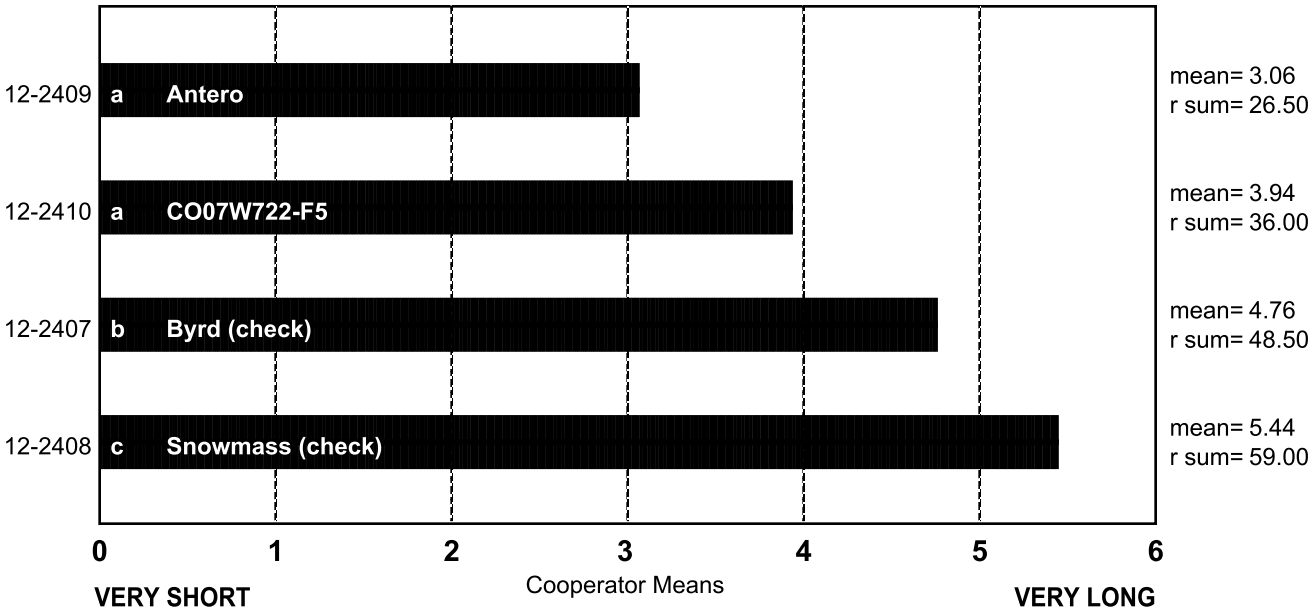
Raw Data

BAKE MIX TIME

(Small Scale) Colorado

ncoop= 17
chisq= 21.41
chisqc= 24.59
cvchisq= 7.82
crdiff= 10.48

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

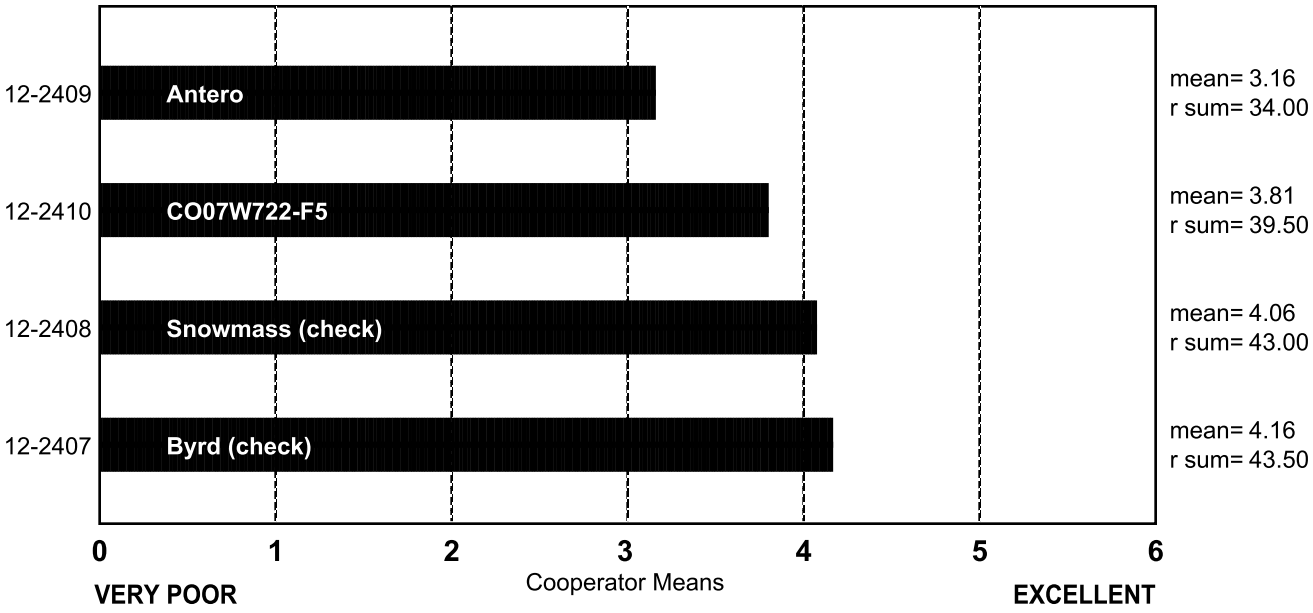


MIXING TOLERANCE

(Small Scale) Colorado

ncoop= 16
chisq= 2.16
chisqc= 2.92
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

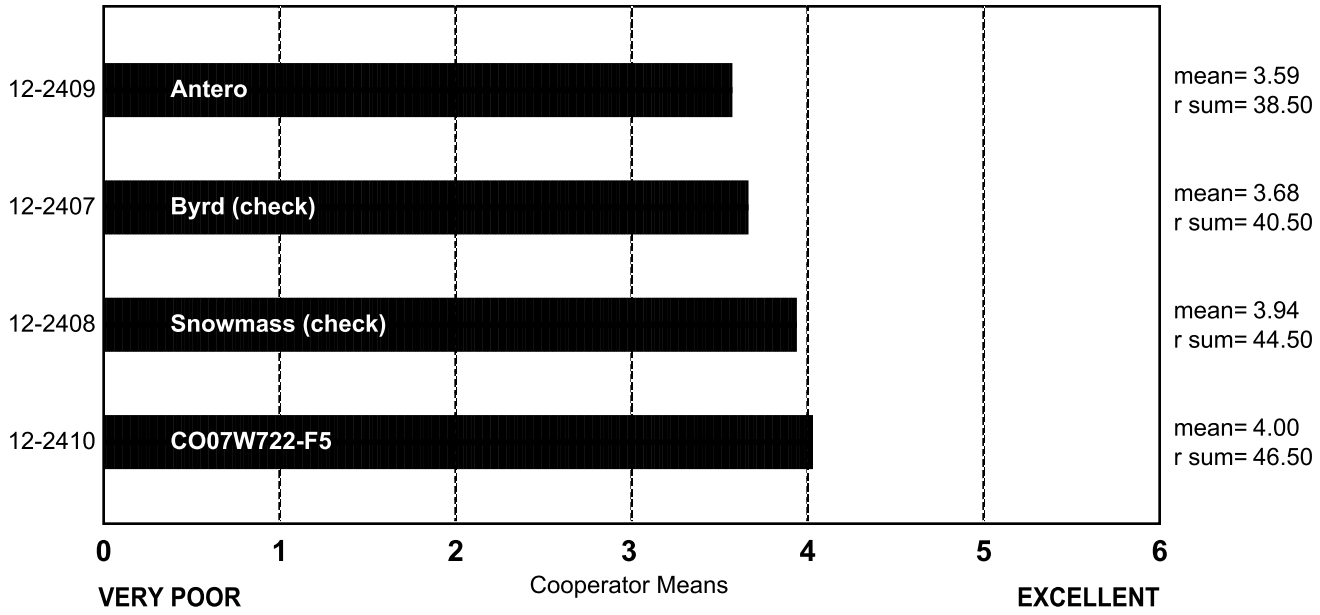


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Colorado

ncoop= 17
chisq= 1.41
chisqc= 1.90
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'OUT OF MIXER', DESCRIBED

(Small Scale) Colorado

	Sticky	Wet	Tough	Good	Excellent
12-2407 Byrd (check)	**2**	**0**	**8**	**6**	**1**
12-2408 Snowmass (check)	**2**	**0**	**8**	**7**	**0**
12-2409 Antero	**4**	**2**	**3**	**8**	**0**
12-2410 CO07W722-F5	**2**	**1**	**4**	**10**	**0**

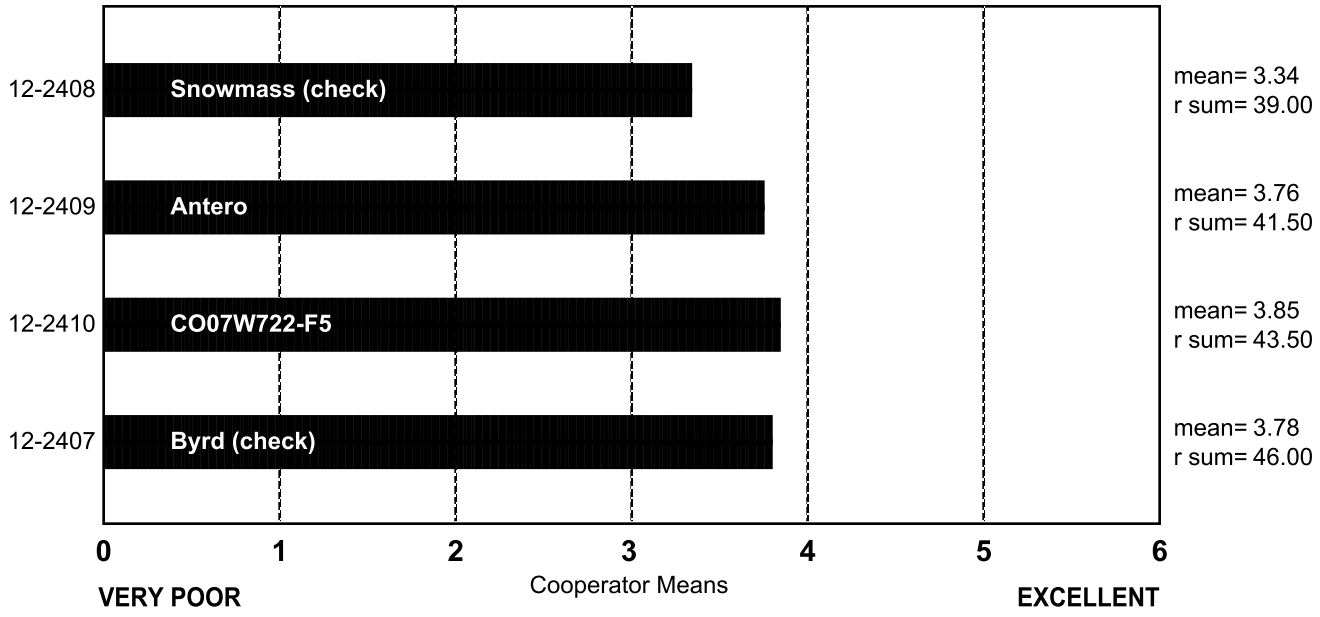
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Colorado

ncoop= 17
chisq= 0.94
chisqc= 1.23
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) Colorado

	Sticky	Wet	Tough	Good	Excellent
12-2407 Byrd (check)	**1**	**1**	**6**	**7**	**2**
12-2408 Snowmass (check)	**1**	**0**	**10**	**4**	**2**
12-2409 Antero	**3**	**2**	**1**	**11**	**0**
12-2410 CO07W722-F5	**1**	**2**	**5**	**8**	**1**

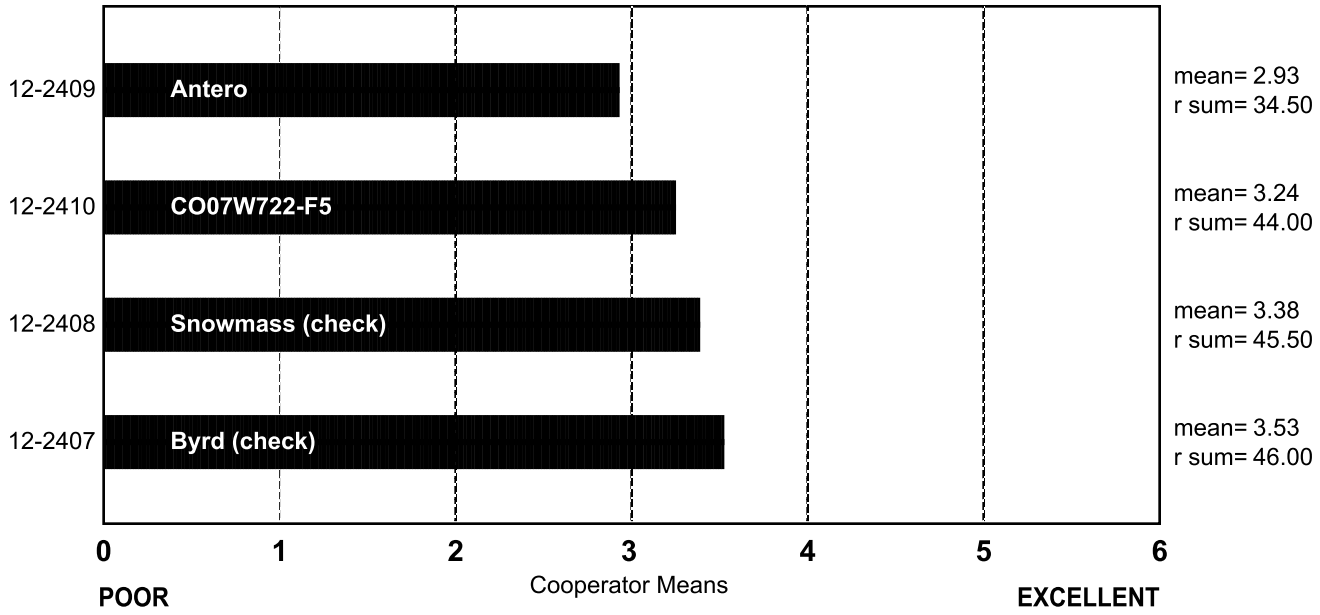
Frequency Table

CRUMB GRAIN

(Small Scale) Colorado

ncoop= 17
chisq= 3.09
chisqc= 3.72
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB GRAIN, DESCRIBED

(Small Scale) Colorado

	Open	Fine	Dense
12-2407 Byrd (check)	**10**	**6**	**1**
12-2408 Snowmass (check)	**10**	**5**	**2**
12-2409 Antero	**9**	**5**	**3**
12-2410 CO07W722-F5	**11**	**4**	**2**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Colorado

	Round	Irregular	Elongated
12-2407 Byrd (check)	**4**	**9**	**4**
12-2408 Snowmass (check)	**3**	**7**	**7**
12-2409 Antero	**8**	**7**	**2**
12-2410 CO07W722-F5	**10**	**6**	**1**

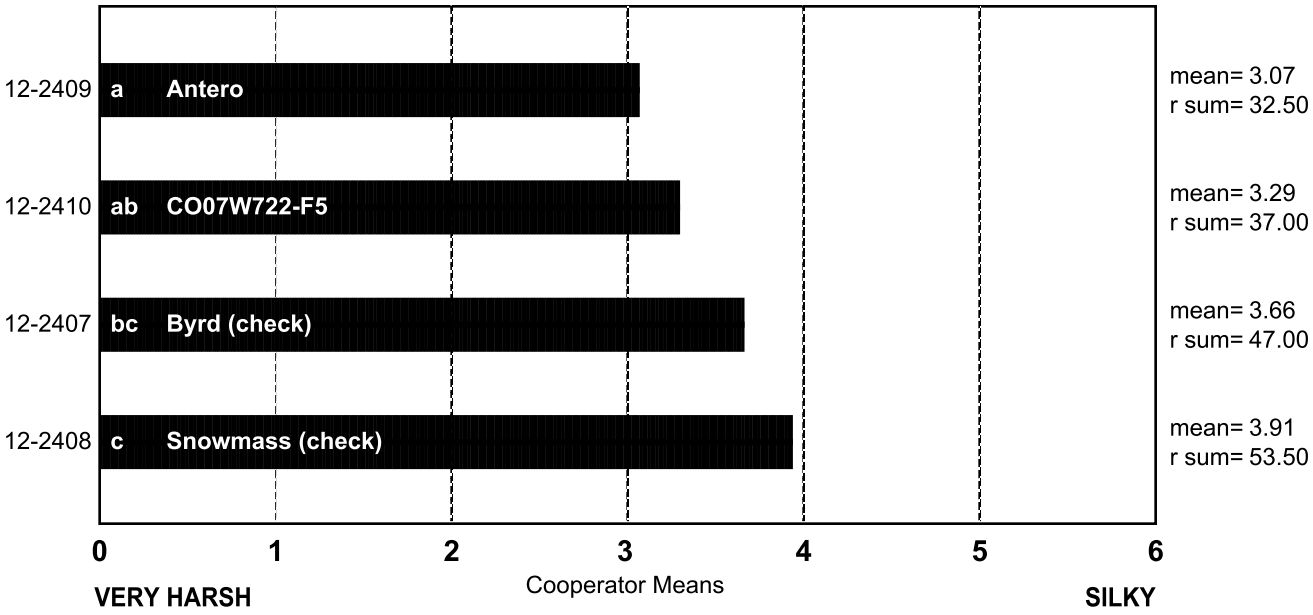
Frequency Table

CRUMB TEXTURE

(Small Scale) Colorado

ncoop= 17
chisq= 9.58
chisqc= 14.54
cvchisq= 7.82
crdiff= 10.71

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB TEXTURE, DESCRIBED

(Small Scale) Colorado

	Harsh	Smooth	Silky
12-2407 Byrd (check)	**3**	**9**	**5**
12-2408 Snowmass (check)	**1**	**11**	**5**
12-2409 Antero	**6**	**10**	**1**
12-2410 CO07W722-F5	**7**	**10**	**0**

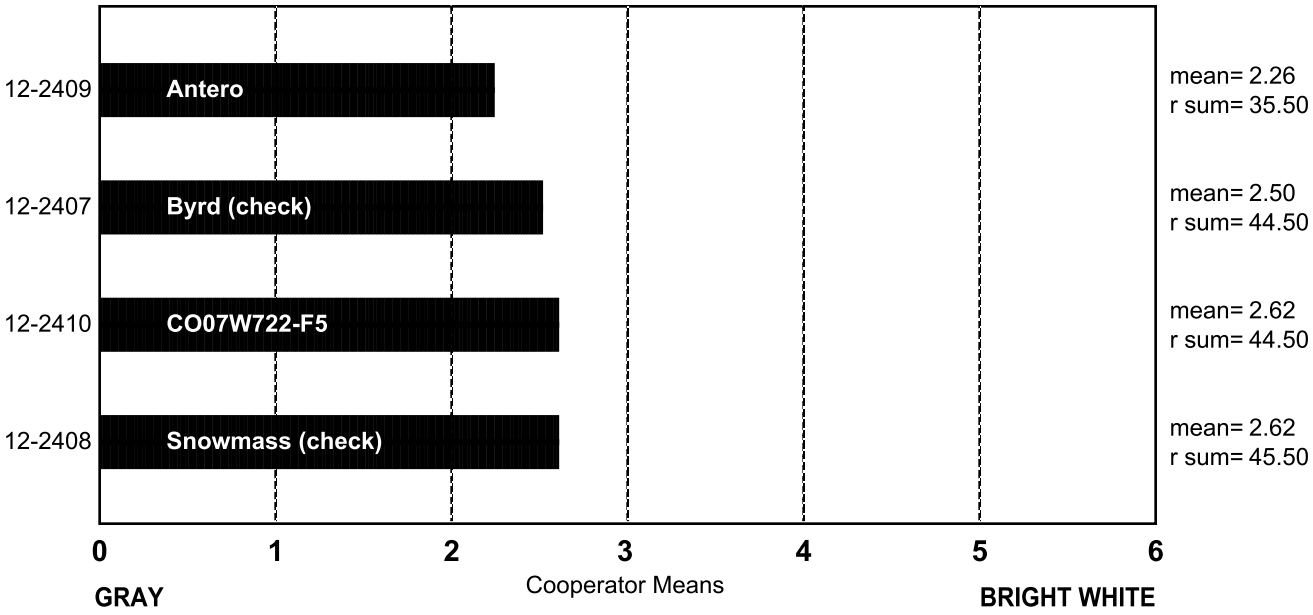
Frequency Table

CRUMB COLOR

(Small Scale) Colorado

ncoop= 17
chisq= 2.33
chisqc= 4.40
cvchisq= 7.82
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB COLOR, DESCRIBED

(Small Scale) Colorado

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
12-2407 Byrd (check)	**0**	**1**	**10**	**4**	**2**	**0**	**0**
12-2408 Snowmass (check)	**0**	**2**	**10**	**2**	**3**	**0**	**0**
12-2409 Antero	**0**	**2**	**11**	**2**	**1**	**1**	**0**
12-2410 CO07W722-F5	**0**	**2**	**9**	**1**	**5**	**0**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Colorado

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2407 Byrd (check)	**178.0**	**462.6**	**142.4**	**140.8**	**488.0**	**410.0**	**475.0**	**129.2**	**490.6**	**152.4**	**125.6**	**149.5**	**454.6**	**487.1**	**134.0**	**140.7**	**464.9**
12-2408 Snowmass (check)	**180.0**	**462.5**	**140.7**	**140.0**	**492.0**	**410.0**	**476.0**	**132.0**	**495.3**	**156.2**	**130.4**	**148.3**	**442.1**	**482.4**	**134.0**	**142.0**	**462.0**
12-2409 Antero	**177.0**	**465.1**	**141.9**	**143.0**	**484.0**	**413.0**	**675.0**	**133.0**	**483.3**	**154.9**	**132.9**	**146.2**	**452.7**	**485.2**	**134.0**	**143.6**	**457.8**
12-2410 CO07W722-F5	**178.0**	**463.6**	**143.9**	**143.2**	**486.0**	**414.0**	**476.0**	**133.8**	**493.0**	**150.2**	**130.3**	**151.4**	**450.5**	**486.0**	**134.0**	**141.8**	**465.9**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Colorado

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2407 Byrd (check)	**973**	**2600**	**1015**	**843**	**3000**	**3150**	**2425**	**930**	**3162**	**1058**	**790**	**955**	**2508**	**2388**	**1058**	**908**	**2700**
12-2408 Snowmass (check)	**860**	**2500**	**1140**	**879**	**2400**	**3100**	**2075**	**930**	**3104**	**956**	**780**	**960**	**2533**	**2363**	**965**	**878**	**2625**
12-2409 Antero	**790**	**2275**	**840**	**662**	**3350**	**2825**	**2025**	**815**	**2633**	**867**	**750**	**780**	**2233**	**2300**	**858**	**810**	**2525**
12-2410 CO07W722-F5	**785**	**2363**	**865**	**686**	**2900**	**2800**	**2075**	**840**	**2927**	**924**	**760**	**760**	**2483**	**2200**	**890**	**823**	**2525**

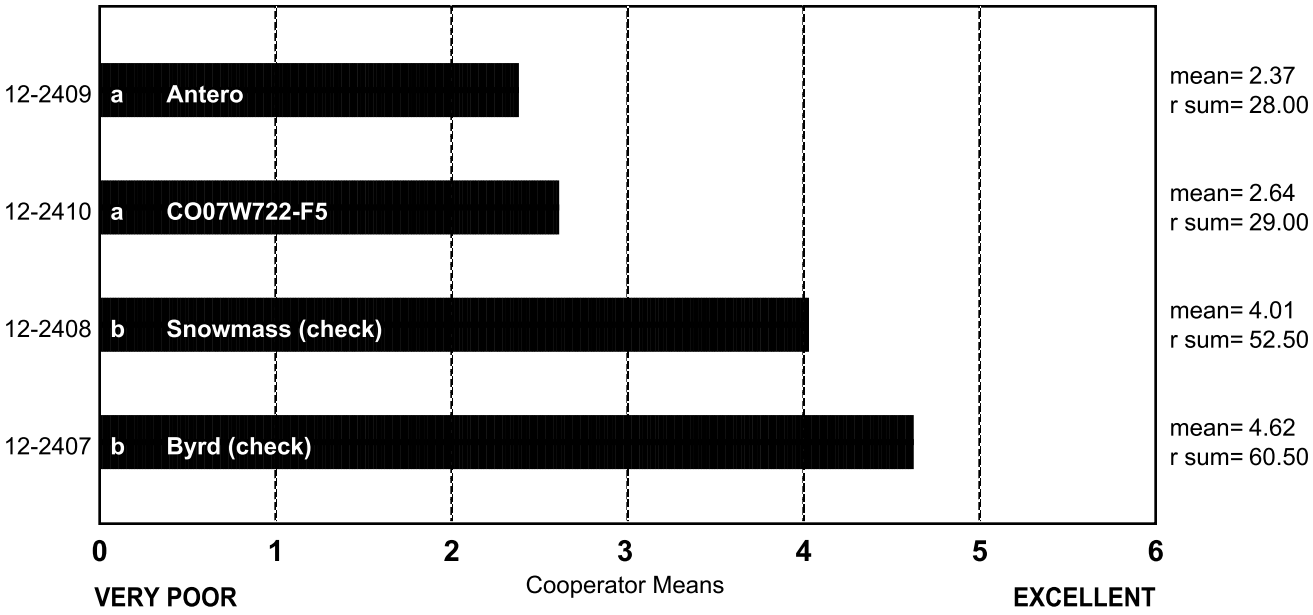
Raw Data

LOAF VOLUME

(Small Scale) Colorado

ncoop= 17
chisq= 28.82
chisqc= 34.74
cvchisq= 7.82
crdiff= 8.02

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

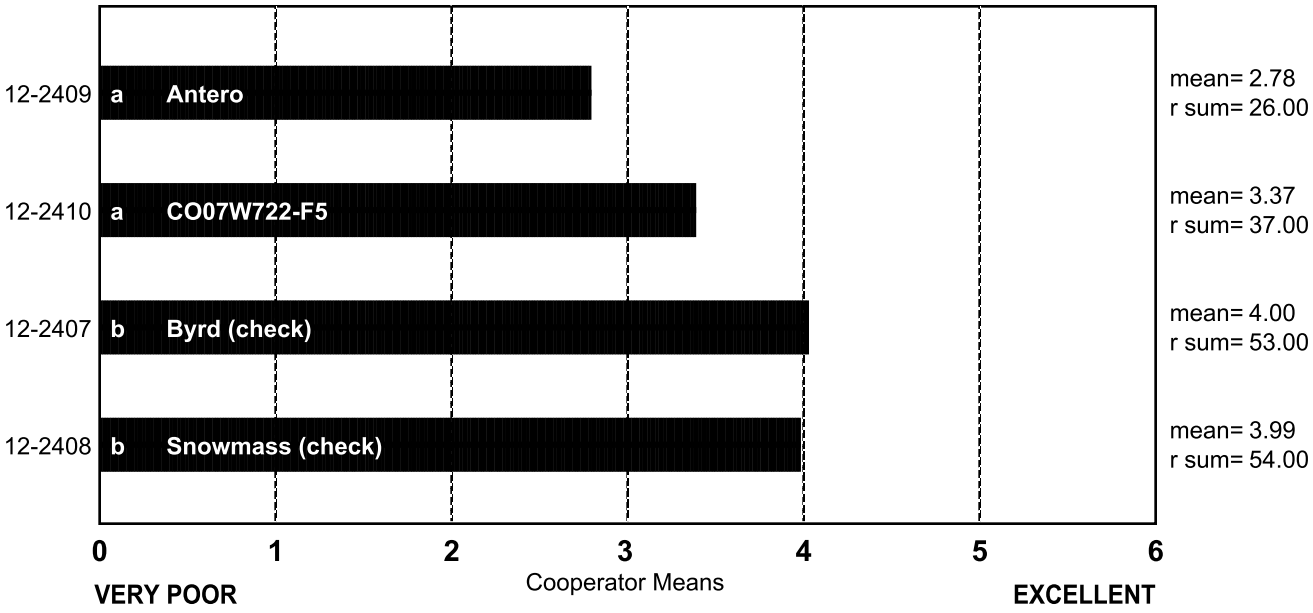


OVERALL BAKING QUALITY

(Small Scale) Colorado

ncoop= 17
chisq= 19.24
chisqc= 20.83
cvchisq= 7.82
crdiff= 11.53

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) Colorado

COOP. **12-2407 Byrd (Check)**

A. No comment.
B. Above avg. abs, long mix time, avg. volume, sl. yellow crumb, sl. open grain, good symmetry.
C. Long time to pick-up, good elasticity.
D. No comment.
E. No comment.
F. Long mix, very tough dough, yellow crumb, excellent volume, tough to sheet.
G. No comment.
H. Good crumb grain.
I. Strong mixing dough, average absorption, tight, consistent, smooth grain, excellent volume.
J. Very nice mixing properties and volume performance for protein level; very nice crumb grain.
K. No comment.
L. 13.7% flour protein, long MT, satisfactory crumb grain, yellow color.
M. Long mix time, high protein, lower abs, dull color, good volume and grain rating.
N. Good absorption, long mix time, open grain, yellow, good volume.
O. Good bake quality but very yellow crumb.
P. Normal Abs, longer MT, slight sticky & strong dough, Hi OS & volume, open & irregular cells, yellow crumb, slight harsh & resilient texture.
Q. No comment.

COOP. **12-2408 Snowmass (check)**

A. No comment.
B. Very high abs, long mix time, sl. below avg. volume, sl. yellow crumb, sl. open grain, good symmetry.
C. Very long time to pick-up, excellent externals.
D. No comment.
E. No comment.
F. Long mix, very bucky dough, yellow crumb, higher protein, very open grain.
G. No comment.
H. Very long mixer, average crumb grain and texture, very small moulder holes for farinograph strength.
I. Very strong dough, high absorption level, tight streaky grain, excellent volume, extremely long farinograph peak and stability.
J. Bucky dough, decreased volume, too long mixing, nice crumb grain considering the tight dough.
K. High bake absorption, long mix time.
L. 13.4% flour protein, good mixing tolerance, good absorption, long MT, excellent LV, questionable crumb grain, yellow color.
M. High protein, abs and stability; long mix time, excellent volume with a good grain rating.
N. High absorption, extremely long mix time, tough dough, open grain, yellow, good volume.
O. Good bake quality but very yellow crumb, long mixing requirement, very strong dough, could take more water.
P. Hi Abs, much longer MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, slight yellow crumb, smooth & resilient texture.
Q. No comment.

COOP. 12-2409 CO07W245 (Antero)

A. No comment.
B. Sl. above avg. abs, avg. mix time, very low volume, yellow crumb, open grain, harsh, very flat.
C. No comment.
D. No comment.
E. No comment.
F. Short mix, very open grain, yellow interior, very pliable at make- up, good volume.
G. No comment.
H. Very poor color.
I. Good absorption, wet, sticky dough, very open, thick cell walls, yellow crumb color, poor volume.
J. Weaker mixing, poor volume for protein level, crumb grain weak looking.
K. No comment.
L. 12.5% flour protein, good MT, poor LV & crumb grain, yellow color, rated lower than check.
M. Good protein, abs and stability; excellent mix time, lower volume, good dense grain.
N. High absorption, short mix time, open grain, yellow, good volume.
O. Poor bake quality and very yellow crumb; poor mix tolerance and mellow dough handling.
P. Normal Abs & MT, slight sticky & strong dough, med Hi OS & volume, dense & round cells, yellow crumb, slight harsh & resilient texture.
Q. No comment.

COOP. 12-2410 CO07W722-F5

A. No comment.
B. Above avg. abs, avg. mix time, low volume, sl. yellow crumb, sl. open grain, flat.
C. No comment.
D. No comment.
E. No comment.
F. Good volume, open grain, excellent dough handling, strong dough.
G. No comment.
H. Very poor color.
I. Very good absorption, strong dough, average interior scores, above average volume.
J. Good mixing properties; poor crumb grain.
K. No comment.
L. 12.8% flour protein, good absorption, medium MT, poor LV, questionable crumb grain, yellow color.
M. Good protein, stability, and abs; excellent volume, yellow color, open grain, harsh texture.
N. High absorption, short mix time, avg. grain, yellow, avg. volume.
O. Acceptable bake quality, soft dough handling.
P. Normal Abs & MT, slight sticky & strong dough, med Hi OS & volume, open & irregular cells, yellow crumb, slight harsh & resilient texture.
Q. No comment.

Notes: **B, E, F, I, M, N, O and Q** conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

Oklahoma - Brett Carver

Oklahoma's 2012 WQC grain samples were produced at the same locations as in past years: 1) the Oklahoma Panhandle Research and Extension Center at Goodwell, OK (High Plains region) with supplemental irrigation, and 2) the North Central Agronomy Research Station at Lahoma (near Enid, OK) with no supplemental irrigation.

The grow-out at Goodwell produced grain yields in the 80-to-100 bu/ac range, in line with standard pre-plant fertilization practices targeting the 100 bu/ac yield level. Wheat protein content averaged 13.1% at Goodwell, which is consistent with historical trends at this site. Grain yields at Lahoma, on the other hand, exceeded the soil-fertility target of 60 bu/ac, averaging 68 bu/ac despite the heavy presence of stripe rust and physiological leaf spotting. Wheat protein averaged 11.5%. Fungicide was not applied at either location, and all OSU entries represented here, with the exception of Ruby Lee, provided effective resistance to the diseases present.

Entries included in the Oklahoma set constitute new submissions for WQC evaluation, with exception of the check, Billings, and Ruby Lee (released in 2011). Gallagher and Iba were more recently released in Spring 2012. All non-check entries have been tested in two years of the SRPN, though OK09634 is currently in its second year. Reactions to head scab are either unknown or scant at best. Ruby Lee and Iba may show moderately susceptible to susceptible reactions to head scab.

Billings (check)

This early maturing HRW variety has appeared in the Oklahoma sample set since 2007, first as the experimental line OK03522, and since 2010 as the Oklahoma check. Billings resulted from a single cross of a line developed by the Plant Breeding and Genetics Institute in Odessa, Ukraine called N566 and OK94P597 (=HBY3598/Fundulea 133//TAM 200). Large kernel size and superior yielding ability in 2012 reflected Billings' resistance to diseases prevalent in Oklahoma and surrounding states. Billings maintained a favorable reaction to stripe rust during three major epidemics in 2005, 2010, and 2012, apparently in the form of adult-plant resistance. Its resistance to leaf rust may be built on more tenuous grounds, postulated as *Lr17+Lr24*. The following represents the average of WQC evaluation data from 2007 to 2010: 34 mg/kernel, 61 lb/bu, 5 min farinograph development time, 19 min farinograph stability, and 368 alveograph W value. Billings consistently has shown excellent bran separation by its appealing cumulative ash curves, and its favorable dough strength is expressed as exceptional recovery of isolated gluten fractions from compressive deformation.

Ruby Lee (OK05526, OK05526-RHf)

Released in 2011 and positioned as an alternative to Billings in non-acidic areas, Ruby Lee was previously tested in the 2009 and 2010 WQC evaluations as OK05526 (KS94U275/OK94P549). The breeder-seed source of Ruby Lee was named OK05526-RHf to represent a single-plant F_9 selection from OK05526 with seedling resistance to Hf. In statewide variety trials Ruby Lee has shown top-end yield potential with no apparent drop in quality relative to Billings. In the spirit of multi-tasking, Ruby Lee combines cold tolerance with early maturity, high test weight with large kernel size, and good grazing tenacity with excellent milling and baking quality. Relative to Billings, it shows better cold and drought tolerance, improved grain yield in a dual-purpose system, greater tolerance to barley yellow dwarf, wider adaptation, but inferior protection against stripe rust.

Gallagher (OK07214) and **Iba** (OK07209)

Two half-sib progenies of Duster were co-developed and released in 2012, named Gallagher and Iba. They each provide strengths compared with Duster, only not the same ones. Two common improvements, however, are grain yield and kernel size. Breeder yield trials in 2012 revealed an 8% yield advantage for Iba and a 16% advantage for Gallagher over Duster. Greater separation for Gallagher in 2012 is attributable to better tolerance to stripe rust and earlier maturity. Long-term kernel size data reveal improvements over Duster of 2.2 mg kernel weight and 0.10 mm kernel diameter for Iba and 4.2 mg kernel weight and 0.18 mm kernel diameter for Gallagher. Agronomically, Gallagher exhibits better yield *protection* and specific adaptation, whereas Iba exhibits better yield *potential* with broad adaptation. Gallagher is considerably earlier than Iba, tolerates acidic soils, and is Hessian-fly resistant, whereas Iba matures similar to Duster, cannot tolerate acidic soils and Hessian fly, but carries an effective *Lr34* gene. Iba also features lower protein (0.5-1.0 percentage units) than Gallagher but greater protein strength.

OK09634

This HRW candidate with pedigree OK95616-98-6756/Overley is currently in the second year of SRPN testing. Yield records place it in the house of Gallagher and Iba, but OK09634 may have a higher yield ceiling than either one if conditions allow, especially across lower elevations of Oklahoma. No obvious weakness has been found in quality performance to deter its candidacy for release. Reactions for barley yellow dwarf, tan spot, stripe rust, and lodging are what we find attractive, but its maturity pattern is nearly overly early.

Oklahoma: 2012 (Small-Scale) Samples

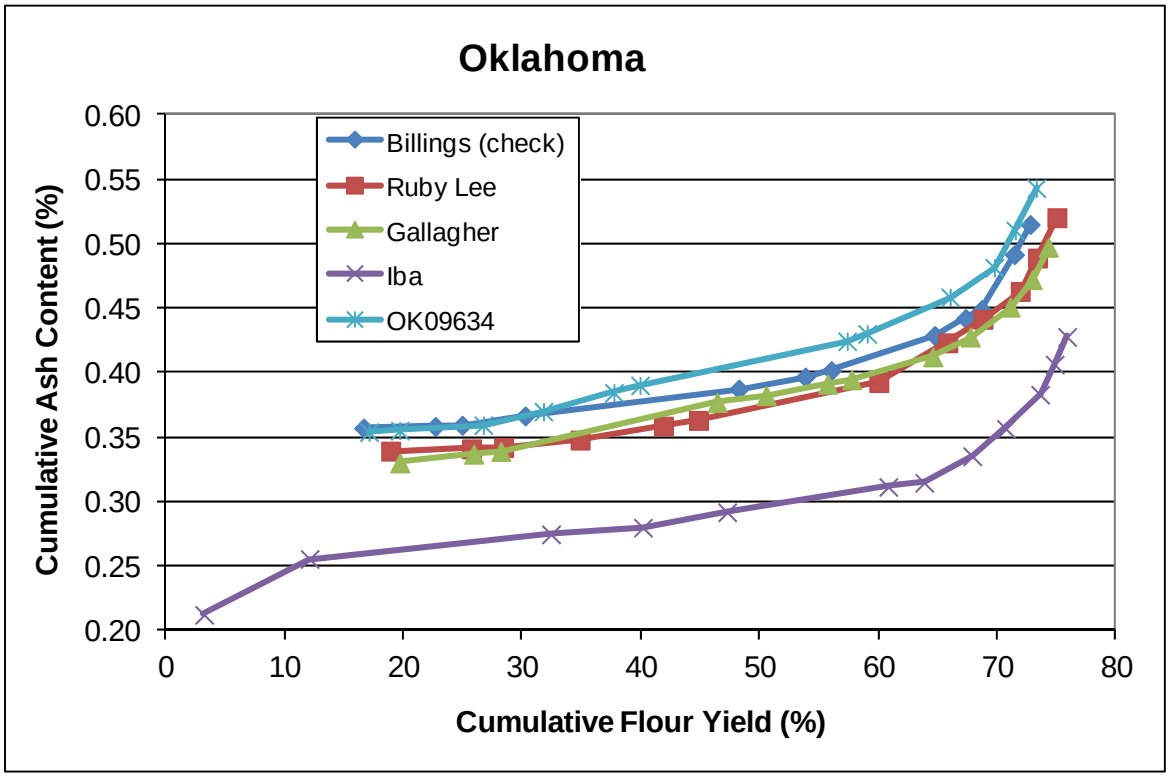
Test entry number	12-2411	12-2412	12-2413	12-2414	12-2415
Sample identification	**Billings (check)**	**Ruby Lee**	**Gallagher**	**Iba**	**OK09634**
Wheat Data					
GIPSA classification	1 HRW	1 HRW	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	62.8	59.2	62.7	62.9	60.6
Hectoliter weight (kg/hl)	82.6	77.9	82.4	82.7	79.7
1000 kernel weight (gm)	34.7	30.0	31.7	28.7	26.6
Wheat kernel size (Rotap)					
Over 7 wire (%)	73.1	68.9	70.3	64.6	54.6
Over 9 wire (%)	26.7	30.2	28.9	34.1	42.8
Through 9 wire (%)	0.2	0.9	0.7	1.3	2.6
Single kernel (skcs)[a]					
Hardness (avg /s.d)	78.9/13.7	66.5/17.3	85.5/14.1	66.2/17.2	76.1/16.1
Weight (mg) (avg/s.d)	34.7/10.1	30.0/9.3	31.7/8.4	28.7/8.3	26.6/7.2
Diameter (mm)(avg/s.d)	2.82/0.34	2.74/0.38	2.75/0.36	2.66/0.32	2.57/0.31
Moisture (%) (avg/s.d)	10.1/0.47	10.3/0.41	10.4/0.41	10.5/0.35	10.1/0.40
SKCS distribution	00-01-08-91-01	03-10-21-66-01	00-01-02-97-01	04-05-24-67-01	01-03-10-86-01
Classification	Hard	Hard	Hard	Hard	Hard
Wheat protein (12% mb)	12.4	11.7	11.7	11.2	13.4
Wheat ash (12% mb)	1.47	1.45	1.32	1.32	1.43
Milling and Flour Quality Data					
Flour yield (%, str. grade)					
Miag Multomat Mill	73.4	75.2	74.4	76.0	73.3
Quadrumat Sr. Mill	69.6	73.8	73.8	75.6	70.4
Flour moisture (%)	11.0	11.3	11.5	10.5	11.0
Flour protein (14% mb)	11.3	10.7	10.7	10.1	12.1
Flour ash (14% mb)	0.52	0.53	0.52	0.48	0.51
Rapid Visco-Analyser					
Peak time (min)	6.2	6.0	6.1	6.1	6.1
Peak viscosity (RVU)	179.4	192.6	176.3	208.3	198.7
Breakdown (RVU)	51.8	67.3	56.6	68.8	68.8
Final viscosity at 13 min (RVU)	240.2	241.1	224.9	258.6	238.3
Minolta color meter					
L*	91.8	91.8	92.06	91.8	91.9
a*	-0.78	-0.90	-1.28	-1.09	-1.04
b*	8.95	9.04	10.28	9.57	9.37
PPO	0.198	0.508	0.194	0.490	0.194
Falling number (sec)	523	509	517	511	490
Damaged Starch					
(AI%)	98.64	97.39	98.07	97.03	97.54
(AACC76-31)	8.48	7.40	7.98	7.09	7.52

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

Oklahoma: Physical Dough Tests and Gluten Analysis For 2012 (Small-Scale) Samples

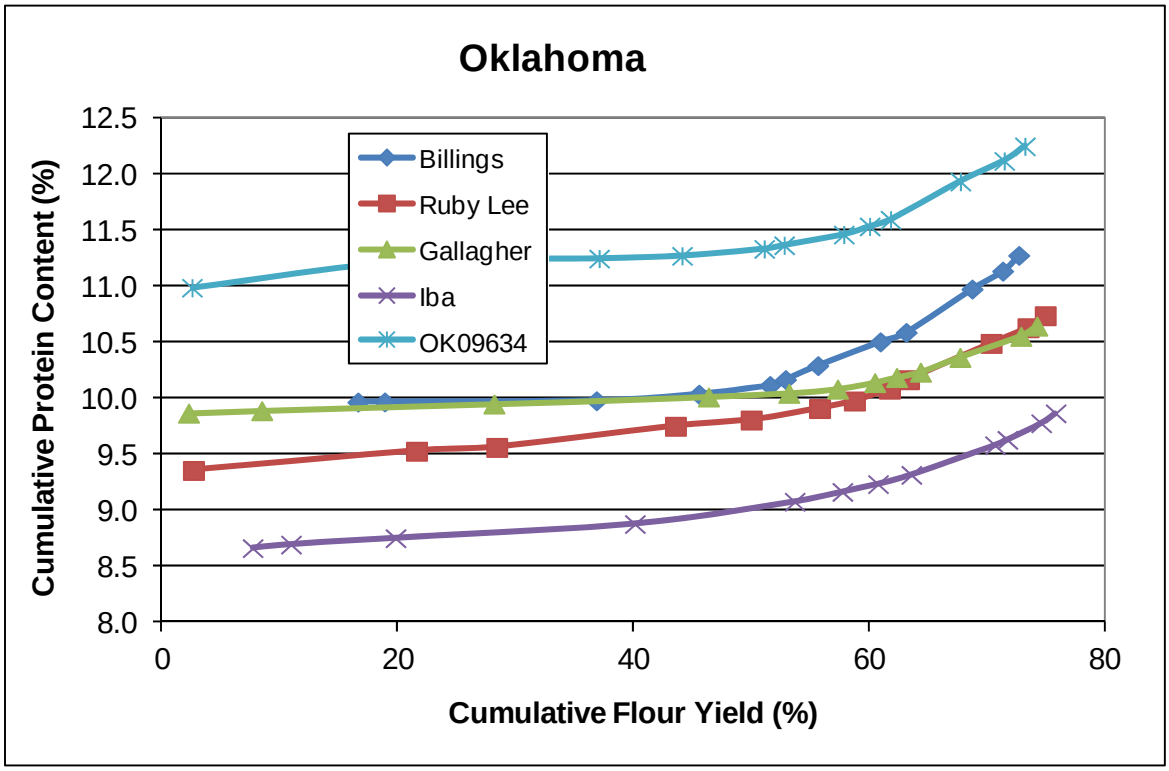
Test Entry Number	12-2411	12-2412	12-2413	12-2414	12-2415
Sample Identification	Billings (check)	Ruby Lee	Gallagher	Iba	OK09634
MIXOGRAPH					
Flour Abs (% as-is)	67.7	64.8	63.7	63.1	68.0
Flour Abs (14% mb)	64.3	61.8	60.9	59.2	64.6
Mix Time (min)	3.3	3.5	4.1	3.6	3.5
Mix tolerance (0-6)	3	4	3	2	3
FARINOGRAPH					
Flour Abs (% as-is)	69.9	63.8	66.8	63.0	66.1
Flour Abs (14% mb)	67.2	61.0	63.9	60.9	63.3
Development time (min)	5.5	5.8	6.0	5.2	6.2
Mix stability (min)	11.2	14.8	12.2	8.9	16.4
Mix Tolerance Index (FU)	32	24	25	37	21
Breakdown time (min)	9.6	12.0	11.9	8.6	14.0
ALVEOGRAPH					
P(mm): Tenacity	135	100	109	77	104
L(mm): Extensibility	84	105	86	100	117
G(mm): Swelling index	20.4	22.8	20.6	22.3	24.1
W(10^{-4} J): strength (curve area)	381	347	314	227	396
P/L: curve configuration ratio	1.61	0.95	1.27	0.77	0.89
Ie(P_{200}/P): elasticity index	54.4	57.6	54.6	49.4	60.3
EXTENSIGRAPH					
Resist (BU at 45/90/135 min)	312/354/368	346/407/456	283/389/434	222/329/364	310/437/480
Extensibility (mm at 45/90/135 min)	160/160/163	176/176/178	133/137/132	144/146/151	152/149/153
Energy (cm^2 at 45/90/135 min)	92/108/118	121/147/171	64/92/95	58/86/98	88/123/144
Resist $_{max}$ (BU at 45/90/135min)	430/520/551	520/645/760	357/524/561	302/454/498	452/656/767
Ratio (at 45/90/135 min)	1.95/2.21/2.26	1.97/2.31/2.56	2.13/2.85/3.28	1.54/2.26/2.41	2.05/2.93/3.14
PROTEIN ANALYSIS					
HMW-GS Composition	1, 7+9, 5+10	2*, 7+8, 2+12	2*, 7+9, 5+10	2*, 7+9, 5+10	2*,17+18, 5+10
%IPP	46.19	41.15	37.94	39.47	35.46
SEDIMENTATION TEST					
Volume (ml)	47.8	46.5	37.4	38.4	47.4

Oklahoma: Cumulative Ash Curves



Billings (check)					Ruby Lee					Gallagher (OK07214)					Iba (OK07209)					OK09634				
Mill	Strm-yld	Ash	Cumul (14%)		Mill	Strm-yld	Ash	Cumul (14%)		Mill	Strm-yld	Ash	Cumul (14%)		Mill	Strm-yld	Ash	Cumul (14%)		Mill	Strm-yld	Ash	Cumul (14%)	
Streams	(14%mb)		Yield	Ash	Streams	(14%mb)		Yield	Ash	Streams	(14%mb)		Yield	Ash	Streams	(14%mb)		Yield	Ash	Streams	(14%mb)		Yield	Ash
2M	16.7	0.36	16.7	0.36	2M	18.9	0.34	18.9	0.34	2M	19.7	0.33	19.7	0.33	1M Red	3.3	0.21	3.3	0.21	2M	17.1	0.35	17.1	0.35
1M	6.0	0.36	22.7	0.36	1M	6.8	0.35	25.7	0.34	1M	6.2	0.36	25.9	0.34	1M	8.9	0.27	12.1	0.26	1M Red	2.6	0.36	19.7	0.36
1M Red	2.3	0.37	25.0	0.36	1M Red	2.7	0.35	28.5	0.34	1M Red	2.3	0.36	28.2	0.34	2M	20.3	0.29	32.4	0.27	1M	7.0	0.37	26.7	0.36
1BK	5.3	0.40	30.3	0.37	1BK	6.4	0.37	34.9	0.35	3M	18.2	0.44	46.4	0.38	1BK	7.7	0.30	40.2	0.28	1BK	5.1	0.43	31.8	0.37
3M	18.0	0.42	48.2	0.39	2BK	7.0	0.41	41.9	0.36	1BK	4.1	0.44	50.6	0.38	2BK	7.1	0.36	47.3	0.29	2BK	5.9	0.46	37.7	0.38
2BK	5.6	0.48	53.8	0.40	Grader	3.0	0.43	44.9	0.36	2BK	5.2	0.48	55.7	0.39	3M	13.6	0.38	60.8	0.31	Grader	2.2	0.49	39.9	0.39
Grader	2.2	0.52	56.0	0.40	3M	15.2	0.48	60.0	0.39	Grader	2.0	0.49	57.8	0.39	Grader	3.0	0.38	63.9	0.31	3M	17.4	0.50	57.4	0.42
4M	8.7	0.60	64.7	0.43	4M	5.8	0.74	65.8	0.42	4M	6.8	0.56	64.6	0.41	4M	4.0	0.66	67.9	0.34	FILTER FLR	1.7	0.63	59.1	0.43
3BK	2.6	0.77	67.3	0.44	FILTER FLR	3.0	0.85	68.8	0.44	FILTER FLR	3.2	0.74	67.7	0.43	FILTER FLR	2.8	0.87	70.7	0.36	4M	7.0	0.70	66.0	0.46
BRAN FLR	1.4	0.79	68.7	0.45	3BK	3.1	0.94	71.9	0.46	3BK	3.4	0.92	71.1	0.45	3BK	2.9	1.04	73.6	0.38	3BK	3.7	0.89	69.8	0.48
5M	2.7	1.56	71.4	0.49	BRAN FLR	1.5	1.76	73.4	0.49	5M	1.9	1.29	73.0	0.47	BRAN FLR	1.2	1.82	74.8	0.41	BRAN FLR	1.8	1.66	71.5	0.51
FILTER FLR	1.3	1.77	72.8	0.51	5M	1.6	1.94	75.0	0.52	BRAN FLR	1.4	1.84	74.3	0.50	5M	1.1	1.94	75.9	0.43	5M	1.8	1.86	73.3	0.54
Break Shorts	4.0	3.18	76.8	0.66	Break Shorts	3.4	3.52	78.4	0.65	Break Shorts	3.5	2.80	77.8	0.60	Break Shorts	3.1	3.62	78.9	0.55	Break Shorts	3.8	3.25	77.1	0.68
Red Dog	2.5	2.85	79.3	0.72	Red Dog	2.5	2.88	80.8	0.72	Red Dog	2.3	2.50	80.1	0.66	Red Dog	1.9	2.70	80.9	0.60	Red Dog	2.5	2.86	79.5	0.74
Red Shorts	0.3	4.27	79.6	0.74	Red Shorts	0.3	3.97	81.1	0.73	Red Shorts	0.2	3.96	80.3	0.66	Red Shorts	0.1	3.72	81.0	0.61	Red Shorts	0.3	3.99	79.8	0.75
Filter Bran	1.0	2.83	80.6	0.76	Filter Bran	1.4	2.02	82.5	0.75	Filter Bran	1.4	1.81	81.7	0.68	Filter Bran	1.4	2.21	82.3	0.63	Filter Bran	1.3	1.55	81.1	0.77
Bran	19.4	4.88	100.0	1.56	Bran	17.5	4.55	100.0	1.41	Bran	18.3	4.53	100.0	1.39	Bran	17.7	4.76	100.0	1.36	Bran	18.9	4.72	100.0	1.51
Wheat		1.44			Wheat		1.42			Wheat		1.29			Wheat		1.29			Wheat		1.40		
St. Grd. Fl.		0.52			St. Grd. Fl.		0.53			St. Grd. Fl.		0.52			St. Grd. Fl.		0.48			St. Grd. Fl.		0.51		

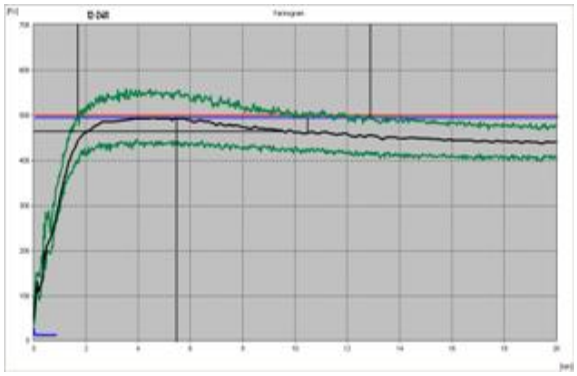
Oklahoma: Cumulative Protein Curves



Billings (check)					Ruby Lee					Gallagher (OK07214)					Iba (OK07214)					OK09634				
Mill	Strm-yld	Protein	Cumulative (14%)		Mill	Strm-yld	Protein	Cumulative (14%)		Mill	Strm-yld	Protein	Cumulative (14%)		Mill	Strm-yld	Protein	Cumulative (14%)		Mill	Strm-yld	Protein	Cumulative (14%)	
Streams	(14%mb)		Yield	Protein	Streams	(14%mb)		Yield	Protein	Streams	(14%mb)		Yield	Protein	Streams	(14%mb)		Yield	Protein	Streams	(14%mb)		Yield	Protein
2M	16.7	10.0	16.7	10.0	1M	2.7	9.4	2.7	9.4	1M Red	2.3	9.9	2.3	9.9	1BK	7.7	8.7	7.7	8.7	1M Red	2.6	11.0	2.6	11.0
1M Red	2.3	10.0	18.9	10.0	2M	18.9	9.6	21.6	9.5	1M	6.2	9.9	8.5	9.9	1M Red	3.3	8.8	11.0	8.7	3M	17.4	11.2	20.0	11.2
3M	18.0	10.0	36.9	10.0	1M Red	6.8	9.7	28.5	9.6	2M	19.7	10.0	28.2	9.9	1M	8.9	8.8	19.9	8.7	2M	17.1	11.3	37.2	11.2
4M	8.7	10.3	45.6	10.0	3M	15.2	10.1	43.6	9.7	3M	18.2	10.1	46.4	10.0	2M	20.3	9.0	40.2	8.9	1M	7.0	11.4	44.2	11.3
1M	6.0	10.7	51.6	10.1	1BK	6.4	10.2	50.1	9.8	4M	6.8	10.3	53.3	10.0	3M	13.6	9.7	53.8	9.1	4M	7.0	11.7	51.2	11.3
FILTER FLR	1.3	12.2	53.0	10.2	4M	5.8	10.8	55.9	9.9	1BK	4.1	10.6	57.4	10.1	4M	4.0	10.3	57.8	9.2	FILTER FLR	1.7	12.3	52.9	11.4
5M	2.7	12.7	55.7	10.3	Grader	3.0	11.2	58.8	10.0	FILTER FLR	3.2	11.2	60.5	10.1	Grader	3.0	10.6	60.8	9.2	1BK	5.1	12.5	57.9	11.5
1BK	5.3	12.7	61.0	10.5	FILTER FLR	3.0	12.2	61.8	10.1	5M	1.9	11.7	62.4	10.2	FILTER FLR	2.8	11.1	63.7	9.3	Grader	2.2	13.4	60.1	11.5
Grader	2.2	12.9	63.2	10.6	5M	1.6	13.4	63.4	10.2	Grader	2.0	11.7	64.4	10.2	2BK	7.1	12.0	70.8	9.6	5M	1.8	13.6	61.9	11.6
2BK	5.6	15.3	68.8	11.0	2BK	7.0	13.4	70.4	10.5	3BK	3.4	12.9	67.8	10.4	5M	1.1	12.9	71.8	9.6	2BK	5.9	15.5	67.8	11.9
3BK	2.6	15.4	71.4	11.1	3BK	3.1	13.8	73.6	10.6	2BK	5.2	13.0	72.9	10.5	3BK	2.9	13.5	74.7	9.8	3BK	3.7	15.5	71.5	12.1
BRAN FLR	1.4	18.6	72.8	11.3	BRAN FLR	1.5	16.1	75.0	10.7	BRAN FLR	1.4	15.5	74.3	10.6	BRAN FLR	1.2	15.3	75.9	9.9	BRAN FLR	1.8	17.5	73.3	12.2
Break Shorts	4.0	13.3	76.8	11.4	Break Shorts	3.4	14.2	78.4	10.9	Break Shorts	3.5	12.6	77.8	10.7	Break Shorts	3.1	13.9	78.9	10.0	Break Shorts	3.8	14.4	77.1	12.4
Red Dog	2.5	13.4	79.3	11.4	Red Dog	2.5	12.8	80.8	10.9	Red Dog	2.3	12.3	80.1	10.8	Red Dog	1.9	12.4	80.9	10.1	Red Dog	2.5	13.4	79.5	12.4
Red Shorts	0.3	13.8	79.6	11.4	Red Shorts	0.3	13.7	81.1	11.0	Red Shorts	0.2	12.6	80.3	10.8	Red Shorts	0.1	12.8	81.0	10.1	Red Shorts	0.3	14.0	79.8	12.4
Filter Bran	1.0	11.5	80.6	11.5	Filter Bran	1.4	11.0	82.5	11.0	Filter Bran	1.4	10.5	81.7	10.8	Filter Bran	1.4	10.8	82.3	10.1	Filter Bran	1.3	12.2	81.1	12.4
Bran	19.4	16.8	100.0	12.5	Bran	17.5	16.2	100.0	11.9	Bran	18.3	14.7	100.0	11.5	Bran	17.7	14.9	100.0	10.9	Bran	18.9	17.4	100.0	13.3
Wheat		12.1			Wheat		11.4			Wheat		11.4			Wheat		11.0			Wheat		13.1		
St. Grd. Fl.		11.3			St. Grd. Fl.		10.7			St. Grd. Fl.		10.7			St. Grd. Fl.		10.1			St. Grd. Fl.		12.1		

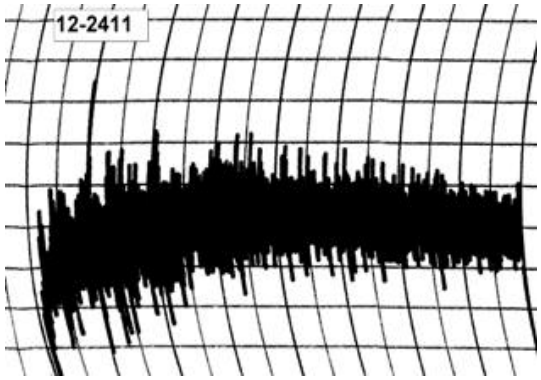
Physical Dough Tests
2012 (Small Scale) Samples - Oklahoma

Farinograms



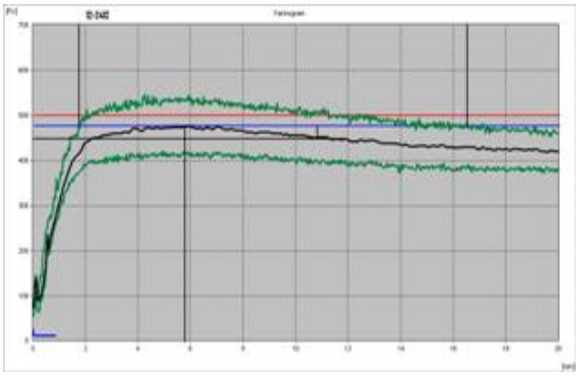
Water abs = 67.2%, Peak time = 5.5 min,
Mix stab = 11.2 min, MTI = 32 FU

Mixograms

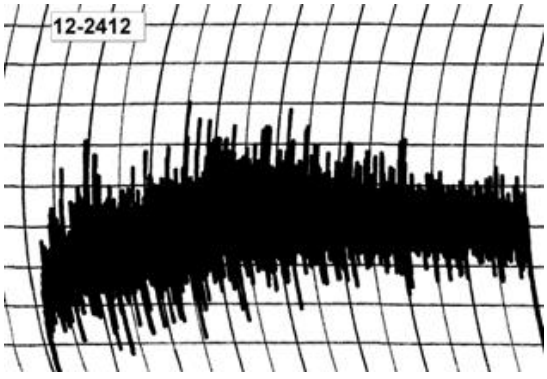


Water abs = 64.3%
Mix time = 3.3 min

12-2411, Billings (check)



Water abs = 61.0%, Peak time = 5.8 min,
Mix stab = 14.8 min, MTI = 24 FU



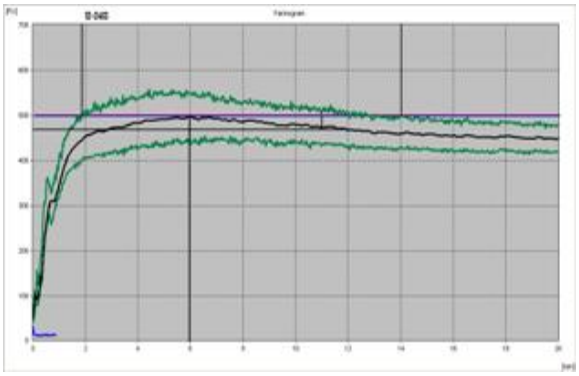
Water abs = 61.8%
Mix time = 3.5 min

12-2412, Ruby Lee

Physical Dough Tests

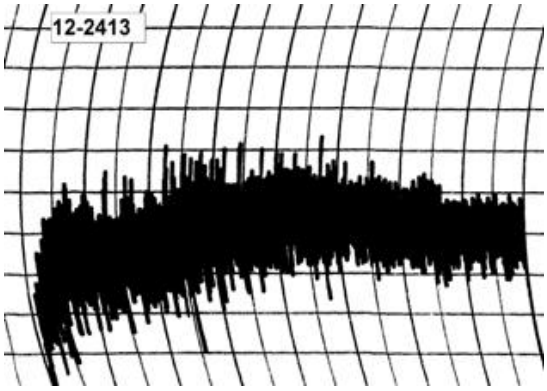
2012 (Small Scale) Samples - Oklahoma (continued)

Farinograms



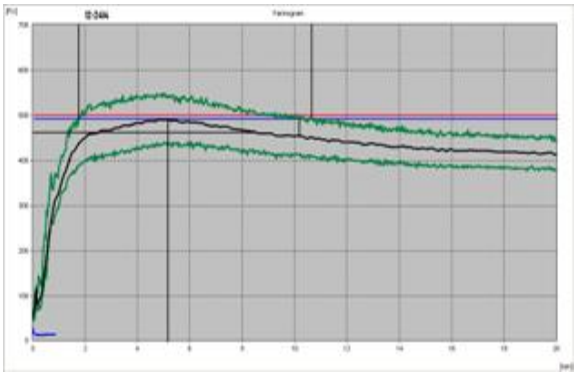
Water abs= 63.9%, Peak time = 6.0 min,
Mix stab = 12.2 min, MTI = 25 FU

Mixograms

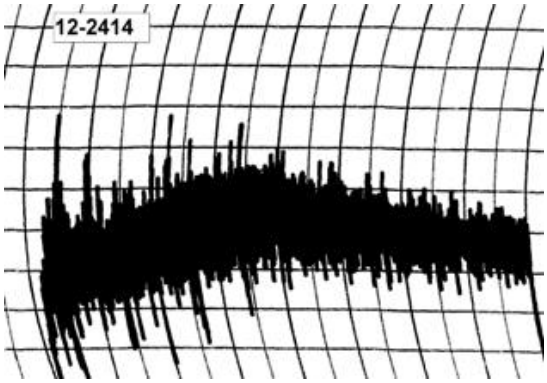


Water abs = 60.9%
Mix time = 4.1 min

12-2413, Gallagher (OK07214)



Water abs= 60.9%, Peak time = 5.2 min,
Mix stab = 8.9 min, MTI = 37 FU



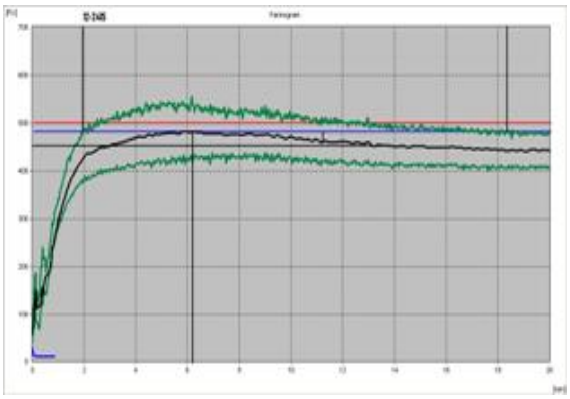
Water abs = 59.2%
Mix time = 3.6 min

12-2414, Iba (OK07209)

Physical Dough Tests

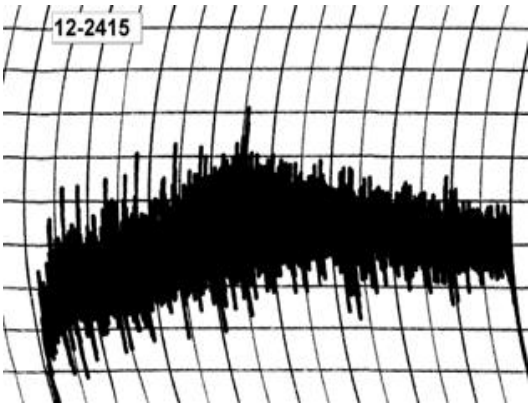
2012 (Small Scale) Samples - Oklahoma (continued)

Farinograms



Water abs= 63.3%, Peak time = 6.2 min,
Mix stab = 16.4 min, MTI = 21 FU

Mixograms

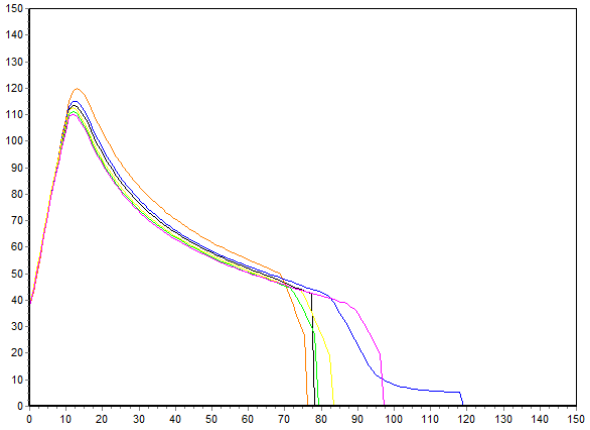


Water abs = 64.6%
Mix time = 3.5 min

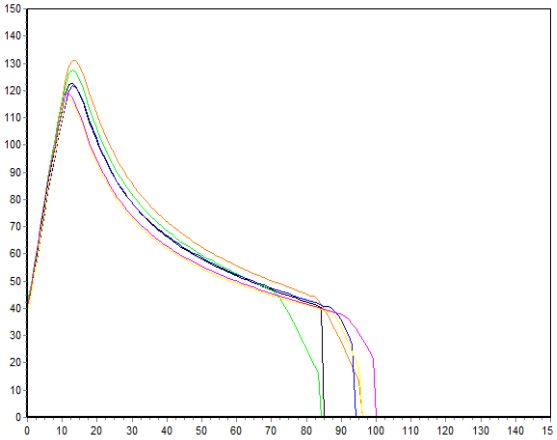
12-2415, OK09634

Physical Dough Tests - Alveograph

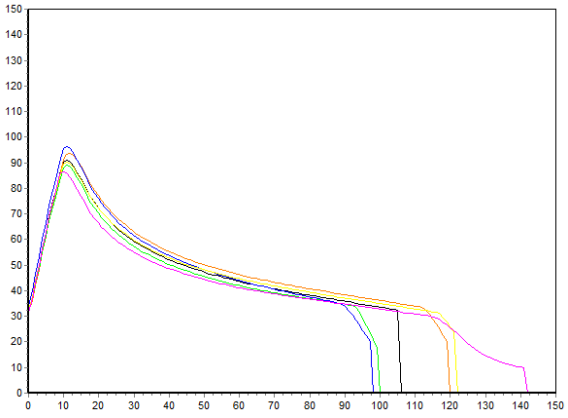
2012 (Small Scale) Samples – Oklahoma



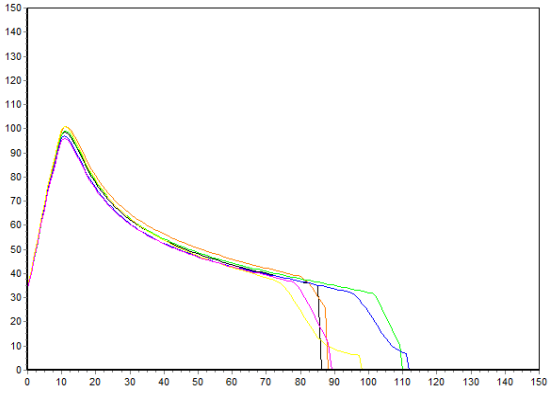
12-2411, Billings (check)
P(mm H_20)=135, L(mm)=84, W(10E^{-4} J)=381



12-2412, Ruby Lee
P(mm H_20)=100, L(mm)=105, W(10E^{-4} J)=347



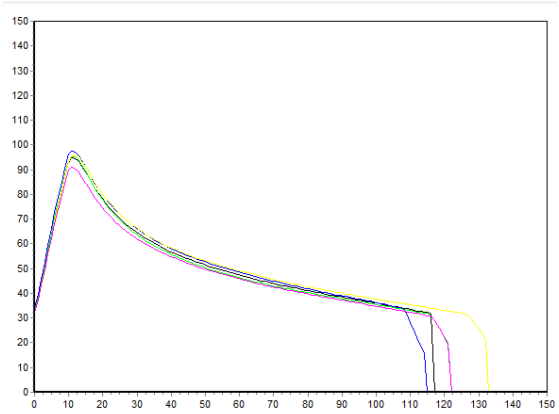
12-2413, Gallagher
P(mm H_20)=109, L(mm)=86, W(10E^{-4} J)=314



12-2414, Iba
P(mm H_20)=77, L(mm)=100, W(10E^{-4} J)=227

Physical Dough Tests - Alveograph

2012 (Small Scale) Samples – Oklahoma

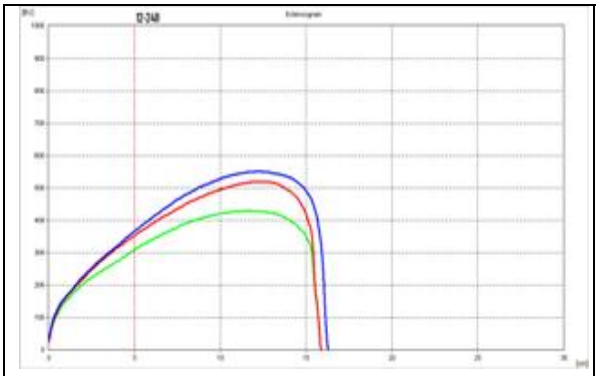


12-2415, OK09634

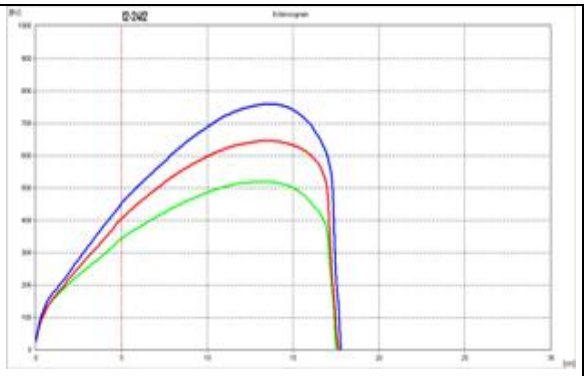
P(mm H_20)=104, L(mm)=117, W($10E^{-4}$ J)=396

Physical Dough Tests - Extensigraph

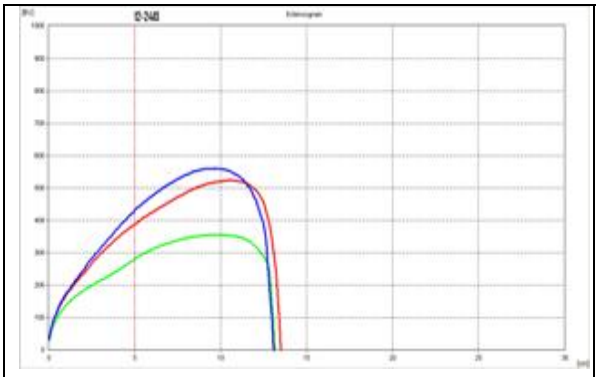
2012 (Small Scale) Samples – Oklahoma



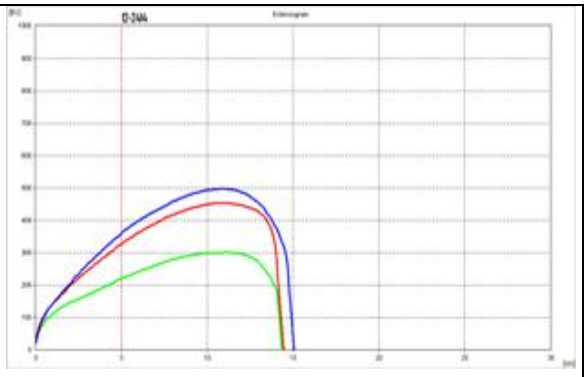
Billings (check) -2411
R (BU) = 354, E (mm) =160, W (cm^2) = 108
Rmax (BU) = 520, Ratio = 2.2 at 90 min



Ruby Lee - 2412
R (BU) = 407, E (mm) =176, W (cm^2) = 147
Rmax (BU) = 645, Ratio = 2.3 at 90 min



Gallagher - 2413
R (BU) = 389, E (mm) =137, W (cm^2) = 92
Rmax (BU) = 524, Ratio = 2.9 at 90 min

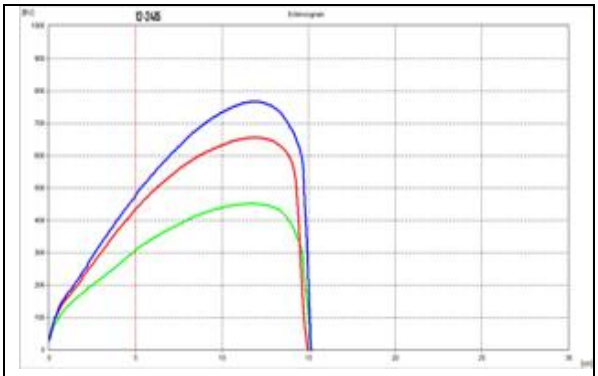


Iba - 2414
R (BU) = 329, E (mm) =146, W (cm^2) = 86
Rmax (BU) = 454, Ratio = 2.3 at 90 min

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

2012 (Small Scale) Samples – Oklahoma

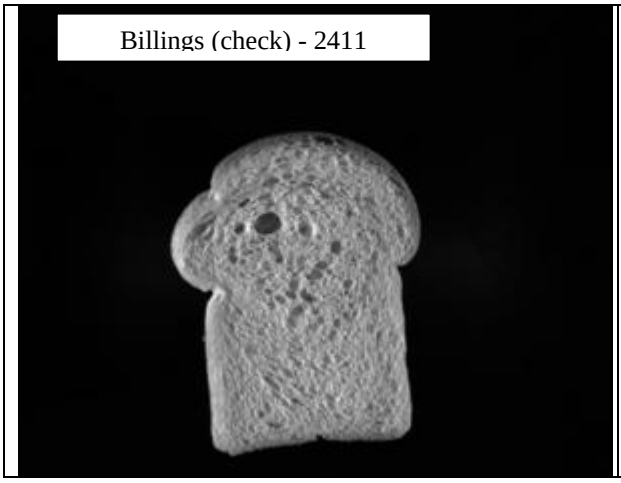


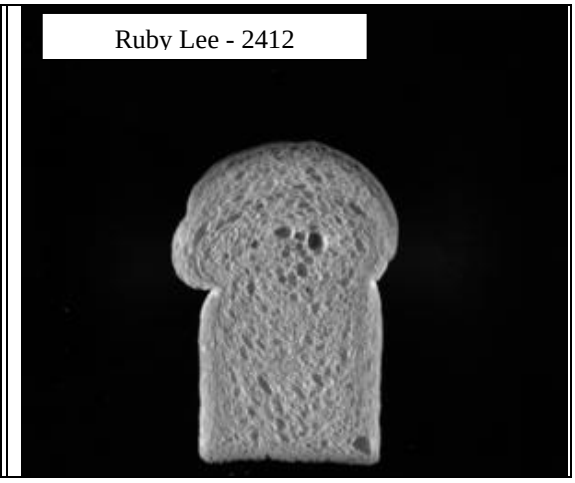
OK09634 -2415

R (BU) = 437, E (mm) =149, W (cm^2) = 123

Rmax (BU) = 656, Ratio = 2.9 at 90 min

Oklahoma: C-Cell Bread Images and Analysis for 2012 (Small-Scale) Samples



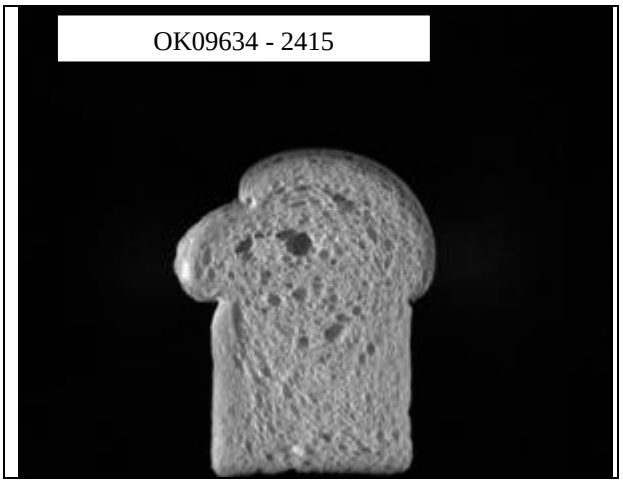


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2411	5902	134.0	3771	0.442	1.976	4.950	1.705	-8.25
2412	5880	133.4	3812	0.439	1.883	3.420	1.685	-12.50

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	5358	136.1	3482	0.442	1.959	1.907	1.720	-4.70
2414	5521	135.9	3902	0.424	1.759	0.492	1.700	-11.10

Oklahoma: C-Cell Bread Images and Analysis for

2012 (Small-Scale) Samples



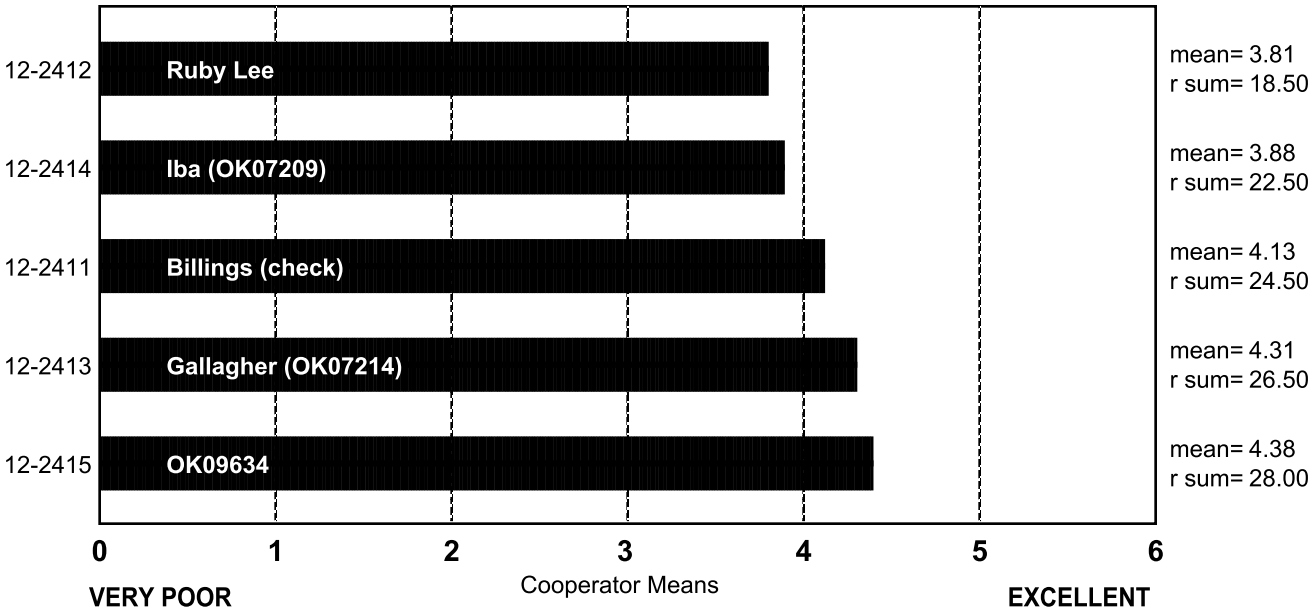
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2415	5678	138.6	3596	0.441	2.026	4.453	1.736	-13.00

SPONGE CHARACTERISTICS

(Small Scale) Oklahoma

ncoop= 8
chisq= 2.75
chisqc= 3.70
cvchisq= 9.49
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

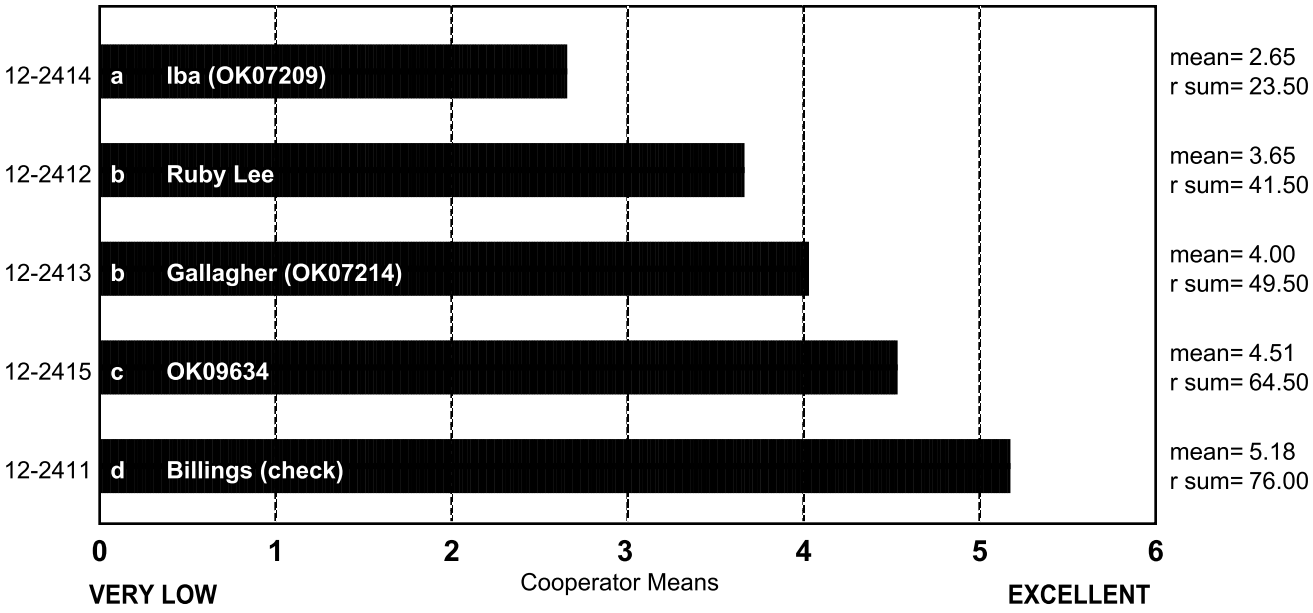


BAKE ABSORPTION

(Small Scale) Oklahoma

ncoop= 17
chisq= 38.96
chisqc= 44.46
cvchisq= 9.49
crdiff= 10.51

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Oklahoma

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2411 Billings (check)	**67.1**	**62.0**	**62.6**	**64.3**	**67.0**	**58.0**	**67.2**	**69.9**	**66.0**	**67.7**	**63.3**	**64.3**	**67.2**	**64.0**	**61.0**	**67.0**	**62.5**
12-2412 Ruby Lee	**64.1**	**60.0**	**61.0**	**64.5**	**61.0**	**57.0**	**61.0**	**64.2**	**61.0**	**65.1**	**57.5**	**60.7**	**61.0**	**62.0**	**60.0**	**62.9**	**59.5**
12-2413 Gallagher (OK07214)	**63.1**	**59.0**	**62.2**	**63.3**	**64.0**	**57.0**	**63.9**	**68.2**	**63.0**	**63.3**	**60.6**	**61.9**	**63.9**	**63.0**	**60.0**	**63.4**	**60.5**
12-2414 Iba (OK07209)	**61.1**	**59.0**	**58.1**	**61.9**	**61.0**	**57.0**	**60.9**	**63.8**	**61.0**	**60.6**	**56.0**	**56.8**	**60.9**	**60.0**	**60.0**	**62.4**	**58.0**
12-2415 OK09634	**67.1**	**63.0**	**64.6**	**67.3**	**63.5**	**59.0**	**63.3**	**67.2**	**63.0**	**64.7**	**59.4**	**63.3**	**63.3**	**64.0**	**62.0**	**66.8**	**61.5**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Oklahoma

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2411 Billings (check)	**3.3**	**9.0**	**3.8**	**3.3**	**5.5**	**20.0**	**10.0**	**3.5**	**25.0**	**3.1**	**2.0**	**5.0**	**7.0**	**4.0**	**6.0**	**4.7**	**25.0**
12-2412 Ruby Lee	**3.5**	**8.0**	**4.5**	**3.5**	**6.0**	**20.0**	**8.0**	**4.3**	**25.0**	**5.7**	**2.5**	**5.8**	**7.0**	**4.0**	**6.0**	**5.6**	**15.0**
12-2413 Gallagher (OK07214)	**4.0**	**5.0**	**4.0**	**4.1**	**6.0**	**7.0**	**8.0**	**3.2**	**16.0**	**3.9**	**2.3**	**5.0**	**6.0**	**4.0**	**3.0**	**4.4**	**14.0**
12-2414 Iba (OK07209)	**2.5**	**3.0**	**3.5**	**3.6**	**5.0**	**8.0**	**8.0**	**3.2**	**11.0**	**3.1**	**2.3**	**5.5**	**4.0**	**4.0**	**6.0**	**4.5**	**6.0**
12-2415 OK09634	**3.3**	**6.0**	**3.8**	**3.5**	**6.0**	**8.0**	**8.0**	**3.2**	**25.0**	**4.1**	**2.5**	**4.8**	**6.0**	**5.0**	**6.0**	**4.4**	**14.0**

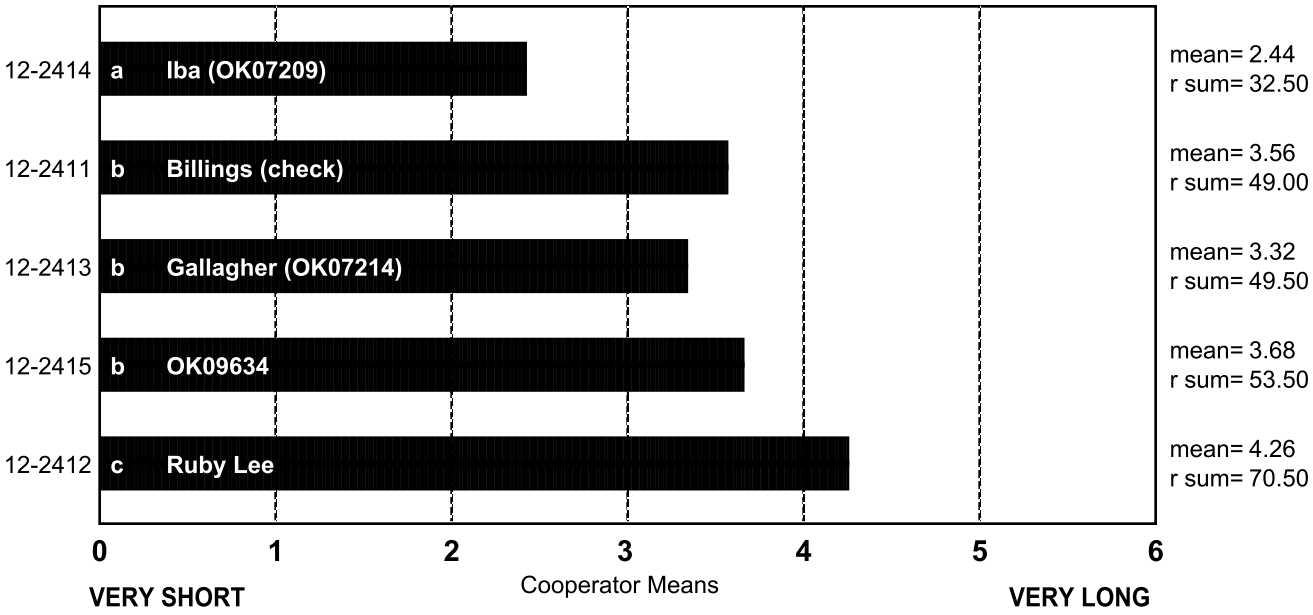
Raw Data

BAKE MIX TIME

(Small Scale) Oklahoma

ncoop= 17
chisq= 17.29
chisqc= 22.62
cvchisq= 9.49
crdiff= 13.63

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

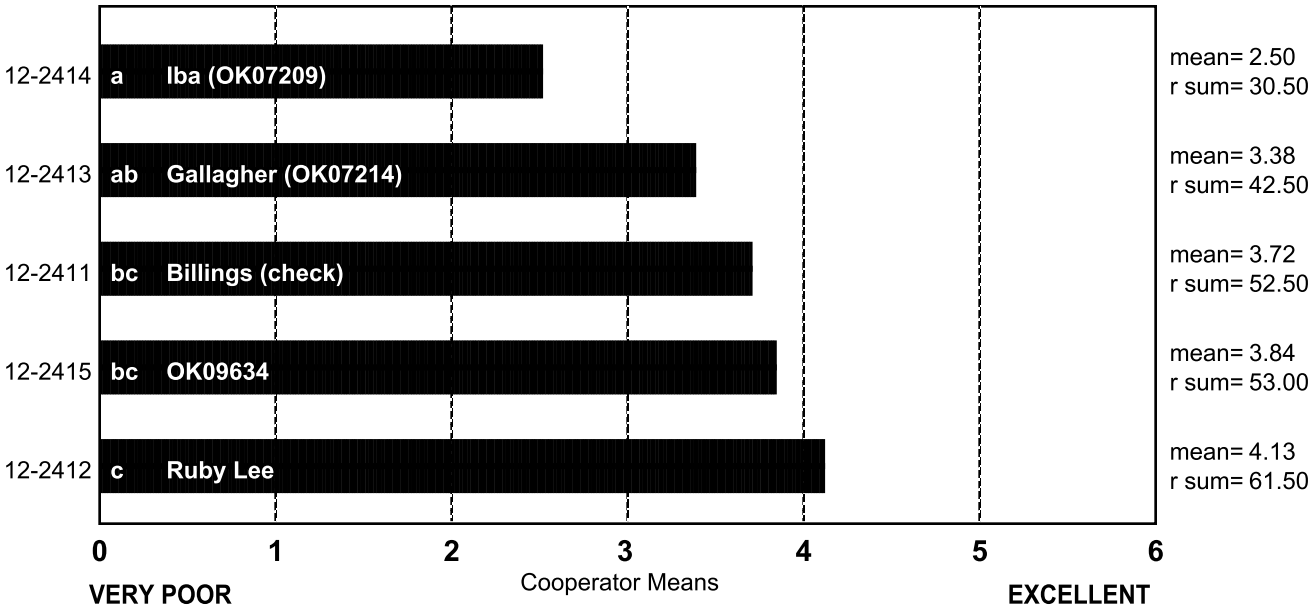


MIXING TOLERANCE

(Small Scale) Oklahoma

ncoop= 16
chisq= 14.10
chisqc= 18.19
cvchisq= 9.49
crdiff= 13.81

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

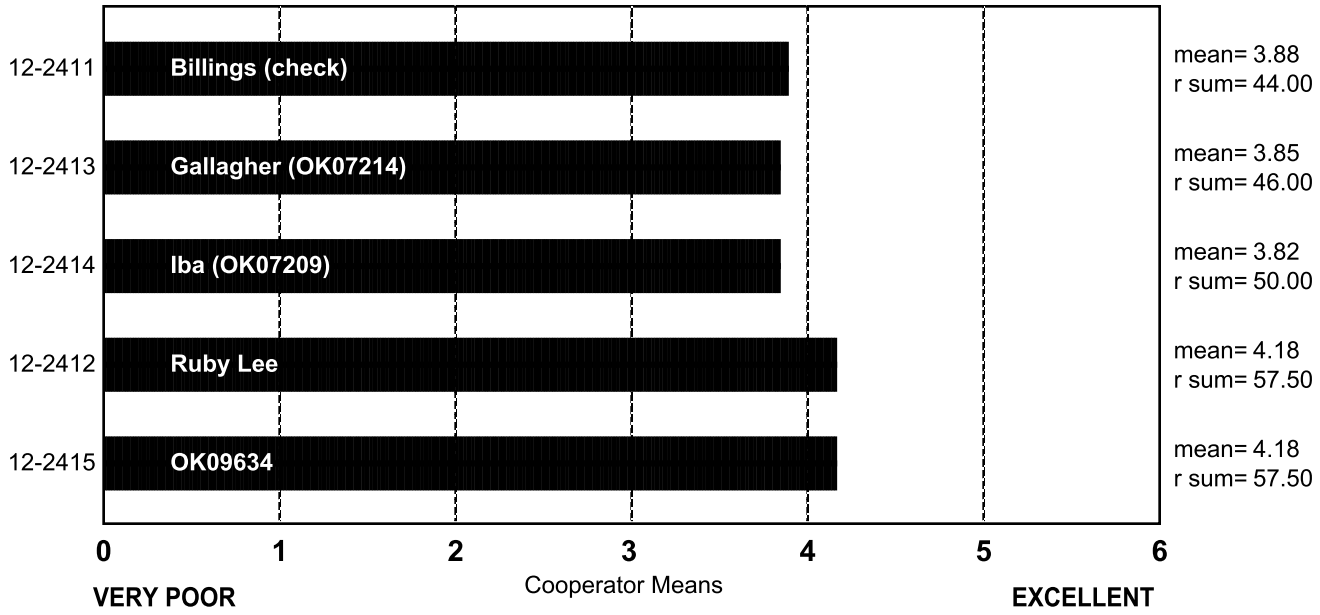


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Oklahoma

ncoop= 17
chisq= 3.75
chisqc= 5.75
cvchisq= 9.49
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'OUT OF MIXER', DESCRIBED

(Small Scale) Oklahoma

	Sticky	Wet	Tough	Good	Excellent
12-2411 Billings (check)	**2**	**0**	**5**	**10**	**0**
12-2412 Ruby Lee	**0**	**0**	**3**	**13**	**1**
12-2413 Gallagher (OK07214)	**3**	**1**	**2**	**11**	**0**
12-2414 Iba (OK07209)	**5**	**1**	**0**	**10**	**1**
12-2415 OK09634	**3**	**1**	**0**	**13**	**0**

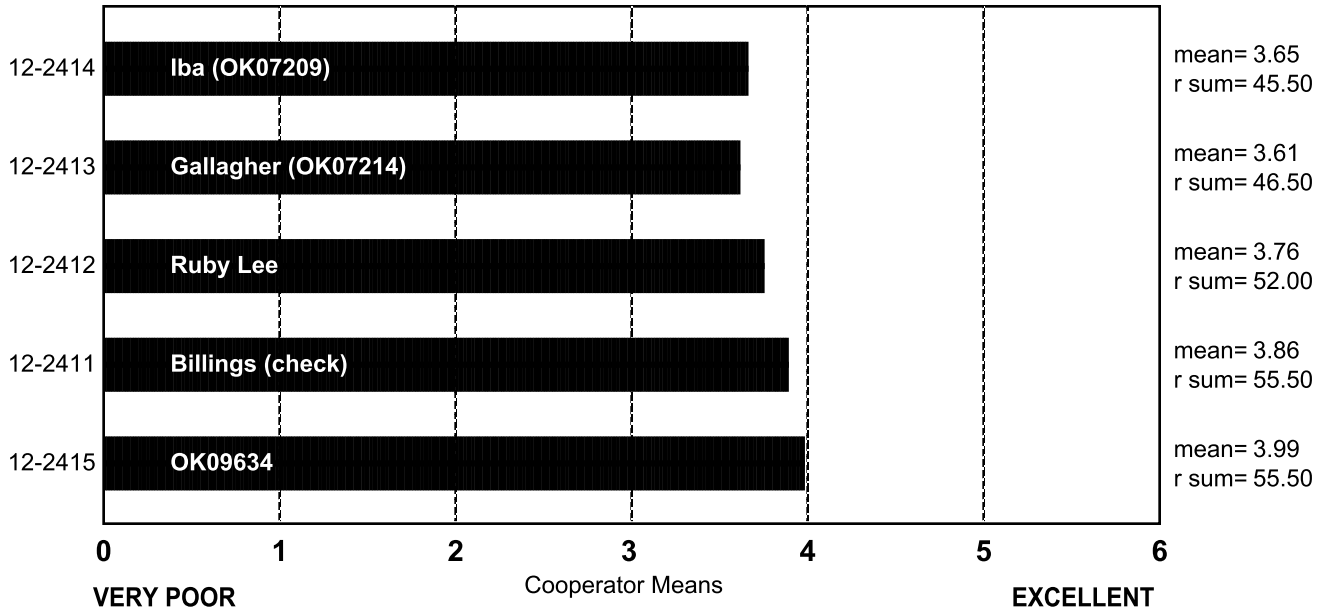
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Oklahoma

ncoop= 17
chisq= 2.16
chisqc= 3.19
cvchisq= 9.49
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) Oklahoma

	Sticky	Wet	Tough	Good	Excellent
12-2411 Billings (check)	**2**	**1**	**4**	**8**	**2**
12-2412 Ruby Lee	**1**	**0**	**4**	**11**	**1**
12-2413 Gallagher (OK07214)	**1**	**2**	**1**	**12**	**1**
12-2414 Iba (OK07209)	**4**	**1**	**0**	**11**	**1**
12-2415 OK09634	**1**	**1**	**1**	**13**	**1**

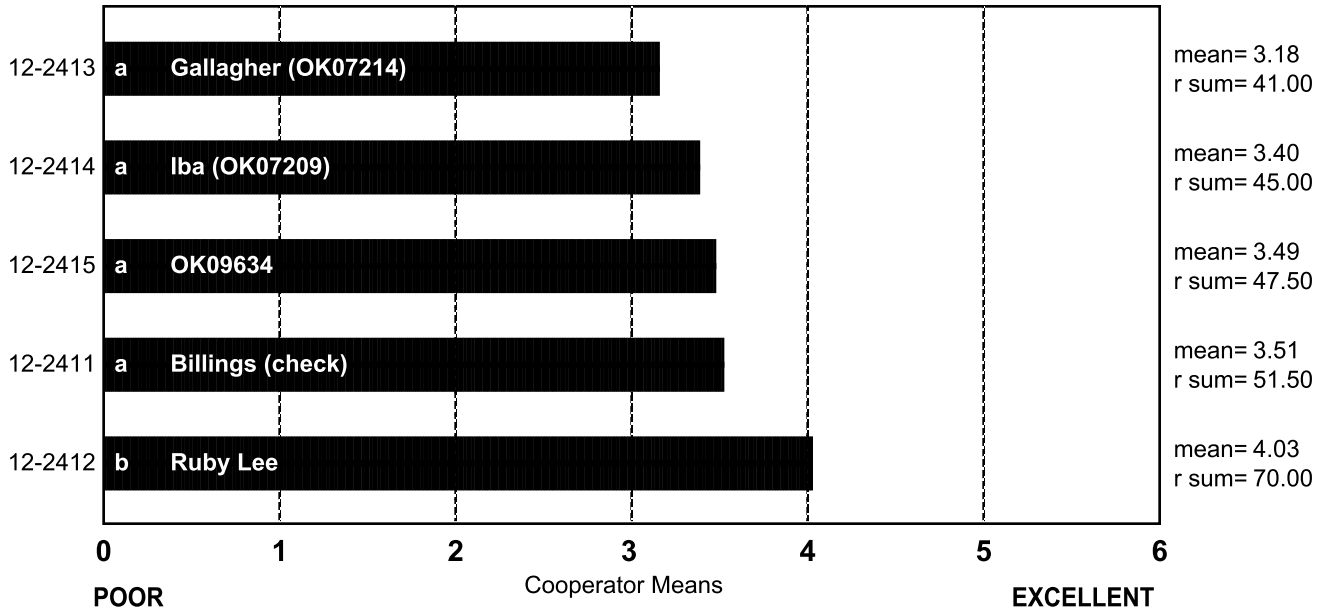
Frequency Table

CRUMB GRAIN

(Small Scale) Oklahoma

ncoop= 17
chisq= 11.99
chisqc= 16.44
cvchisq= 9.49
crdiff= 14.18

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB GRAIN, DESCRIBED

(Small Scale) Oklahoma

	Open	Fine	Dense
12-2411 Billings (check)	9	7	1
12-2412 Ruby Lee	5	12	0
12-2413 Gallagher (OK07214)	12	4	1
12-2414 Iba (OK07209)	8	7	2
12-2415 OK09634	8	7	2

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Oklahoma

	Round	Irregular	Elongated
12-2411 Billings (check)	**3**	**9**	**5**
12-2412 Ruby Lee	**3**	**9**	**5**
12-2413 Gallagher (OK07214)	**6**	**8**	**3**
12-2414 Iba (OK07209)	**7**	**7**	**3**
12-2415 OK09634	**3**	**8**	**6**

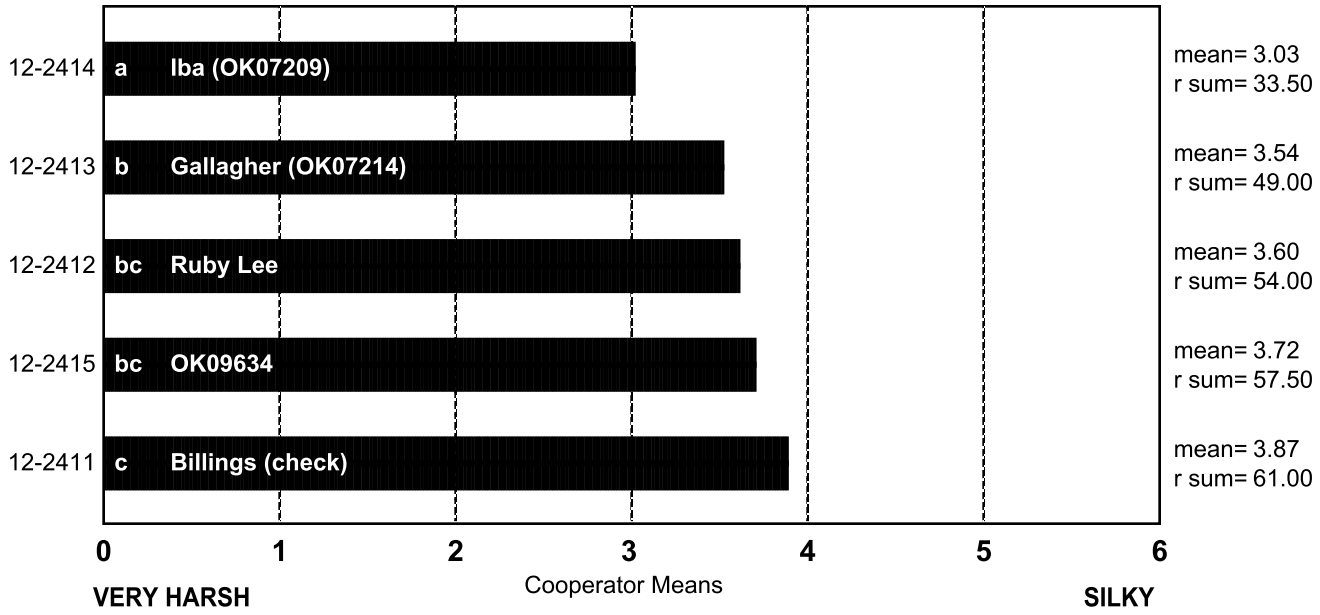
Frequency Table

CRUMB TEXTURE

(Small Scale) Oklahoma

ncoop= 17
chisq= 10.86
chisqc= 17.84
cvchisq= 9.49
crdiff= 11.92

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB TEXTURE, DESCRIBED

(Small Scale) Oklahoma

	Harsh	Smooth	Silky
12-2411 Billings (check)	**2**	**12**	**3**
12-2412 Ruby Lee	**5**	**9**	**3**
12-2413 Gallagher (OK07214)	**3**	**13**	**1**
12-2414 Iba (OK07209)	**7**	**10**	**0**
12-2415 OK09634	**2**	**9**	**6**

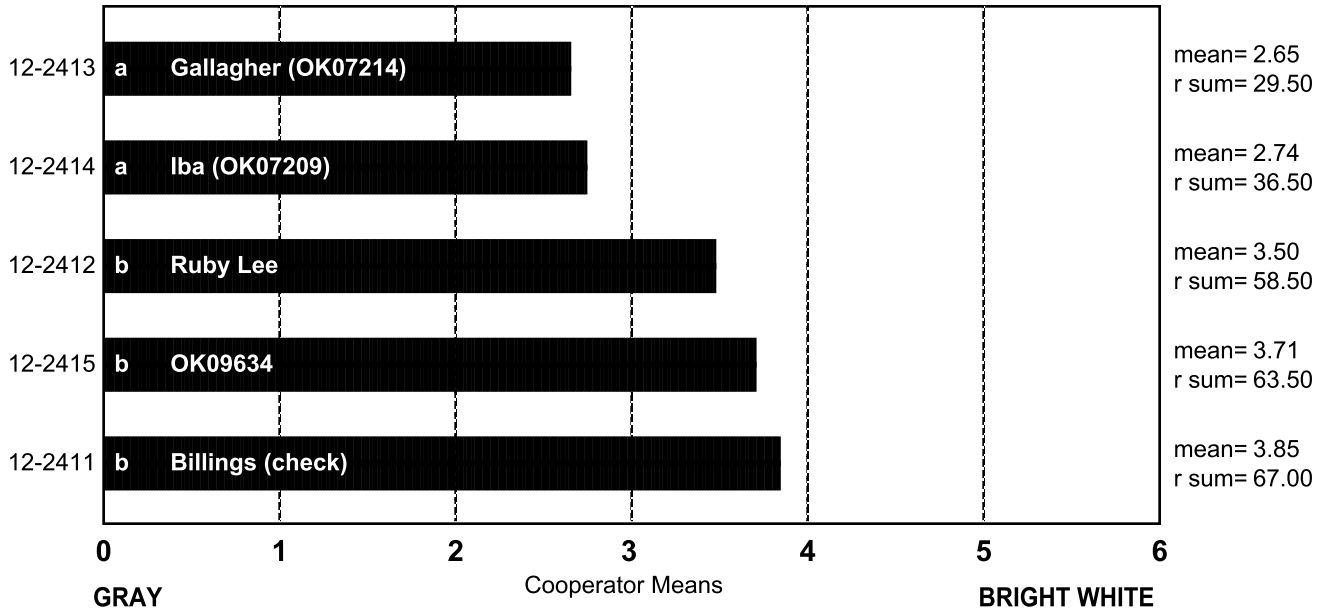
Frequency Table

CRUMB COLOR

(Small Scale) Oklahoma

ncoop= 17
chisq= 26.85
chisqc= 35.11
cvchisq= 9.49
crdiff= 11.60

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB COLOR, DESCRIBED

(Small Scale) Oklahoma

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
12-2411 Billings (check)	**0**	**0**	**3**	**3**	**8**	**3**	**0**
12-2412 Ruby Lee	**0**	**0**	**2**	**7**	**6**	**2**	**0**
12-2413 Gallagher (OK07214)	**0**	**1**	**8**	**3**	**5**	**0**	**0**
12-2414 Iba (OK07209)	**1**	**1**	**6**	**6**	**3**	**0**	**0**
12-2415 OK09634	**0**	**0**	**2**	**7**	**4**	**4**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Oklahoma

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2411 Billings (check)	**178.0**	**464.5**	**141.3**	**144.2**	**479.5**	**416.0**	**669.0**	**132.1**	**480.1**	**157.4**	**135.4**	**150.8**	**452.2**	**484.3**	**134.0**	**146.4**	**461.3**
12-2412 Ruby Lee	**177.0**	**463.7**	**138.2**	**143.7**	**482.0**	**406.0**	**470.0**	**127.3**	**480.7**	**154.2**	**130.5**	**148.7**	**451.3**	**484.9**	**134.0**	**142.2**	**461.4**
12-2413 Gallagher (OK07214)	**176.0**	**466.3**	**141.1**	**143.9**	**484.5**	**412.0**	**469.0**	**131.6**	**479.2**	**153.1**	**132.4**	**151.4**	**450.1**	**482.8**	**134.0**	**146.9**	**459.2**
12-2414 Iba (OK07209)	**175.0**	**466.8**	**139.9**	**142.0**	**485.5**	**413.0**	**468.0**	**128.4**	**466.7**	**150.9**	**128.8**	**144.8**	**448.6**	**487.1**	**134.0**	**141.4**	**460.5**
12-2415 OK09634	**178.0**	**463.2**	**141.3**	**141.9**	**476.0**	**412.0**	**466.0**	**131.2**	**484.4**	**152.1**	**131.7**	**148.6**	**448.0**	**484.5**	**134.0**	**134.4**	**462.3**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Oklahoma

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2411 Billings (check)	**770**	**2525**	**965**	**647**	**3000**	**2650**	**2100**	**835**	**3015**	**949**	**780**	**800**	**2042**	**2338**	**880**	**833**	**2500**
12-2412 Ruby Lee	**788**	**2588**	**1030**	**638**	**2800**	**2950**	**2175**	**835**	**3074**	**1076**	**765**	**835**	**2442**	**2350**	**910**	**845**	**2600**
12-2413 Gallagher (OK07214)	**710**	**2300**	**865**	**687**	**2800**	**2700**	**2300**	**770**	**2633**	**971**	**725**	**740**	**2450**	**2313**	**825**	**805**	**2500**
12-2414 Iba (OK07209)	**745**	**2375**	**845**	**693**	**2800**	**2725**	**2425**	**780**	**2868**	**1040**	**700**	**780**	**2458**	**2313**	**845**	**833**	**2650**
12-2415 OK09634	**913**	**2588**	**1025**	**753**	**3200**	**2950**	**2450**	**900**	**3045**	**974**	**785**	**875**	**2467**	**2325**	**933**	**885**	**2575**

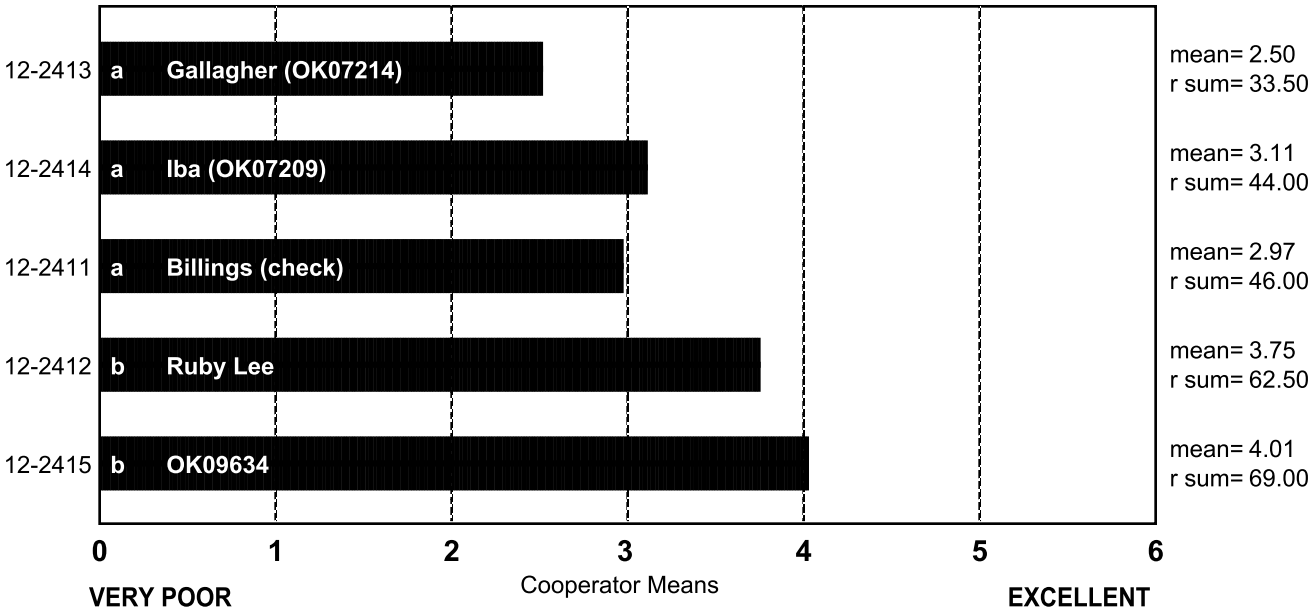
Raw Data

LOAF VOLUME

(Small Scale) Oklahoma

ncoop= 17
chisq= 19.68
chisqc= 22.76
cvchisq= 9.49
crdiff= 14.47

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

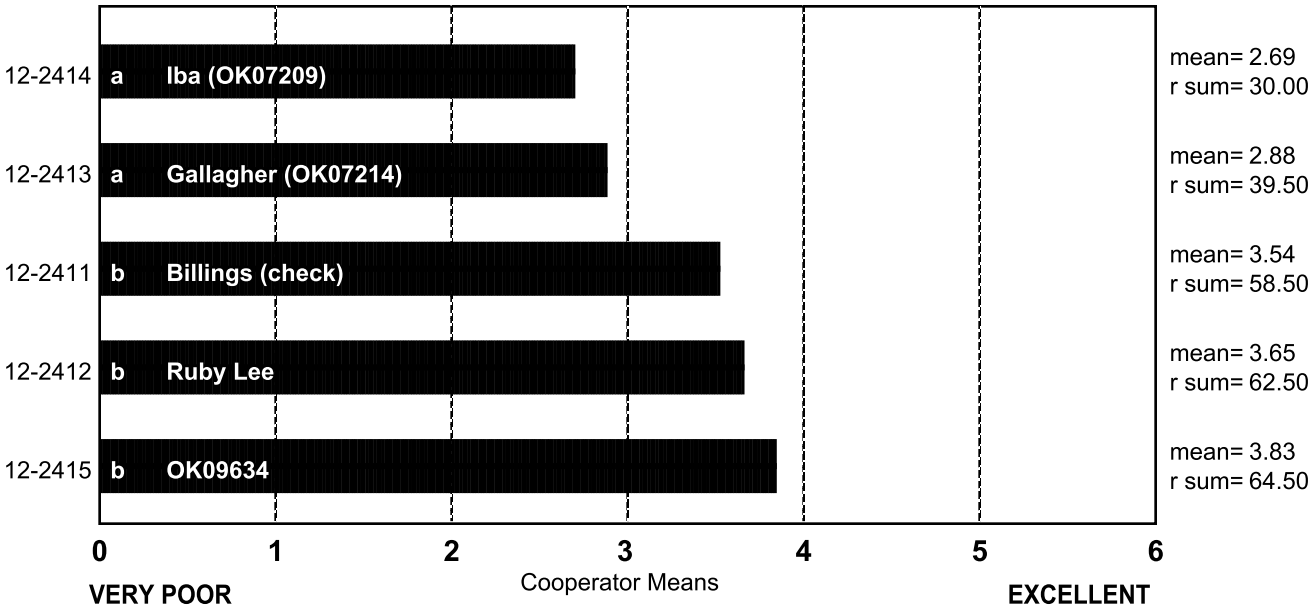


OVERALL BAKING QUALITY

(Small Scale) Oklahoma

ncoop= 17
chisq= 22.21
chisqc= 24.44
cvchisq= 9.49
crdiff= 14.55

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) Oklahoma

COOP. **12-2411 Billings (check)**

A. No comment.
B. Sl. above avg. abs, avg. mix time, sl. below avg. volume, white crumb, sl. open grain, sl. flat.
C. Good out of mixer, excellent externals.
D. No comment.
E. No comment.
F. Very tough dead dough, no elasticity, long mix, low volume.
G. No comment.
H. No comment.
I. Very strong mixing dough, excellent absorption, good interiors, very good volume.
J. Weak mixing properties, poor crumb grain, good volume performance for protein level.
K. High bake absorption.
L. Good absorption, medium long MT, low LV, questionable-satisfactory crumb grain, dull crumb color.
M. Bread collapsed, abs was too high, reran farinograph and came up with 62.2%, re-baked with new abs and did not collapse; overall score on re-bake was 4.0.
N. High absorption, short mix time, good grain, creamy, good volume.
O. Acceptable bake quality, pliable dough handling.
P. Hi Abs, normal MT, slight sticky & strong dough, med Hi OS & volume, fine & elongated cells, slight yellow crumb, smooth & resilient texture.
Q. No comment.

COOP. **12-2412 Ruby Lee**

A. No comment.
B. Avg. abs, avg. mix time, avg. volume, sl. white crumb, sl. open grain, sl. flat.
C. Excellent externals, slightly dry.
D. No comment.
E. No comment.
F. Very tough dead dough, no elasticity, long mix, good volume.
G. No comment.
H. No comment.
I. Strong dough, absorption was sl. above average, excellent volume.
J. Very nice overall performance for such low protein.
K. No comment.
L. Good mixing tolerance, low bake absorption, crumb grain satisfactory, good LV.
M. Excellent volume and grain rating, great mix time, white in color.
N. Good absorption, short mix time, sticky and wet at make-up, good grain, good volume.
O. Acceptable bake quality, stiff dough handling, could take more water.
P. Normal Abs & MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, creamy crumb, silky & resilient texture.
Q. No comment.

COOP. 12-2413 Gallagher (OK07214)

A. No comment.
B. Sl. below avg. abs, short mix time, low volume, sl. yellow crumb, sl. open grain, very flat.
C. No comment.
D. No comment.
E. No comment.
F. Sl. soft and sticky out of mixer, good recovery, good volume, sl. open grain, creamy interior, avg. mix for protein.
G. No comment.
H. Low absorption, average mixer but low loaf volume.
I. Good absorption, doughs were wet and sticky, very open, thick cell walls, low volume.
J. Very nice overall performance for such low protein.
K. Low loaf volume.
L. Low absorption, long MT, questionable crumb grain, yellow crumb color.
M. Excellent volume and grain rating, great mix time.
N. Good absorption, short mix time, poor tolerance, open grain, good volume.
O. Poor bake quality, weak dough handling and poor mix tolerance.
P. Normal Abs & MT, slight sticky & strong dough, med. Hi OS & volume, fine & elongated cells, slight yellow crumb, smooth & resilient texture.
Q. No comment.

COOP. 12-2414 Iba (OK07209)

A. No comment.
B. Sl. below avg. abs, very short mix time, low volume, sl. yellow crumb, sl. open grain, flat.
C. Short mix time.
D. No comment.
E. No comment.
F. Sl. soft and sticky out of mixer, good recovery, good volume, sl. open grain, creamy interior, avg. mix for protein.
G. No comment.
H. Poor volume, crumb grain and texture.
I. Yellow crumb color, weak mixing strength, average volume.
J. Very nice overall performance for such low protein.
K. Low loaf volume, low flour protein.
L. 9.8% flour protein, long MT, low absorption, sticky out of mix, low LV, questionable-satisfactory crumb grain.
M. Excellent volume, lower protein and abs, open grain, low mix time.
N. Avg. absorption, short mix time, poor tolerance, sticky and wet dough, dense grain, yellow, good volume.
O. Poor bake quality, very weak putty dough handling, poor grain and mix tolerance.
P. Normal Abs & MT, slight sticky & strong dough, med Hi OS & volume, open & irregular cells, yellow crumb, slight harsh & resilient texture.
Q. No comment.

COOP. 12-2415 OK09634

A. No comment.
B. Above avg. abs, avg. mix time, avg. volume, creamy crumb, sl. open grain, good symmetry.
C. Excellent externals.
D. No comment.
E. No comment.
F. Sl. soft and sticky out of mixer, good recovery, good volume, open grain, short mix for protein.
G. No comment.
H. No comment.
I. Good absorption, tight, consistent, smooth grain, very good volume.
J. Average quality.
K. No comment.
L. 12.1% flour protein, good absorption & bake MT, excellent at make-up, questionable crumb grain, best LV rating in OK group.
M. Excellent volume, good protein and abs, creamy white.
N. High absorption, wet dough at make-up, avg. grain, good volume.
O. Acceptable bake quality, soft dough handling.
P. Hi Abs, normal MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, creamy crumb, smooth & resilient texture.
Q. No comment.

Notes: **B, E, F, I, M, N, O and Q** conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

South Dakota – Bill Berzonsky

Sample Plot - Growing Conditions
For the 2012 WQC Trials, SDSU submitted Lyman as a check along with two experimental breeding lines, SD06158 and SD08080. Samples combining equal amounts of seed were composited from Brookings and Dakota Lakes, SD (east river locations), and Winner, SD (a west river location). Sample plots were approximately 5 ft. wide by 400 ft. long at each location. Despite the absence of consistent snow cover, sample plots across locations exhibited little winterkill because of a relatively mild winter. During the season, some winter wheat in the state was significantly impacted by the early development of stripe rust, due to a generally wet, cool spring, but stripe rust symptoms rapidly faded with the onset of hot and extremely dry conditions through the remainder of the season. Overall, the 2012 production season for winter wheat in South Dakota was outstanding, with significantly higher than average grain yields and test weights compared with the 3-year averages. The average yield for the SD Winter Wheat Crop Performance Trial (CPT)-East River locations was 74 bu/a, compared with 69 bu/a for the 3-year average, and the average grain yield for the same nursery over West River locations was 67 bu/a, compared with 59 bu/a for the 3-year average. Average CPT test weights were in the range of 60 to 65 lbs/bu, which also highlights the relatively disease-free growing conditions that existed in South Dakota for 2012.

Lyman (Check)
Released in 2008, and available as certified seed in 2010, Lyman is a hard red winter wheat variety developed from the cross KS93U134/Arapahoe. It is a medium maturity and medium height variety, and its winter hardiness is similar to Arapahoe. It was targeted as a replacement for both Arapahoe and Harding, and it is complementary to Millennium and Overland in its agronomic performance. Lyman has above average disease resistance, including leaf and stem rust resistance, and it is among the most resistant winter wheat varieties for Fusarium head blight. Lyman has a tendency to lodge under high moisture conditions, similar to Arapahoe, and is rated as having excellent milling and satisfactory baking quality.

SD06158
A hard red winter wheat breeding line with the pedigree Wesley/CDC Falcon, this line is a bronze-chaff type that is similar in appearance to Wesley. It is a consistent high grain yield performer that is semi-dwarf and heads about 3 days later than Wesley. SD06158 exhibits average to below average resistance to Fusarium head blight, but typically expresses high test weight. This is the third year for SD06158 in the WQC Trials, having been rated as above average for bake quality in both of the prior years it was entered. In the 2011 NRPN, SD06158 ranked 3rd in average grain yield among 29 entries, and in the 2012 NRPN, SD06158 ranked 4th for average grain yield among the 34 entries tested. This past season was the fourth year SD06158 was entered in the CPT,

and in the 2011 CPT, SD06158 exhibited an average grain yield of 62 bu/a compared with the 56 bu/a average for genotypes at east river locations; whereas, its average grain yield for west river locations was about equal to the 51 bu/a average for genotypes at those locations. In the 2012 CPT, SD06158 exhibited an average grain yield of 71 bu/a, compared with the 74 bu/a average for genotypes at east river locations; whereas, its average grain yield for west river locations was 65 bu/a, compared with the 67 bu/a average for genotypes at west river locations.

SD08080

A hard red winter wheat breeding line with the pedigree SD97059-2/G980723, this breeding line is a white-chaff type with above average grain yield potential. This is its first year as an entry in the WQC Trials. It is a mid-maturity breeding line, heading about the same as Wesley, but about one day earlier than Overland. SD08080 is slightly taller than Wesley, but shorter than Overland. It exhibits a good level of resistance to the prevalent races of leaf rust, but it is moderately susceptible to stem rust and Fusarium head blight. In the 2011 NRPN, SD08080 ranked 4th for grain yield among the 29 entries tested, and in the 2012 NRPN, it ranked 19th for grain yield among the 34 entries tested. This past season was the second year SD08080 was entered in the statewide CPT. In the 2011 CPT, SD08080 exhibited an average grain yield of 61 bu/a, compared with 56 bu/a for genotypes tested in the CPT at east river locations; whereas, its average grain yield for west river locations was 50 bu/a, compared with an average of 51 bu/a for genotypes tested at the west river locations. In the 2012 CPT, SD08080 exhibited an average grain yield of 73 bu/a, or just below the average for genotypes at east river locations; whereas, its average grain yield for west river locations was 64 bu/a, compared with the 67 bu/a average for genotypes tested at west river locations. SD08080 appears to be slightly more adapted to the higher moisture east river areas of the state.

South Dakota: 2012 (Small-Scale) Samples

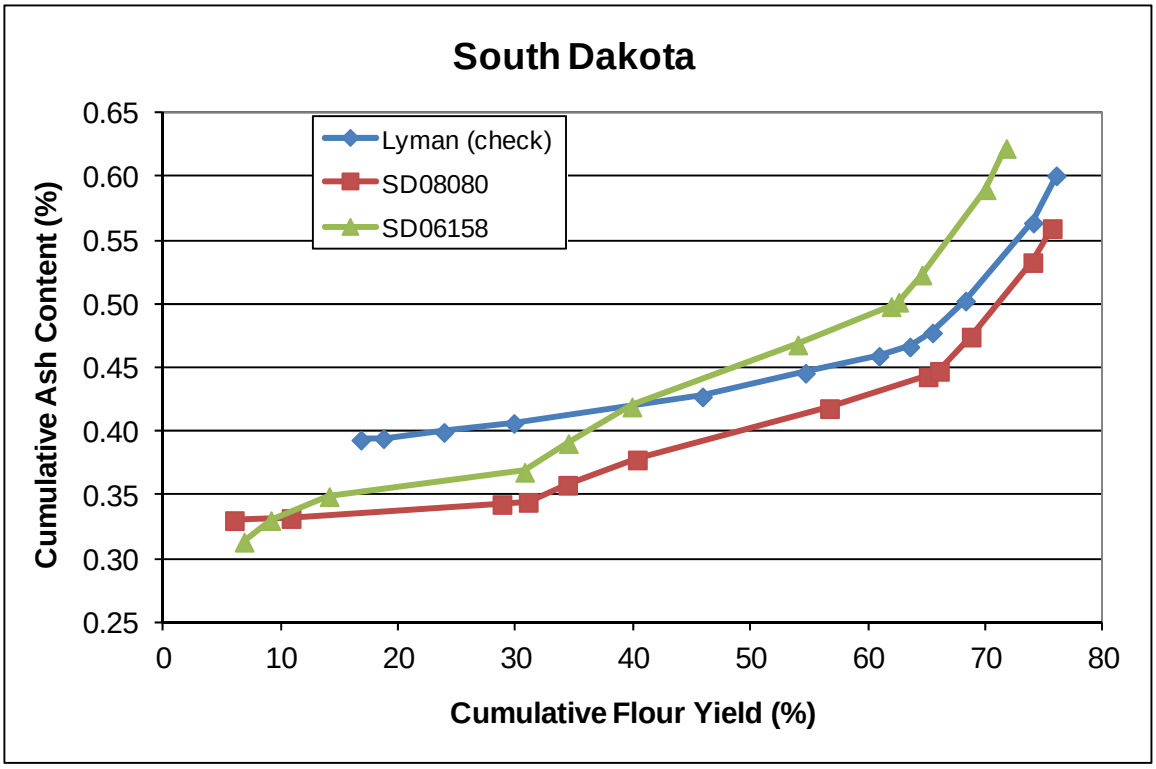
Test entry number	12-2416	12-2417	12-2418
Sample identification	**Lyman (check)**	**SD08080**	**SD06158**
Wheat Data			
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	62.4	60.4	60.8
Hectoliter weight (kg/hl)	82.0	79.5	80.0
1000 kernel weight (gm)	36.3	34.2	32.2
Wheat kernel size (Rotap)			
Over 7 wire (%)	82.9	84.5	71.1
Over 9 wire (%)	17.1	15.4	28.7
Through 9 wire (%)	0.1	0.1	0.2
Single kernel (skcs)[a]			
Hardness (avg /s.d)	74.5/12.2	58.7/13.2	58.3/15.4
Weight (mg) (avg/s.d)	36.3/7.2	34.2/7.8	32.2/8.3
Diameter (mm)(avg/s.d)	2.84/0.32	2.76/0.30	2.69/0.31
Moisture (%) (avg/s.d)	11.1/0.38	10.9/0.38	11.6/0.34
SKCS distribution	00-01-09-90-01	02-15-30-53-01	05-17-30-48-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb)	13.0	13.8	11.2
Wheat ash (12% mb)	1.57	1.46	1.53
Milling and Flour Quality Data			
Flour yield (%, str. grade)			
Miag Multomat Mill	76.1	75.7	71.9
Quadrumat Sr. Mill	72.8	73.9	70.5
Flour moisture (%)	11.2	10.9	10.8
Flour protein (14% mb)	12.3	12.8	10.5
Flour ash (14% mb)	0.66	0.61	0.67
Rapid Visco-Analyser			
Peak Time (min)	6.3	6.2	6.1
Peak Viscosity (RVU)	178.4	207.8	206.4
Breakdown (RVU)	46.6	71.7	68.0
Final Viscosity at 13 min (RVU)	244.3	249.8	259.9
Minolta color meter			
L*	91.2	91.7	91.9
a*	-0.87	-0.25	-0.39
b*	9.41	6.98	6.97
PPO	0.529	0.555	0.550
Falling number (sec)	469	482	474
Damaged Starch			
(AI%)	96.91	96.31	97.11
(AACC76-31)	7.00	6.52	7.16

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

South Dakota: Physical Dough Tests and Gluten Analysis For 2012 (Small-Scale) Samples

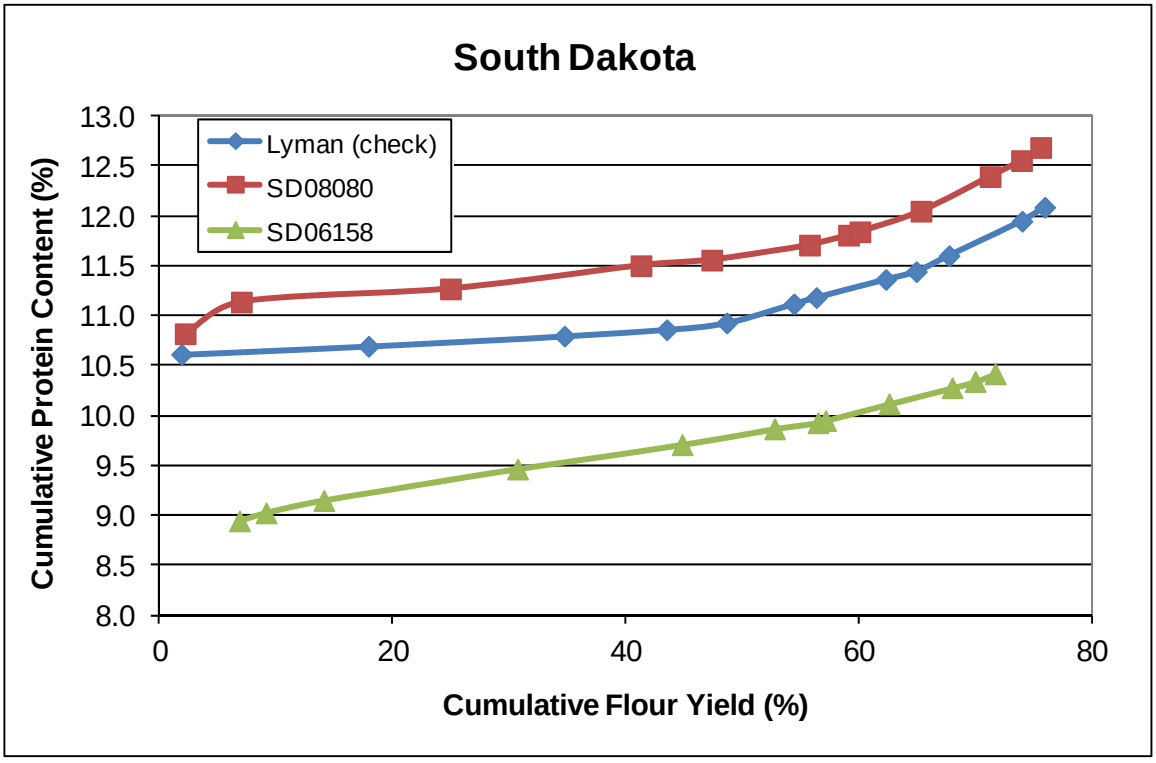
Test Entry Number	12-2416	12-2417	12-2418
Sample Identification	Lyman (check)	SD08080	SD06158
MIXOGRAPH			
Flour Abs (% as-is)	66.4	68.2	63.7
Flour Abs (14% mb)	63.2	64.7	60.1
Mix Time (min)	3.1	3.8	4.4
Mix tolerance (0-6)	3	4	4
FARINOGRAPH			
Flour Abs (% as-is)	65.4	65.8	61.4
Flour Abs (14% mb)	62.8	63.4	59.1
Development time (min)	7.2	8.2	5.8
Mix stability (min)	16.9	18.1	17.1
Mix Tolerance Index (FU)	19	28	23
Breakdown time (min)	17.0	13.3	12.7
ALVEOGRAPH			
P(mm): Tenacity	89	91	88
L(mm): Extensibility	107	125	115
G(mm): Swelling index	23.0	24.9	23.9
W(10^{-4} J): strength (curve area)	293	364	323
P/L: curve configuration ratio	0.83	0.73	0.77
Ie(P_{200}/P): elasticity index	54.0	59.5	57.6
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	258/329/379	304/383/445	440/605/687
Extensibility (mm at 45/90/135 min)	161/154/154	159/169/170	144/132/129
Energy (cm^2 at 45/90/135 min)	77/95/107	89/130/152	113/137/151
Resist $_{max}$ (BU at 45/90/135 min)	350/471/533	429/604/705	615/827/737
Ratio (at 45/90/135 min)	1.60/2.14/2.47	1.91/2.26/2.62	3.05/4.57/5.33
PROTEIN ANALYSIS			
HMW-GS Composition	2*, 7+9, 5+10	2*, 7+9, 5+10	2*, 7+8, 5+10
%IPP	47.62	47.58	53.89
SEDIMENTATION TEST			
Volume (ml)	43.6	57.9	41.5

South Dakota: Cumulative Ash Curves



Lyman (check)					SD08080					SD06158				
Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash
2M	16.8	0.39	16.8	0.39	1BK	6.1	0.33	6.1	0.33	1BK	6.9	0.31	6.9	0.31
1M Red	1.9	0.40	18.7	0.39	1M	4.8	0.33	10.9	0.33	1M Red	2.3	0.38	9.2	0.33
1M	5.1	0.42	23.9	0.40	2M	17.9	0.35	28.8	0.34	1M	5.0	0.38	14.1	0.35
1BK	6.0	0.43	29.9	0.41	1M Red	2.2	0.37	31.1	0.34	2M	16.6	0.38	30.8	0.37
3M	16.0	0.47	45.9	0.43	Grader	3.4	0.48	34.4	0.36	Grader	3.7	0.58	34.5	0.39
4M	8.8	0.54	54.7	0.45	2BK	5.9	0.49	40.4	0.38	2BK	5.4	0.60	39.9	0.42
2BK	6.3	0.58	60.9	0.46	3M	16.4	0.52	56.7	0.42	3M	14.1	0.61	54.0	0.47
Grader	2.6	0.64	63.6	0.47	4M	8.4	0.61	65.1	0.44	4M	7.9	0.70	62.0	0.50
FILTER FLR	1.9	0.84	65.5	0.48	FILTER FLR	1.0	0.74	66.1	0.45	FILTER FLR	0.6	0.83	62.6	0.50
3BK	2.8	1.09	68.3	0.50	3BK	2.7	1.13	68.8	0.47	3BK	2.0	1.20	64.6	0.52
5M	5.8	1.29	74.1	0.56	5M	5.2	1.30	74.0	0.53	5M	5.5	1.38	70.0	0.59
BRAN FLR	2.0	2.00	76.0	0.60	BRAN FLR	1.6	1.76	75.7	0.56	BRAN FLR	1.7	1.94	71.8	0.62
Break Shorts	4.1	3.55	80.1	0.75	Break Shorts	4.1	3.70	79.8	0.72	Break Shorts	4.0	3.49	75.8	0.77
Red Dog	2.5	3.96	82.6	0.85	Red Dog	2.3	3.86	82.1	0.81	Red Dog	2.0	3.57	77.7	0.84
Red Shorts	1.5	4.22	84.1	0.91	Red Shorts	1.1	4.23	83.2	0.86	Red Shorts	1.1	3.56	78.8	0.88
Filter Bran	0.7	3.00	84.8	0.93	Filter Bran	0.5	2.56	83.7	0.87	Filter Bran	3.8	2.39	82.6	0.95
Bran	15.2	4.93	100.0	1.54	Bran	16.3	5.01	100.0	1.54	Bran	17.4	4.64	100.0	1.59
Wheat		1.53			Wheat		1.43			Wheat		1.50		
St. Grd. Fl.		0.66			St. Grd. Fl.		0.61			St. Grd. Fl.		0.67		

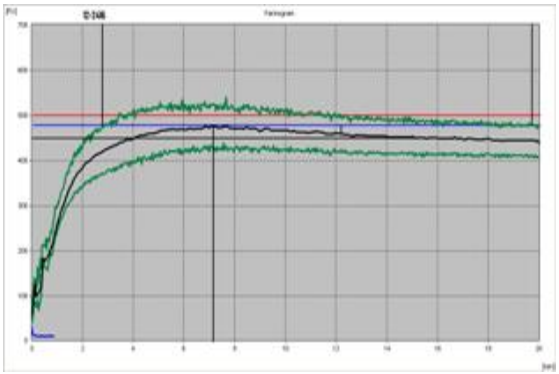
South Dakota: Cumulative Protein Curves



Lyman (check)					SD08080					SD06158				
Mill Streams	Strm-yld (14%mb)	Protein	Cumulative Yield	(14%) Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative Yield	(14%) Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative Yield	(14%) Protein
1M Red	1.9	10.6	1.9	10.6	1M Red	2.2	10.8	2.2	10.8	1BK	6.9	8.9	6.9	8.9
3M	16.0	10.7	18.0	10.7	1M	4.8	11.3	7.1	11.1	1M Red	2.3	9.3	9.2	9.0
2M	16.8	10.9	34.8	10.8	2M	17.9	11.3	25.0	11.3	1M	5.0	9.4	14.1	9.1
4M	8.8	11.1	43.6	10.9	3M	16.4	11.9	41.4	11.5	2M	16.6	9.7	30.8	9.5
1M	5.1	11.5	48.7	10.9	1BK	6.1	11.9	47.4	11.6	3M	14.1	10.2	44.9	9.7
5M	5.8	12.7	54.5	11.1	4M	8.4	12.6	55.8	11.7	4M	7.9	10.8	52.8	9.9
FILTER FLR	1.9	13.0	56.4	11.2	Grader	3.4	13.4	59.2	11.8	Grader	3.7	10.8	56.5	9.9
1BK	6.0	13.1	62.4	11.4	FILTER FLR	1.0	13.9	60.1	11.8	FILTER FLR	0.6	11.8	57.2	9.9
Grader	2.6	13.3	65.0	11.4	5M	5.2	14.4	65.4	12.0	5M	5.5	11.9	62.7	10.1
3BK	2.8	15.3	67.8	11.6	2BK	5.9	16.2	71.3	12.4	2BK	5.4	12.1	68.1	10.3
2BK	6.3	15.7	74.1	11.9	3BK	2.7	16.8	74.0	12.5	3BK	2.0	12.5	70.0	10.3
BRAN FLR	2.0	17.4	76.0	12.1	BRAN FLR	1.6	18.6	75.7	12.7	BRAN FLR	1.7	13.6	71.8	10.4
Break Shorts	4.1	14.5	80.1	12.2	Break Shorts	4.1	15.7	79.8	12.8	Break Shorts	4.0	12.7	75.8	10.5
Red Dog	2.5	14.6	82.6	12.3	Red Dog	2.3	14.9	82.1	12.9	Red Dog	2.0	12.7	77.7	10.6
Red Shorts	1.5	13.7	84.1	12.3	Red Shorts	1.1	14.5	83.2	12.9	Red Shorts	1.1	12.0	78.8	10.6
Filter Bran	0.7	13.6	84.8	12.3	Filter Bran	0.5	14.2	83.7	12.9	Filter Bran	3.8	11.8	82.6	10.7
Bran	15.2	16.5	100.0	13.0	Bran	16.3	18.2	100.0	13.8	Bran	17.4	13.3	100.0	11.1
Wheat		12.7			Wheat		13.5			Wheat		10.91		
St. Grd. Fl.		12.3			St. Grd. Fl.		12.8			St. Grd. Fl.		10.48		

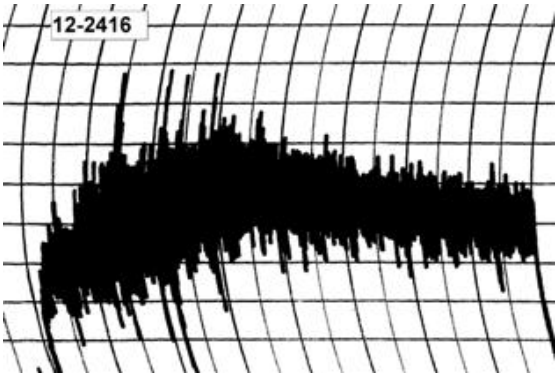
Physical Dough Tests
2012 (Small Scale) Samples – South Dakota

Farinograms



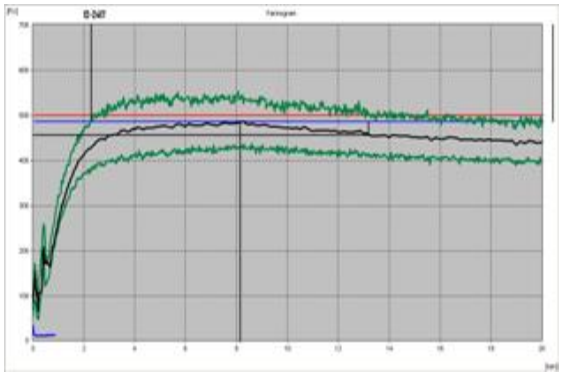
Water abs = 62.8%, Peak time = 7.2 min,
Mix stab = 16.9 min, MTI = 19 FU

Mixograms

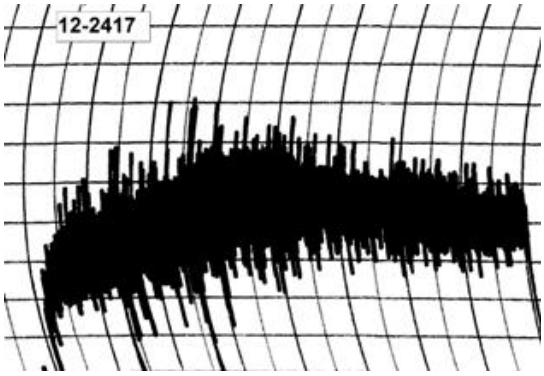


Water abs = 63.2%
Mix time = 3.1 min

12-2416, Lyman (check)



Water abs = 63.4%, Peak time = 8.2 min,
Mix stab = 18.1 min, MTI = 28 FU



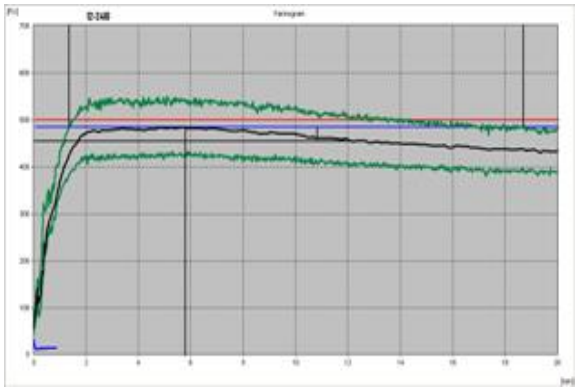
Water abs = 64.7%
Mix time = 3.8 min

12-2417, SD08080

Physical Dough Tests

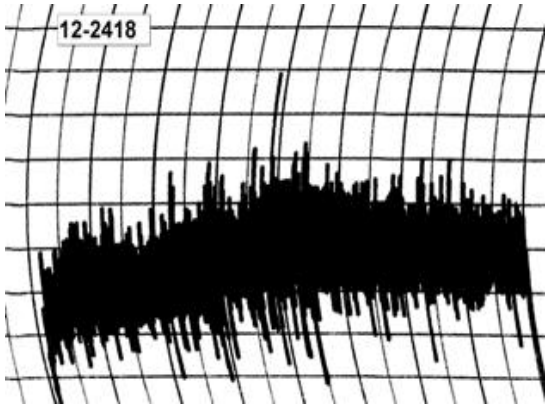
2012 (Small Scale) Samples – South Dakota (continued)

Farinograms



Water abs. = 59.1%, Peak time = 5.8 min,
Mix stab = 17.3 min, MTI = 23 FU

Mixograms

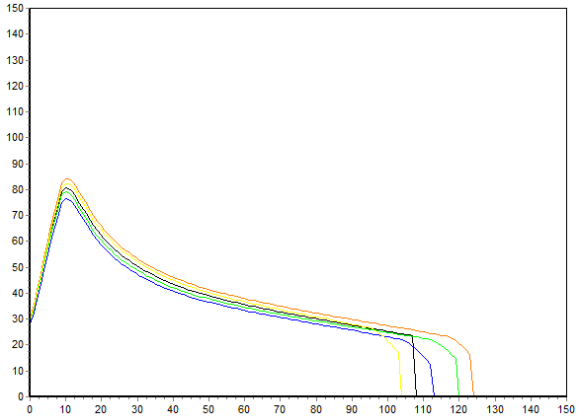


Water abs = 60.1%
Mix time = 4.4 min

12-2418, SD06158

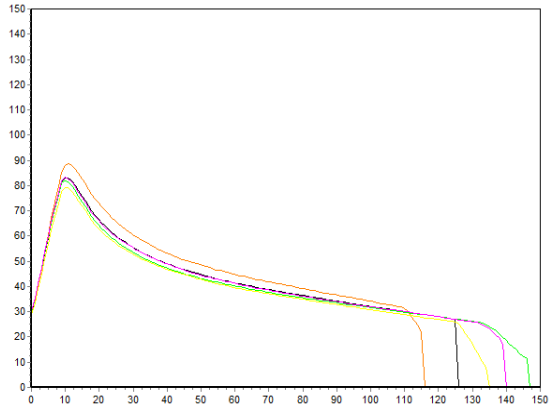
Physical Dough Tests - Alveograph

2012 (Small Scale) Samples – South Dakota



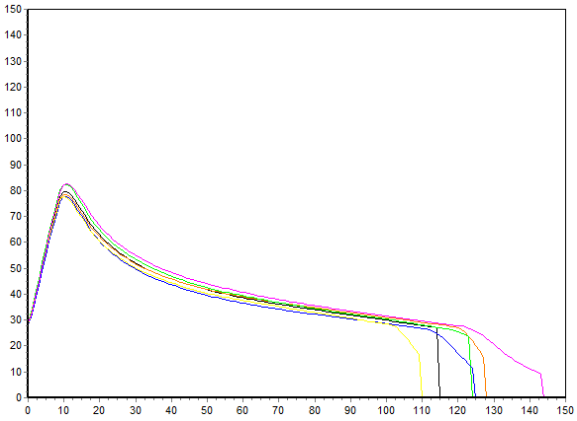
12-2416, Lyman (check)

P (mm H_20) = 89, L (mm) = 107, W ($10E^{-4}J$) = 293



12-2417, SD08080

P (mm H_20) = 91, L (mm) = 125, W ($10E^{-4}J$) = 364

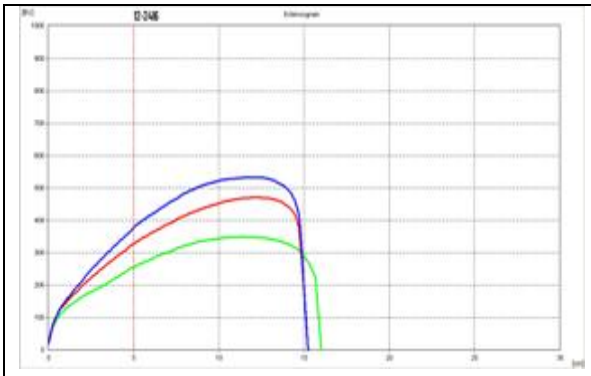


12-2418, SD06158

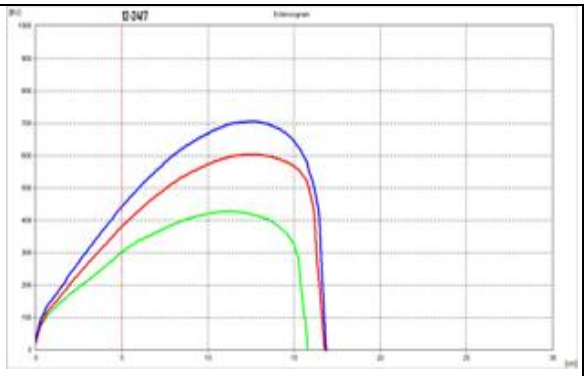
P (mm H_20) = 88, L (mm) = 115, W ($10E^{-4}J$) = 323

Physical Dough Tests - Extensigraph

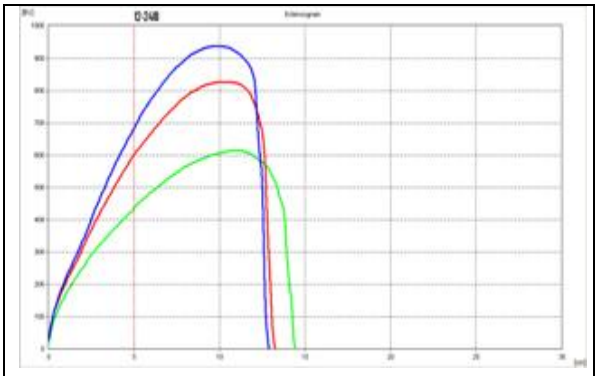
2012 (Small Scale) Samples – South Dakota



Lyman (check) - 2416
R (BU) = 329, E (mm) = 154, W (cm^2) = 95
Rmax (BU) = 471, Ratio = 2.1 at 90 min



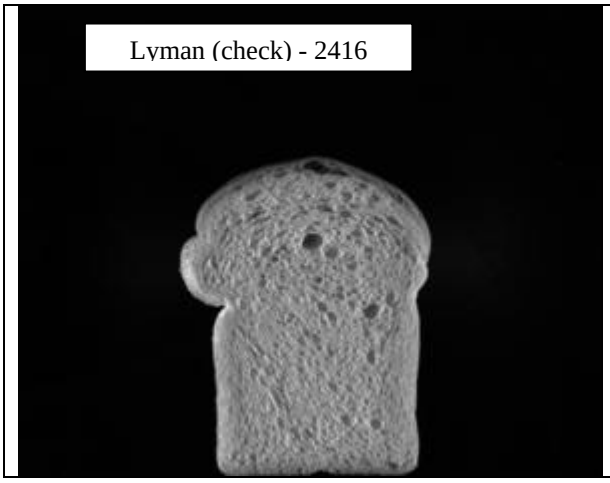
SD08080 - 2417
R (BU) = 383, E (mm) = 169, W (cm^2) = 130
Rmax (BU) = 604, Ratio = 2.3 at 90 min



SD06158 - 2418
R (BU) = 605, E (mm) = 132, W (cm^2) = 137
Rmax (BU) = 827, 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.

South Dakota: C-Cell Bread Images and Analysis for 2012 (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	5760	137.0	3566	0.445	2.035	1.290	1.715	-13.50
2417	6166	130.1	4012	0.435	1.972	1.615	1.715	-12.85

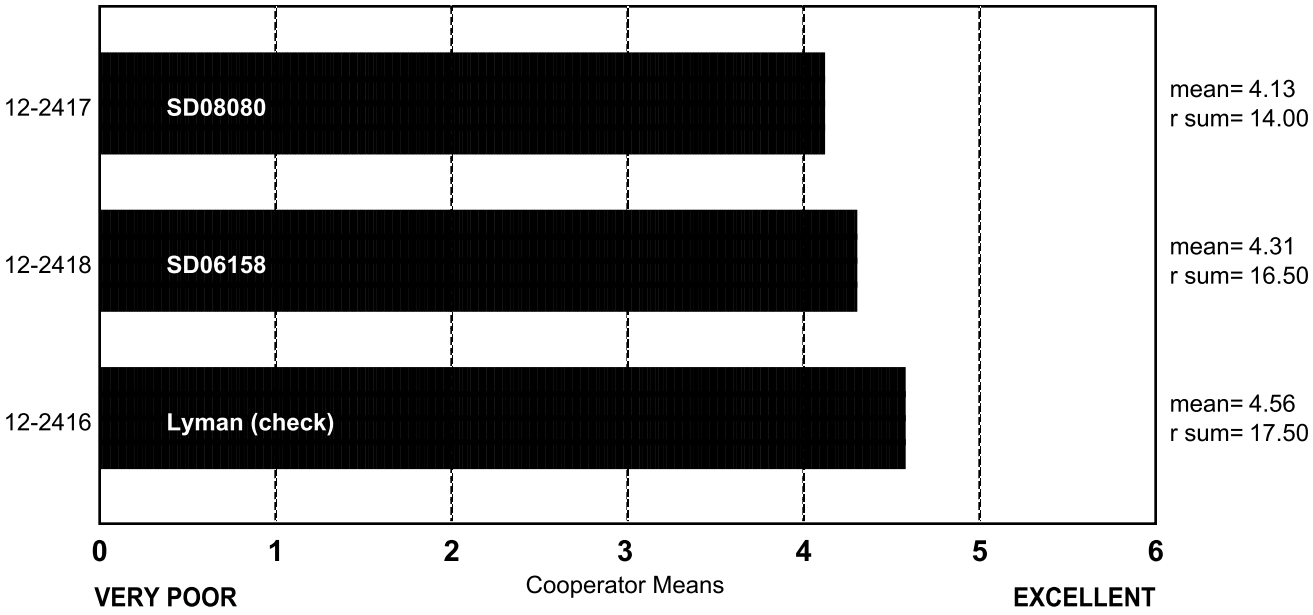
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2418	5894	132.9	3883	0.434	1.874	7.651	1.795	-15.85

SPONGE CHARACTERISTICS

(Small Scale) South Dakota

ncoop= 8
chisq= 0.81
chisqc= 2.00
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

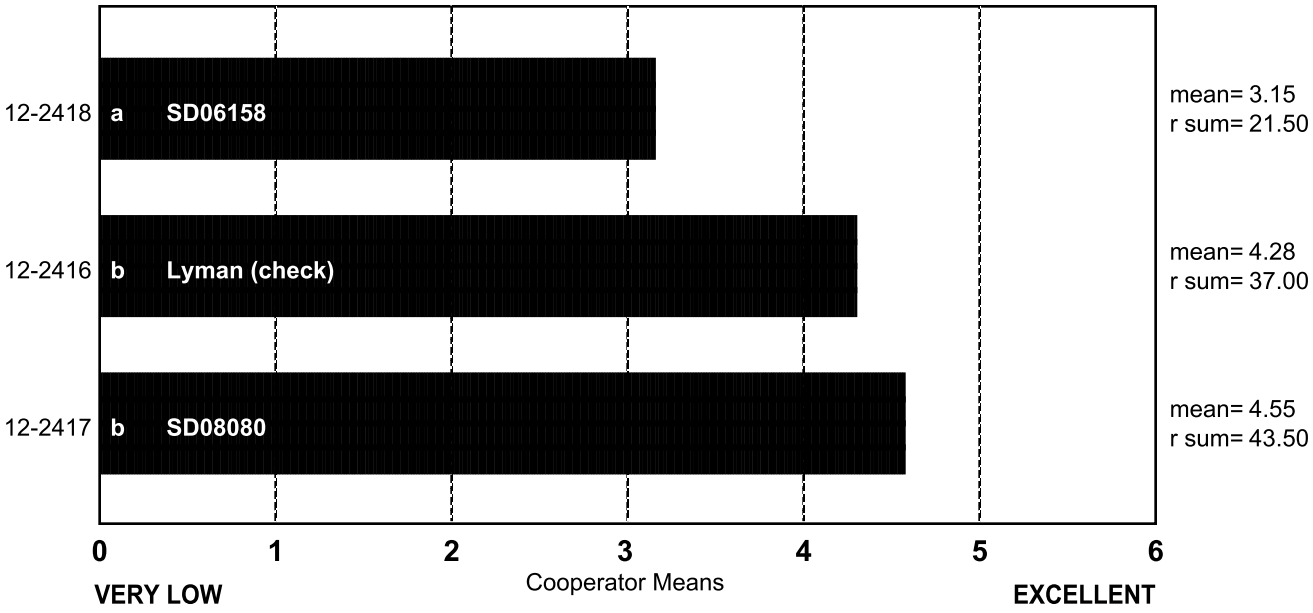


BAKE ABSORPTION

(Small Scale) South Dakota

ncoop= 17
chisq= 15.03
chisqc= 17.93
cvchisq= 5.99
crdiff= 7.71

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) South Dakota

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2416 Lyman (check)	**65.1**	**63.0**	**63.8**	**65.6**	**63.0**	**59.0**	**62.8**	**65.7**	**63.0**	**64.9**	**58.1**	**61.5**	**62.8**	**65.0**	**63.0**	**66.8**	**61.5**
12-2417 SD08080	**67.1**	**63.0**	**63.5**	**67.4**	**63.5**	**59.0**	**63.4**	**66.8**	**63.0**	**66.6**	**58.4**	**64.7**	**63.4**	**65.0**	**63.0**	**63.1**	**63.0**
12-2418 SD06158	**62.1**	**60.0**	**60.4**	**62.8**	**59.0**	**57.0**	**59.1**	**62.5**	**59.0**	**63.5**	**55.0**	**60.1**	**59.1**	**62.0**	**60.0**	**61.4**	**59.5**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) South Dakota

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2416 Lyman (check)	**3.3**	**5.0**	**3.3**	**3.1**	**7.0**	**7.0**	**8.0**	**2.5**	**20.0**	**3.3**	**2.0**	**4.6**	**6.0**	**4.0**	**3.0**	**3.5**	**10.0**
12-2417 SD08080	**3.5**	**7.0**	**3.8**	**3.8**	**8.0**	**11.0**	**8.0**	**3.2**	**25.0**	**3.6**	**2.0**	**4.5**	**8.0**	**5.0**	**6.0**	**3.2**	**24.0**
12-2418 SD06158	**4.5**	**7.0**	**5.3**	**4.4**	**6.0**	**20.0**	**9.0**	**4.0**	**25.0**	**5.4**	**3.0**	**7.0**	**7.0**	**5.0**	**6.0**	**6.5**	**18.0**

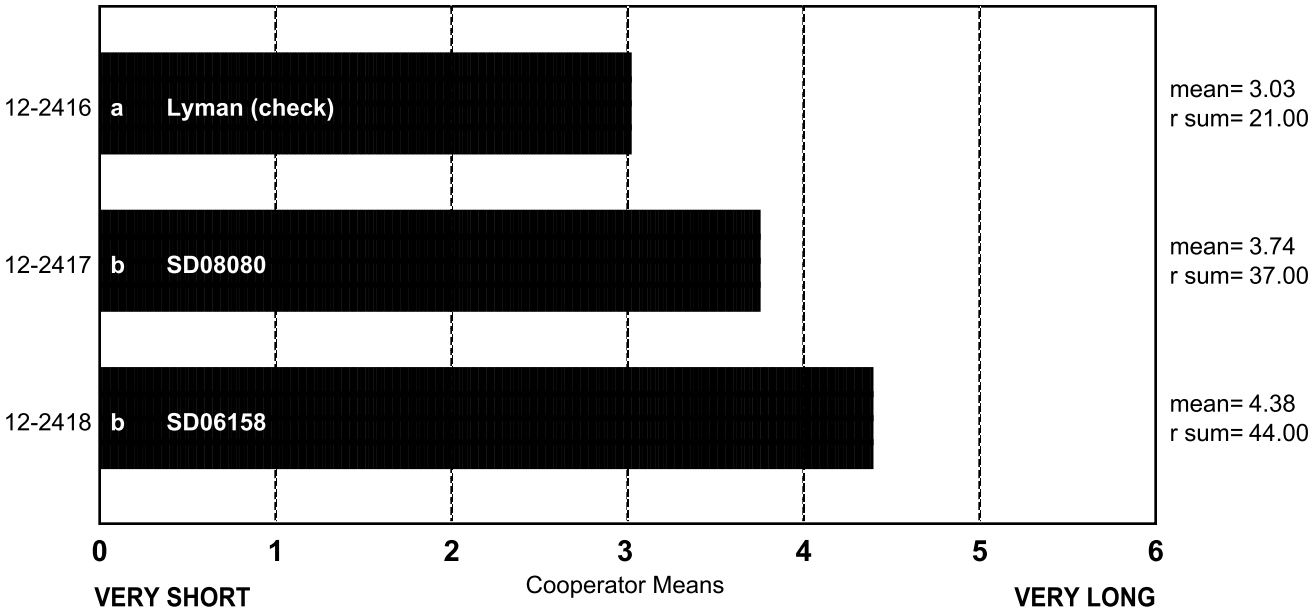
Raw Data

BAKE MIX TIME

(Small Scale) South Dakota

ncoop= 17
chisq= 16.35
chisqc= 19.51
cvchisq= 5.99
crdiff= 7.32

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

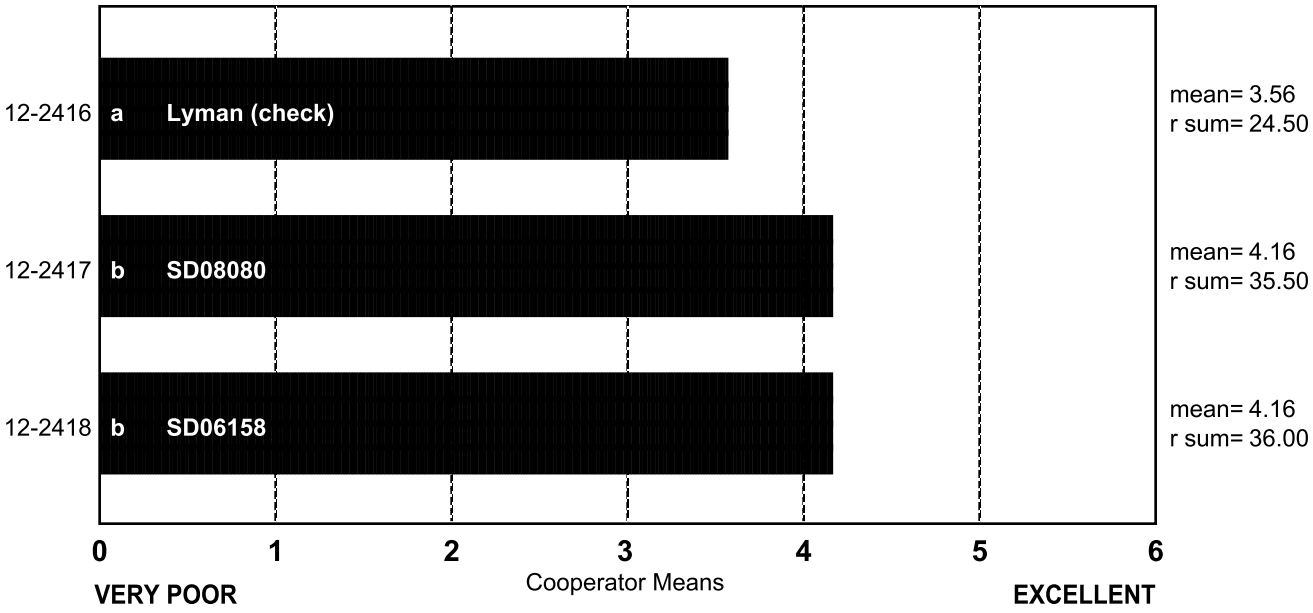


MIXING TOLERANCE

(Small Scale) South Dakota

ncoop= 16
chisq= 5.28
chisqc= 8.24
cvchisq= 5.99
crdiff= 8.23

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

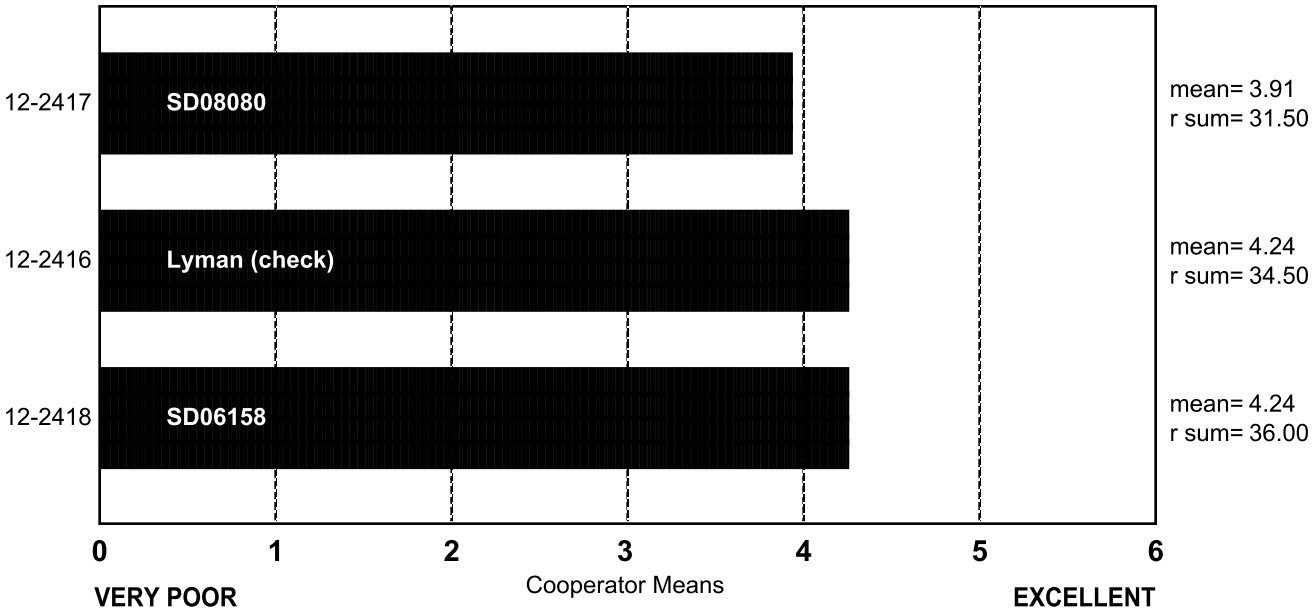


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) South Dakota

ncoop= 17
chisq= 0.62
chisqc= 0.93
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'OUT OF MIXER', DESCRIBED

(Small Scale) South Dakota

	Sticky	Wet	Tough	Good	Excellent
12-2416 Lyman (check)	**4**	**0**	**1**	**11**	**1**
12-2417 SD08080	**1**	**2**	**3**	**11**	**0**
12-2418 SD06158	**1**	**1**	**5**	**9**	**1**

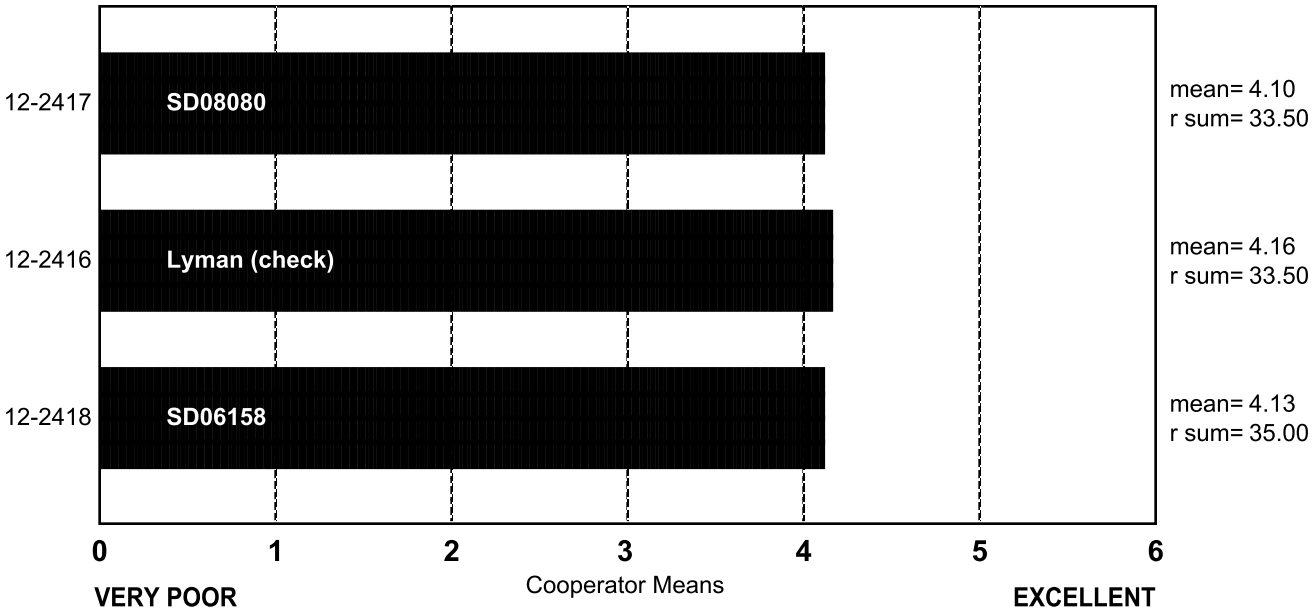
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) South Dakota

ncoop= 17
chisq= 0.09
chisqc= 0.16
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) South Dakota

	Sticky	Wet	Tough	Good	Excellent
12-2416 Lyman (check)	**1**	**2**	**0**	**14**	**0**
12-2417 SD08080	**1**	**1**	**2**	**11**	**2**
12-2418 SD06158	**1**	**0**	**3**	**11**	**2**

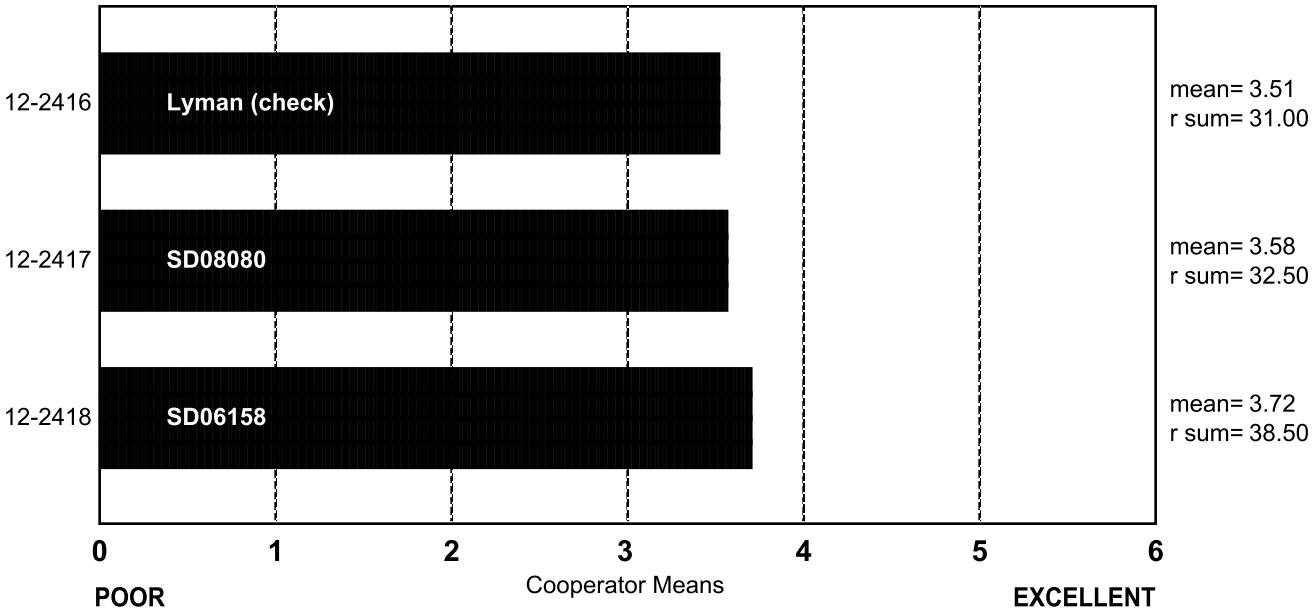
Frequency Table

CRUMB GRAIN

(Small Scale) South Dakota

ncoop= 17
chisq= 1.85
chisqc= 2.57
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB GRAIN, DESCRIBED

(Small Scale) South Dakota

	Open	Fine	Dense
12-2416 Lyman (check)	**7**	**7**	**3**
12-2417 SD08080	**13**	**4**	**0**
12-2418 SD06158	**5**	**7**	**5**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) South Dakota

	Round	Irregular	Elongated
12-2416 Lyman (check)	**5**	**9**	**3**
12-2417 SD08080	**7**	**7**	**3**
12-2418 SD06158	**2**	**9**	**6**

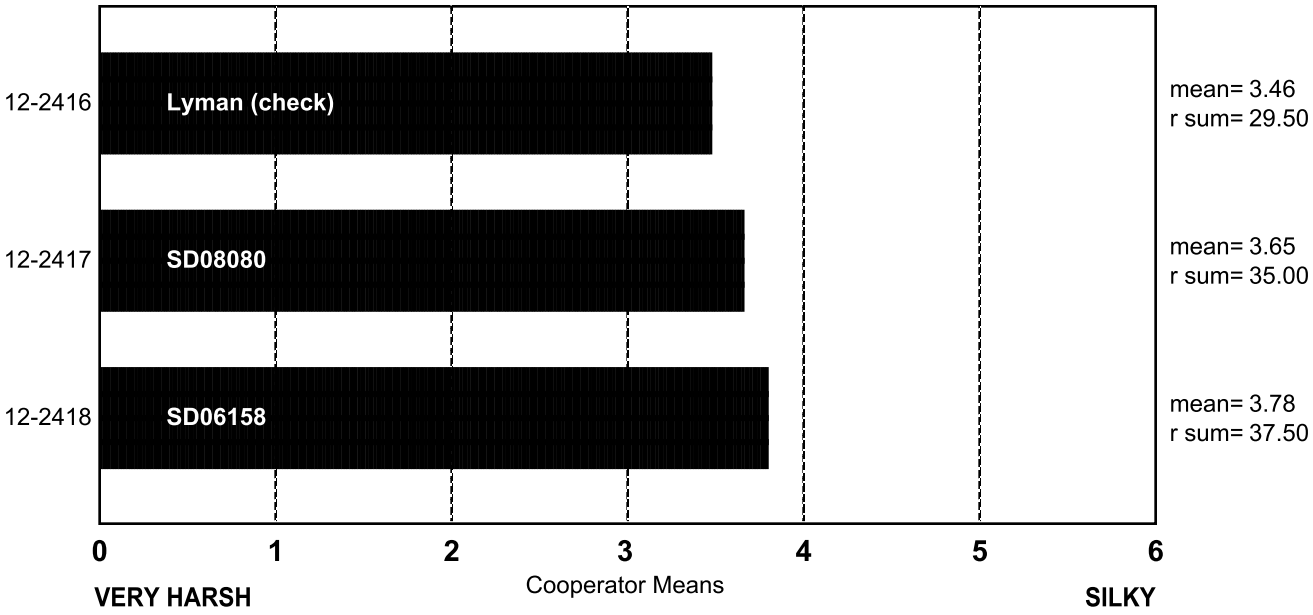
Frequency Table

CRUMB TEXTURE

(Small Scale) South Dakota

ncoop= 17
chisq= 1.97
chisqc= 2.85
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB TEXTURE, DESCRIBED

(Small Scale) South Dakota

	Harsh	Smooth	Silky
12-2416 Lyman (check)	**6**	**8**	**3**
12-2417 SD08080	**5**	**9**	**3**
12-2418 SD06158	**4**	**10**	**3**

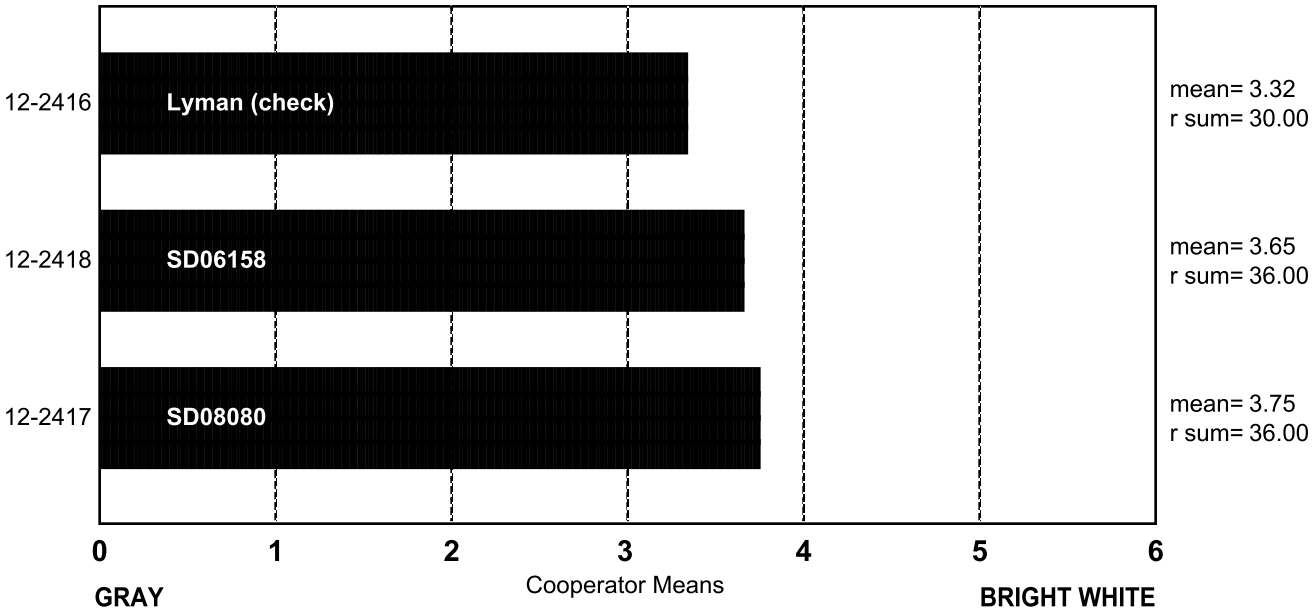
Frequency Table

CRUMB COLOR

(Small Scale) South Dakota

ncoop= 17
chisq= 1.41
chisqc= 2.34
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB COLOR, DESCRIBED

(Small Scale) South Dakota

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
12-2416 Lyman (check)	**0**	**0**	**3**	**6**	**8**	**0**	**0**
12-2417 SD08080	**0**	**0**	**3**	**4**	**7**	**2**	**1**
12-2418 SD06158	**0**	**0**	**2**	**4**	**8**	**3**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) South Dakota

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2416 Lyman (check)	**177.0**	**464.2**	**144.1**	**144.6**	**485.0**	**415.0**	**466.0**	**130.7**	**487.3**	**157.0**	**130.9**	**150.7**	**449.1**	**487.5**	**134.0**	**145.1**	**459.8**
12-2417 SD08080	**178.0**	**465.3**	**142.6**	**139.8**	**485.5**	**415.0**	**467.0**	**131.7**	**480.1**	**150.9**	**128.4**	**152.4**	**455.4**	**487.6**	**134.0**	**144.6**	**461.8**
12-2418 SD06158	**178.0**	**467.7**	**138.9**	**142.8**	**485.5**	**411.0**	**472.0**	**128.3**	**487.1**	**153.7**	**128.9**	**147.4**	**451.7**	**483.8**	**134.0**	**140.7**	**461.3**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) South Dakota

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2416 Lyman (check)	**838**	**2463**	**860**	**605**	**3100**	**2650**	**2550**	**835**	**3045**	**995**	**740**	**810**	**2433**	**2388**	**898**	**775**	**2600**
12-2417 SD08080	**945**	**2475**	**930**	**771**	**3100**	**2750**	**2550**	**910**	**3104**	**1022**	**760**	**880**	**2375**	**2250**	**995**	**755**	**2625**
12-2418 SD06158	**810**	**2538**	**965**	**756**	**2850**	**2725**	**2275**	**810**	**3074**	**1058**	**750**	**800**	**2542**	**2413**	**908**	**850**	**2650**

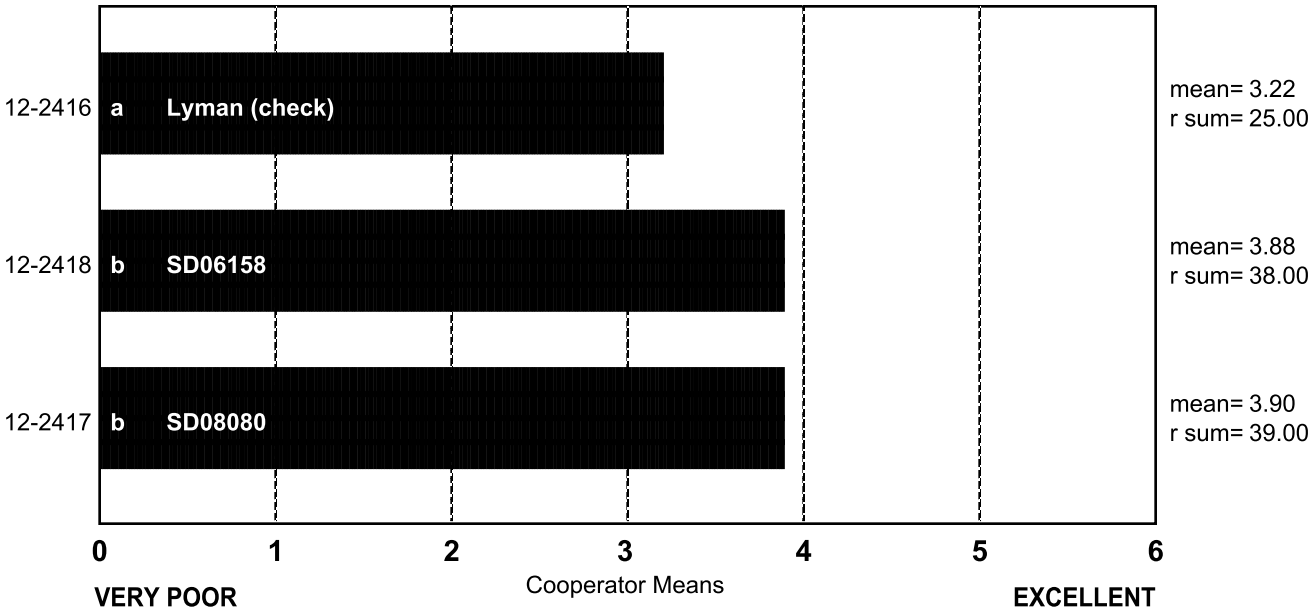
Raw Data

LOAF VOLUME

(Small Scale) South Dakota

ncoop= 17
chisq= 7.18
chisqc= 8.71
cvchisq= 5.99
crdiff= 9.58

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

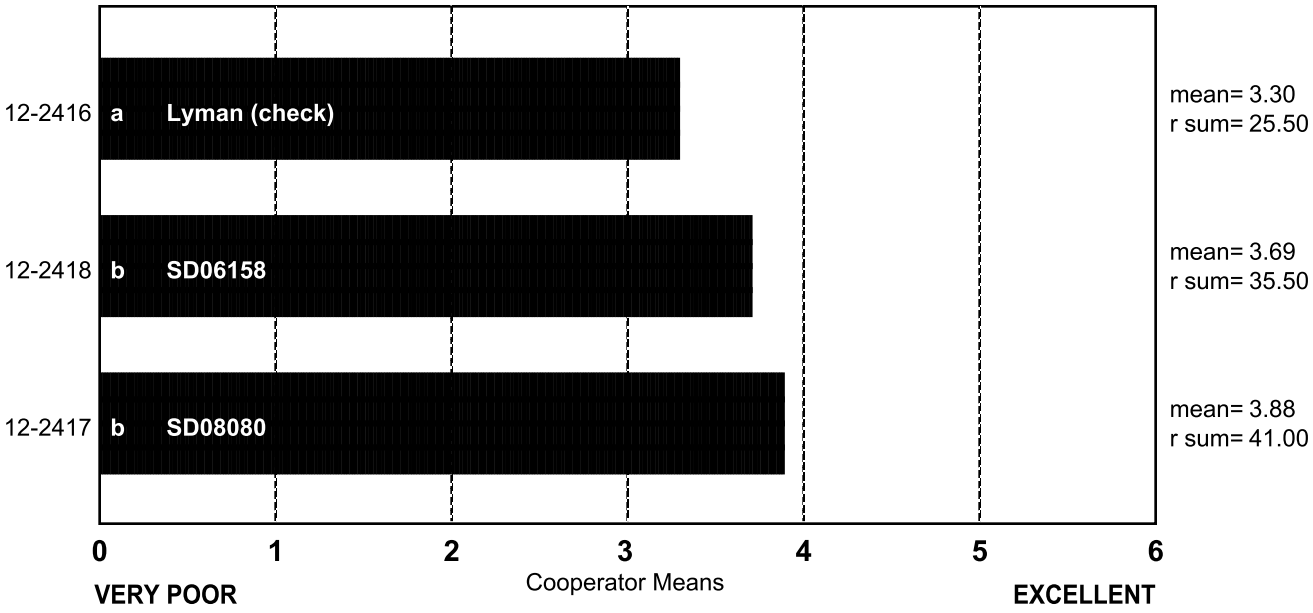


OVERALL BAKING QUALITY

(Small Scale) South Dakota

ncoop= 17
chisq= 7.26
chisqc= 8.98
cvchisq= 5.99
crdiff= 9.45

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) South Dakota

COOP. **12-2416 Lyman (check)**

A. No comment.
B. Above avg. abs, sl. short mix time, below avg. volume, tan crumb, sl. open grain, flat.
C. Short mix time, rough break.
D. No comment.
E. No comment.
F. Sticky, short mix, low volume, open grain, sl. creamy.
G. No comment.
H. No comment.
I. Good absorption, open, irregular grain, harsh texture, very good volume.
J. OK but minimal dough strength, good volume performance for protein.
K. Low loaf volume.
L. 12.1% flour protein, lower bake absorption, good bake MT, good at make-up, questionable crumb grain, dull crumb color, low LV.
M. Good volume, protein and abs; good mix time, open grain and dull color.
N. High absorption, short mix time, avg. grain, yellow, good volume.
O. Acceptable bake quality, soft dough handling and slightly weak mix tolerance.
P. Hi Abs, shorter MT, slight sticky & strong dough, med Hi OS, low volume, dense & round cells, yellow crumb, harsh & tight texture.
Q. No comment.

COOP. **12-2417 SD08080**

A. No comment.
B. Above avg. abs, avg. mix time, low volume, dull crumb, sl. open grain, sl. flat.
C. No comment.
D. No comment.
E. No comment.
F. Sticky, avg. mix, avg. volume, good recovery, sl. creamy.
G. No comment.
H. Good color, crumb grain and texture.
I. White crumb color, sl. open grain, excellent volume.
J. Good overall performance; nice crumb grain.
K. No comment.
L. 12.5% flour protein, good bake absorption & MT, good at make-up, questionable crumb grain, good LV, rated higher than check.
M. Good volume, protein, and abs; good mix time, open grain.
N. High absorption, wet dough at make-up, avg. grain, creamy, avg. volume.
O. Good overall.
P. Normal Abs, shorter MT, slight sticky & strong dough, low OS & volume, open & round cells, slight yellow crumb, slight harsh & resilient texture.
Q. No comment.

COOP. 12-2418 SD06158

A. No comment.
B. Avg. abs, avg. mix time, sl. below avg. volume, dull crumb, sl. open grain, sl. flat.
C. Excellent externals.
D. No comment.
E. No comment.
F. Low protein, very long mix, tough dough, good volume, nice interior.
G. No comment.
H. Good color and texture but dense crumb grain.
I. Below average absorption, excellent strength, good interior scores, excellent volume.
J. Great performance for such low protein flour.
K. No comment.
L. Lower flour protein, long MT, low absorption, excellent at make-up, satisfactory crumb grain, higher than the check.
M. Excellent volume, grain rating and texture; great mix time, lower abs.
N. Good absorption, sticky and wet at make-up, avg. grain, creamy, high volume.
O. Acceptable bake quality; pliable dough handling.
P. Normal Abs & MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, creamy crumb, silky & resilient texture.
Q. No comment.

Notes: **B, E, F, I, M, N, O and Q** conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

Montana – Phil Bruckner/Jim Berg

The Post Agronomy Farm (6mi west of Bozeman) had a 40% decrease in average rainfall for the 2012 crop year (9.0in versus 15.9in for the 55yr average). There was reduced snow cover during winter months but no winterkill was observed. Heading (June 17) was earlier than average by 2 days. Average temperatures from March to August (except May) were above average with below average moisture recorded in each of those months (except March and April). Above average July temperatures allowed us to harvest August 3, about 10 days earlier than our normal mid-August harvest. Stripe rust was negligible.

The Montana Intrastate Winter Wheat Test (varieties and elite lines) which includes lines grown in the WQC drill strips had yields (x = 77 bu/a, range 62-91) and test weights (x = 58.8 lb/bu, range 56.2-61.6) which were below recent averages. Proteins were higher than average at 15.2%.

Yellowstone (check)

Hard red winter wheat developed by the Montana Agricultural Experiment Station and released to seed growers in 2005. Yellowstone is a very high yielding winter hardy variety with medium test weight, maturity, height, and grain protein. Yellowstone has excellent baking and good Asian noodle quality. It is moderately resistant to TCK smut and resistant to stripe rust, but susceptible to stem rust. PVP, Title V has been issued (Certificate #200600284). Yellowstone became the leading winter wheat variety planted in Montana in 2012 with 22.8% of the acreage (500,500 acres). Yellowstone surpassed Genou (19.7% of acreage, 433,500 acres), the leading variety since 2007.

MT08172

A hollow stemmed hard red winter wheat line with the pedigree MT9982*2/BZ9W96-895. MT9982 is a Yellowstone sib line, while BZ9W96-895 is a WestBred line with an unknown pedigree from a male sterile population. MT08172 is most similar to Yellowstone. MT08172 has above average yield and test weight, and average protein. Over 39 location-years, yield of MT08172 was 1 bu/a higher and test weight was 0.5 lb/bu higher than Yellowstone. MT08172 has medium-late heading date and is taller than most Montana lines, with average winter-hardiness. MT08172 is moderately resistant to stem rust (Yellowstone is susceptible) and resistant to stripe rust (similar to Yellowstone). Milling and baking characteristics were above average and similar to Yellowstone in Montana tests.

MT0978

A hollow stemmed hard red winter wheat line with a complex pedigree (same as last year's MT0871). MT0978 is a selection from of a composite of 2 crosses with a common parent combination, MTW0072/NW97S151 (MTW0072 = hard white exp. line, Erhardt sib//NuWest/Erhardt; NW97S151 = hard white exp. line from Nebraska) crossed to either MT9982 (= Yellowstone sib.) or MTW0047 (hard white exp. line, = Judith/(PI262605, Karagach, RWA resis.)/3/(S86-740, Norstar/ Plainsman V //Ulianovka)). MT0978 has above average yield, with average test weight and protein. Over 15 location-years, yield of MT0978 was 3 bu/a higher and test weight was 1.0 lb/bu higher than MT0871. MT0978 has medium to late heading and average plant height, with above average winter-hardiness. MT0978 is resistant to both stem and stripe rust. Milling and baking characteristics were above average in Montana tests. MT0978 is a low PPO line and has shown good noodle scores in our tests.

Montana: 2012 (Small-Scale) Samples

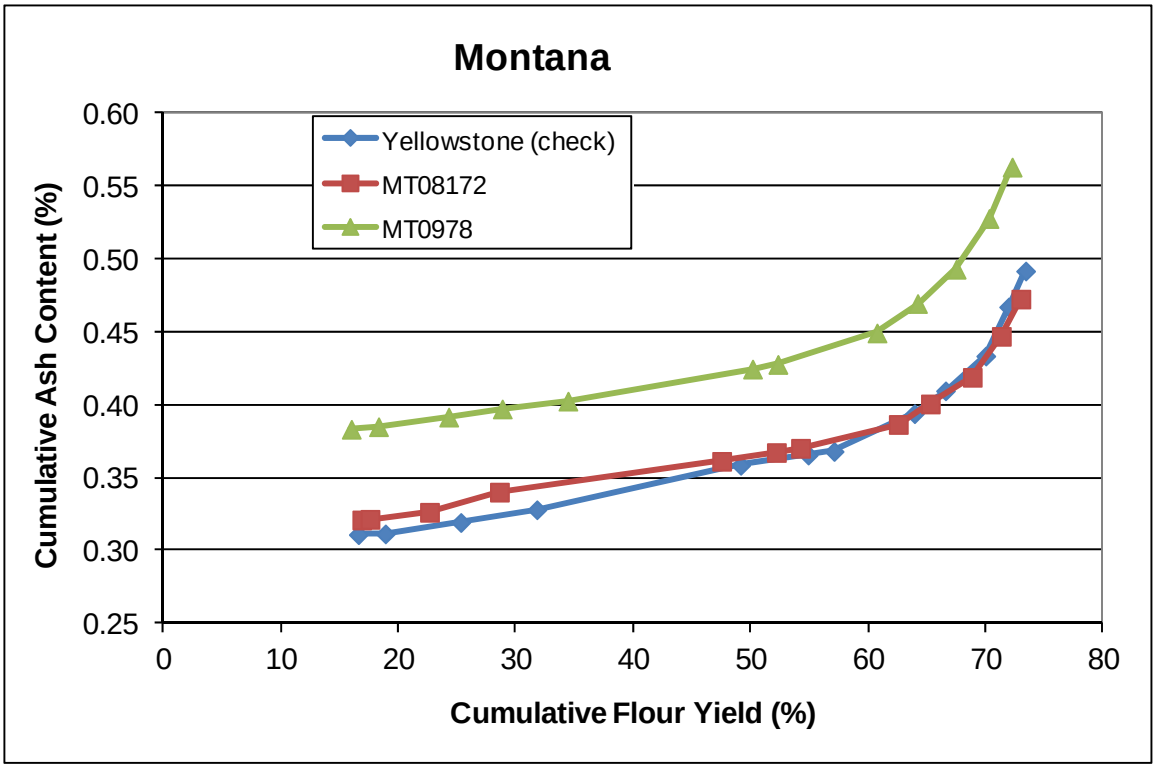
Test entry number	12-2419	12-2420	12-2421
Sample identification	**Yellowstone (check)**	**MT08172**	**MT0978**
Wheat Data			
GIPSA classification	2 HRW	2 HRW	2 HRW
Test weight (lb/bu)	59.6	59.9	58.5
Hectoliter weight (kg/hl)	78.4	78.8	77.0
1000 kernel weight (gm)	27.1	29.8	23.8
Wheat kernel size (Rotap)			
Over 7 wire (%)	53.7	68.0	31.0
Over 9 wire (%)	45.6	31.9	67.9
Through 9 wire (%)	0.7	0.1	1.1
Single kernel (skcs)[a]			
Hardness (avg /s.d)	74.2/13.4	71.9/12.4	78.2/15.4
Weight (mg) (avg/s.d)	27.1/7.1	29.8/7.2	23.8/6.2
Diameter (mm)(avg/s.d)	2.51/0.30	2.70/0.31	2.46/0.26
Moisture (%) (avg/s.d)	9.0/0.67	8.4/0.64	8.3/0.75
SKCS distribution	00-02-10-88-01	00-03-13-84-01	00-02-09-89-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb)	14.7	14.7	14.7
Wheat ash (12% mb)	1.44	1.38	1.43
Milling and Flour Quality Data			
Flour yield (%, str. grade)			
Miag Multomat Mill	73.5	73.0	72.3
Quadrumat Sr. Mill	70.0	70.7	70.1
Flour moisture (%)	11.7	11.3	11.8
Flour protein (14% mb)	13.8	13.6	14.0
Flour ash (14% mb)	0.50	0.46	0.54
Rapid Visco-Analyser			
Peak Time (min)	6.4	6.3	6.4
Peak Viscosity (RVU)	204.2	203.3	207.8
Breakdown (RVU)	48.7	50.0	48.3
Final Viscosity at 13 min (RVU)	270.7	274.7	276.4
Minolta color meter			
L*	91.4	91.9	91.2
a*	-0.78	-0.86	-1.06
b*	10.00	9.89	10.87
PPO	0.370	0.433	0.222
Falling number (sec)	538	499	583
Damaged Starch			
(AI%)	96.86	97.32	97.22
(AACC76-31)	6.95	7.33	7.26

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

Montana: Physical Dough Tests and Gluten Analysis For 2012 (Small-Scale) Samples

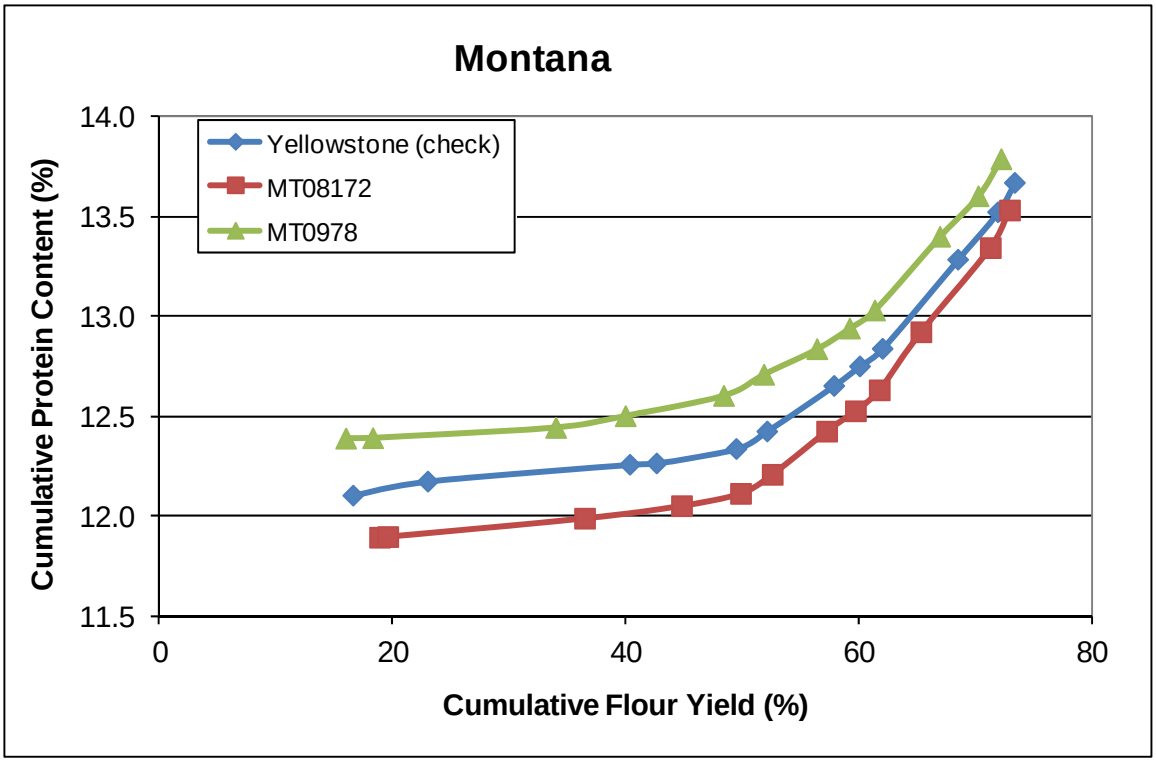
Test Entry Number	12-2419	12-2420	12-2421
Sample Identification	Yellowstone (check)	MT08172	MT0978
MIXOGRAPH			
Flour Abs (% as-is)	69.7	69.2	68.3
Flour Abs (14% mb)	67.1	66.1	65.8
Mix Time (min)	6.3	8.5	3.6
Mix tolerance (0-6)	5	5	3
FARINOGRAPH			
Flour Abs (% as-is)	65.4	66.7	69.8
Flour Abs (14% mb)	63.0	65.1	67.7
Development time (min)	6.7	7.7	7.7
Mix stability (min)	21.2	18.8	13.8
Mix Tolerance Index (FU)	21	28	17
Breakdown time (min)	14.0	13.2	15.6
ALVEOGRAPH			
P(mm): Tenacity	106	146	114
L(mm): Extensibility	106	80	106
G(mm): Swelling index	22.9	19.9	22.9
W(10^{-4} J): strength (curve area)	456	513	407
P/L: curve configuration ratio	1.00	1.83	1.08
Ie(P_{200}/P): elasticity index	72.3	75.6	60.3
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	584/728/793	775/991/991	399/519/591
Extensibility (mm at 45/90/135 min)	146/141/139	125/125/107	151/153/147
Energy (cm^2 at 45/90/135 min)	155/181/183	151/170/145	75/98/112
Resist $_{max}$ (BU at 45/90/135 min)	891/998/994	964/999/997	374/488/617
Ratio (at 45/90/135 min)	14.01/5.17/5.69	6.19/7.96/9.28	1.82/2.35/2.88
PROTEIN ANALYSIS			
HMW-GS Composition	1, 7+8, 5+10	1, 7+9, 5+10	2*, 7+8, 5+10
%IPP	55.10	58.07	49.00
SEDIMENTATION TEST			
Volume (ml)	70.1	68.8	63.4

Montana: Cumulative Ash Curves



Yellowstone (check)					MT08172					MT0978				
Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul Yield	(14%) Ash
2M	16.6	0.31	16.6	0.31	2M	16.9	0.32	16.9	0.32	2M	16.0	0.38	16.0	0.38
1M Red	2.3	0.31	18.9	0.31	1M Red	0.7	0.33	17.6	0.32	1M Red	2.3	0.40	18.3	0.38
1M	6.4	0.34	25.3	0.32	1M	5.1	0.34	22.7	0.33	1M	6.0	0.41	24.3	0.39
2BK	6.5	0.36	31.8	0.33	2BK	6.0	0.39	28.6	0.34	1BK	4.6	0.43	28.9	0.40
3M	17.3	0.41	49.1	0.36	3M	18.9	0.39	47.5	0.36	2BK	5.6	0.43	34.4	0.40
1BK	5.7	0.43	54.9	0.37	1BK	4.7	0.43	52.2	0.37	3M	15.7	0.47	50.2	0.42
Grader	2.2	0.43	57.1	0.37	Grader	2.1	0.44	54.2	0.37	Grader	2.2	0.50	52.3	0.43
4M	6.8	0.61	63.9	0.39	4M	8.3	0.49	62.6	0.39	4M	8.4	0.58	60.8	0.45
FILTER FLR	2.6	0.79	66.6	0.41	FILTER FLR	2.7	0.72	65.3	0.40	FILTER FLR	3.4	0.83	64.2	0.47
3BK	3.4	0.90	70.0	0.43	3BK	3.6	0.75	68.9	0.42	3BK	3.3	0.95	67.5	0.49
5M	1.9	1.68	72.0	0.47	5M	2.5	1.23	71.3	0.45	5M	2.8	1.37	70.3	0.53
BRAN FLR	1.4	1.72	73.4	0.49	BRAN FLR	1.7	1.57	73.0	0.47	BRAN FLR	2.0	1.83	72.3	0.56
Break Shorts	3.5	3.46	76.9	0.63	Break Shorts	3.8	3.22	76.8	0.61	Break Shorts	3.6	3.08	75.8	0.68
Red Dog	2.8	2.80	79.6	0.70	Red Dog	2.9	2.52	79.6	0.68	Red Dog	3.0	2.52	78.9	0.75
Red Shorts	0.4	4.27	80.0	0.72	Red Shorts	0.4	4.23	80.1	0.70	Red Shorts	0.4	3.91	79.2	0.77
Filter Bran	1.1	2.06	81.1	0.74	Filter Bran	1.1	2.53	81.1	0.72	Filter Bran	1.3	1.99	80.5	0.79
Bran	18.9	4.76	100.0	1.50	Bran	18.9	4.82	100.0	1.49	Bran	19.5	4.58	100.0	1.53
Wheat		1.41			Wheat		1.35			Wheat		1.39		
St. Grd. Fl.		0.50			St. Grd. Fl.		0.46			St. Grd. Fl.		0.54		

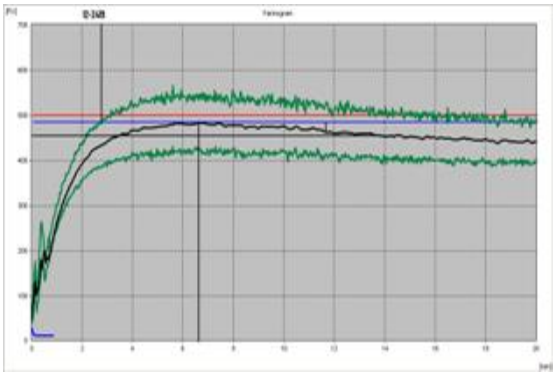
Montana: Cumulative Protein Curves



Yellowstone (check)					MT08172					MT0978				
Mill Streams	Strm-yld (14%mb)	Protein	Cumulative Yield	(14%) Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative Yield	(14%) Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative Yield	(14%) Protein
2M	16.6	12.1	16.6	12.1	3M	18.9	11.9	18.9	11.9	2M	16.0	12.4	16.0	12.4
1M	6.4	12.4	23.0	12.2	1M Red	0.7	12.0	19.6	11.9	1M Red	2.3	12.4	18.3	12.4
3M	17.3	12.4	40.4	12.3	2M	16.9	12.1	36.5	12.0	3M	15.7	12.5	34.0	12.4
1M Red	2.3	12.4	42.7	12.3	4M	8.3	12.3	44.8	12.0	1M	6.0	12.8	40.0	12.5
4M	6.8	12.8	49.5	12.3	1M	5.1	12.7	49.9	12.1	4M	8.4	13.1	48.4	12.6
FILTER FLR	2.6	14.1	52.2	12.4	FILTER FLR	2.7	13.9	52.6	12.2	FILTER FLR	3.4	14.2	51.9	12.7
1BK	5.7	14.7	57.9	12.7	1BK	4.7	14.9	57.3	12.4	1BK	4.6	14.3	56.4	12.8
Grader	2.2	15.3	60.1	12.7	5M	2.5	14.9	59.8	12.5	5M	2.8	15.0	59.2	12.9
5M	1.9	15.6	62.1	12.8	Grader	2.1	15.7	61.8	12.6	Grader	2.2	15.5	61.4	13.0
2BK	6.5	17.6	68.5	13.3	3BK	3.6	18.0	65.4	12.9	2BK	5.6	17.5	67.0	13.4
3BK	3.4	18.3	72.0	13.5	2BK	6.0	18.0	71.3	13.3	3BK	3.3	17.7	70.3	13.6
BRAN FLR	1.4	21.0	73.4	13.7	BRAN FLR	1.7	21.6	73.0	13.5	BRAN FLR	2.0	20.4	72.3	13.8
Break Shorts	3.5	17.2	76.9	13.8	Break Shorts	3.8	16.3	76.8	13.7	Break Shorts	3.6	15.4	75.8	13.9
Red Dog	2.8	15.1	79.7	13.9	Red Dog	2.9	15.8	79.6	13.7	Red Dog	3.0	15.2	78.8	13.9
Red Shorts	0.4	15.9	80.0	13.9	Red Shorts	0.4	16.6	80.1	13.8	Red Shorts	0.4	15.0	79.2	13.9
Filter Bran	1.1	12.9	81.1	13.9	Filter Bran	1.1	13.3	81.1	13.8	Filter Bran	1.3	13.0	80.5	13.9
Bran	18.9	18.4	100.0	14.7	Bran	18.9	16.8	100.0	14.3	Bran	19.5	16.5	100.0	14.4
Wheat		14.4			Wheat		14.4			Wheat		14.4		
St. Grd. Fl.		13.8			St. Grd. Fl.		13.6			St. Grd. Fl.		14.0		

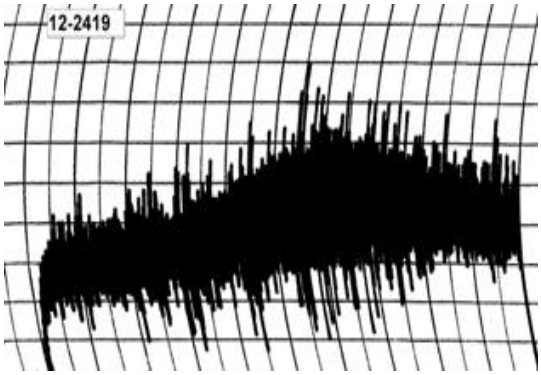
Physical Dough Tests
2012 (Small Scale) Samples – Montana

Farinograms



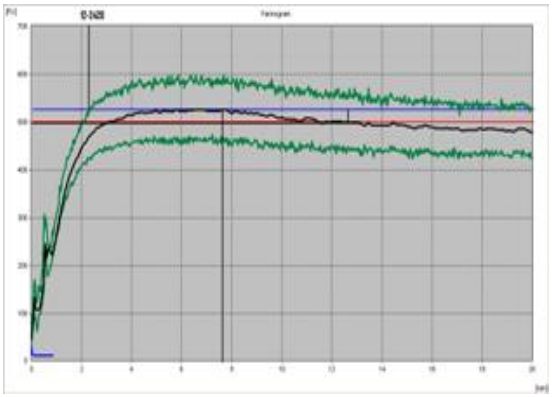
Water abs = 63.0%, Peak time = 6.7 min,
Mix stab = 21.2 min, MTI = 21 FU

Mixograms

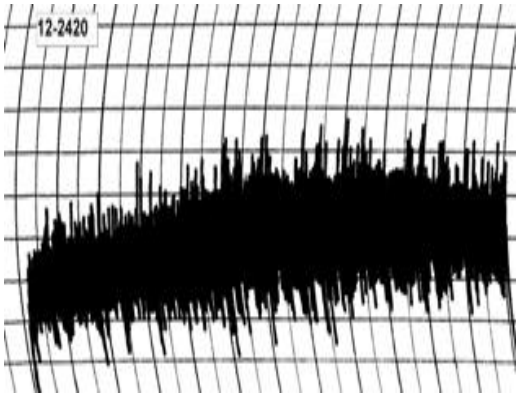


Water abs = 67.1%
Mix time = 6.3 min

12-2419, Yellowstone (check)



Water abs = 65.1%, Peak time = 7.7 min,
Mix stab = 18.8 min, MTI = 28 FU



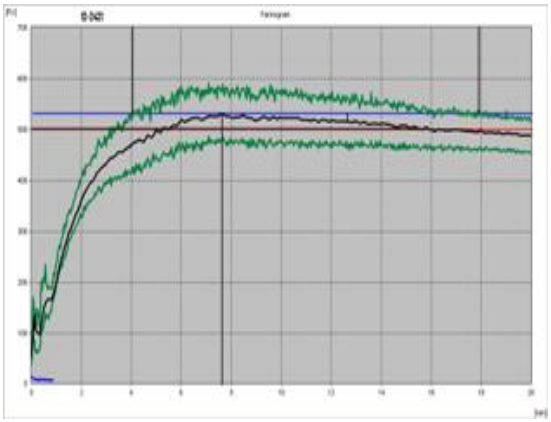
Water abs = 66.1%
Mix time = 8.5 min

12-2420, MT08172

Physical Dough Tests

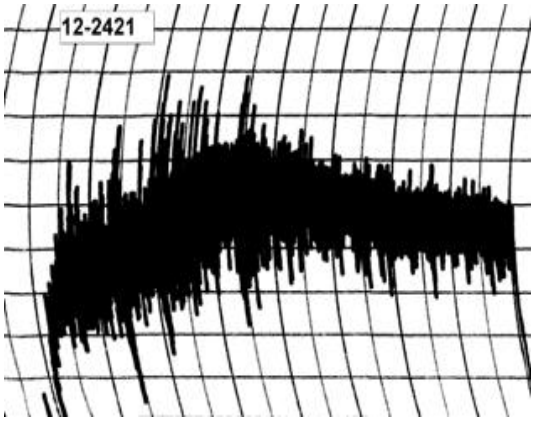
2012 (Small Scale) Samples – Montana (continued)

Farinograms



Water abs. = 67.7%, Peak time = 7.7 min,
Mix stab = 13.8 min, MTI = 17 FU

Mixograms

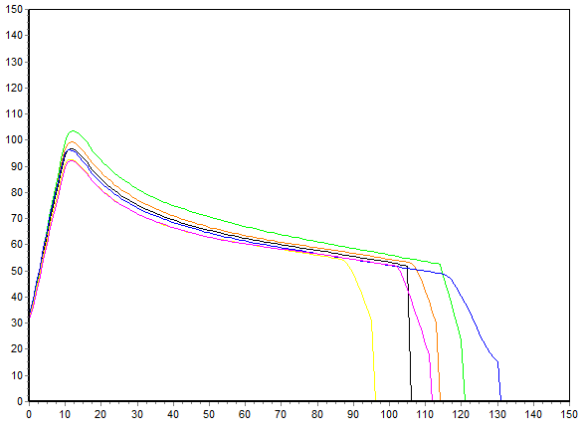


Water abs = 65.8%
Mix time = 3.6 min

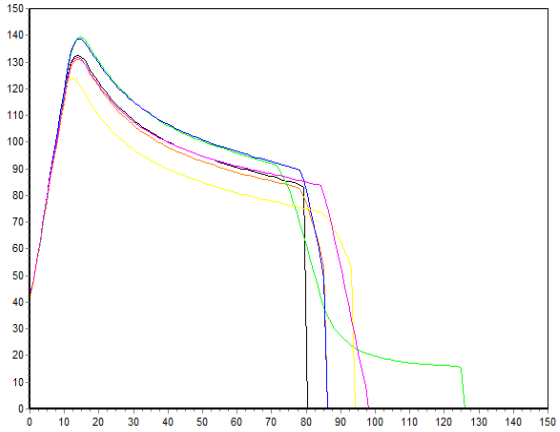
12-2421, MT0978

Physical Dough Tests - Alveograph

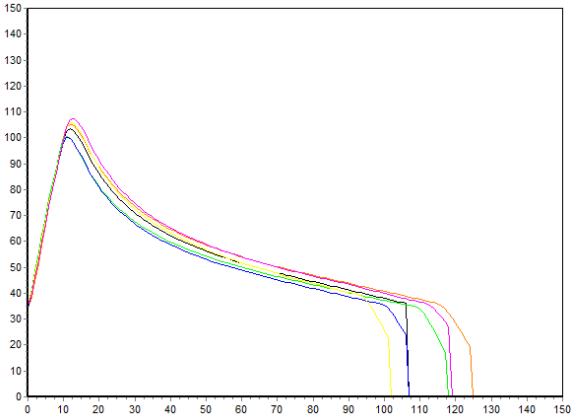
2012 (Small Scale) Samples – Montana



12-2419, Yellowstone (check)
P (mm H_20) = 106, L (mm) = 106, W ($10E^{-4}J$) = 456



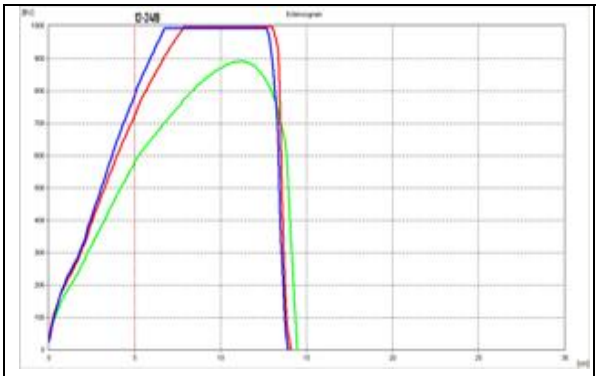
12-2420, MT08172
P (mm H_20) = 146, L (mm) = 80, W ($10E^{-4}J$) = 513



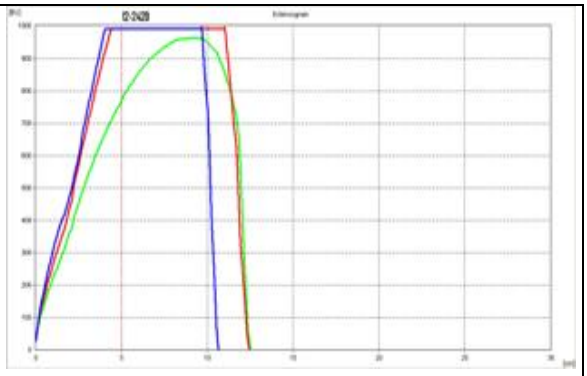
12-2421, MT0978
P (mm H_20) = 114, L (mm) = 106, W ($10E^{-4}J$) = 407

Physical Dough Tests - Extensigraph

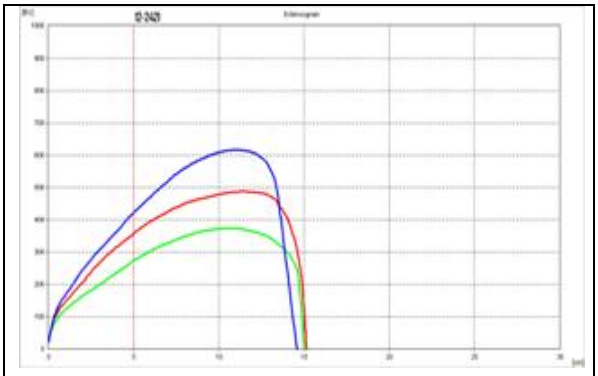
2012 (Small Scale) Samples – Montana



Yellowstone (check) - 2419
R (BU) = 728, E (mm) = 141, W (cm^2) = 181
Rmax (BU) = 998, Ratio = 5.2 at 90 min



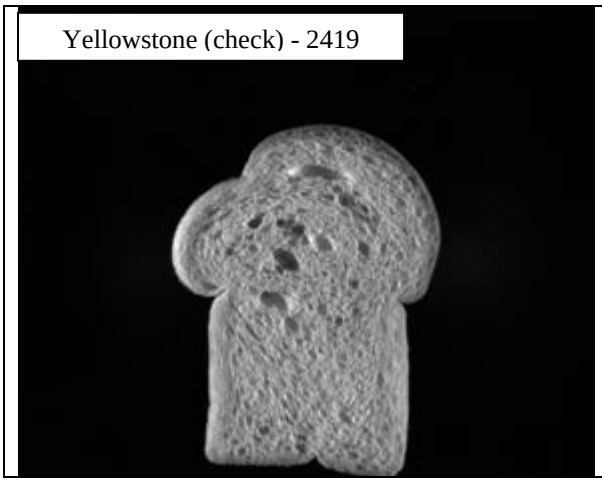
MT08172 - 2420
R (BU) = 991, E (mm) = 125, W (cm^2) = 170
Rmax (BU) = 999, Ratio = 8.0 at 90 min



MT0978 - 2421
R (BU) = 359, E (mm) = 153, W (cm^2) = 98
Rmax (BU) = 488, Ratio = 2.4 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 for 2012 (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	6499	131.5	3994	0.442	2.014	0.729	1.750	-9.35
2420	6727	134.1	3935	0.449	2.154	2.211	1.740	-14.45

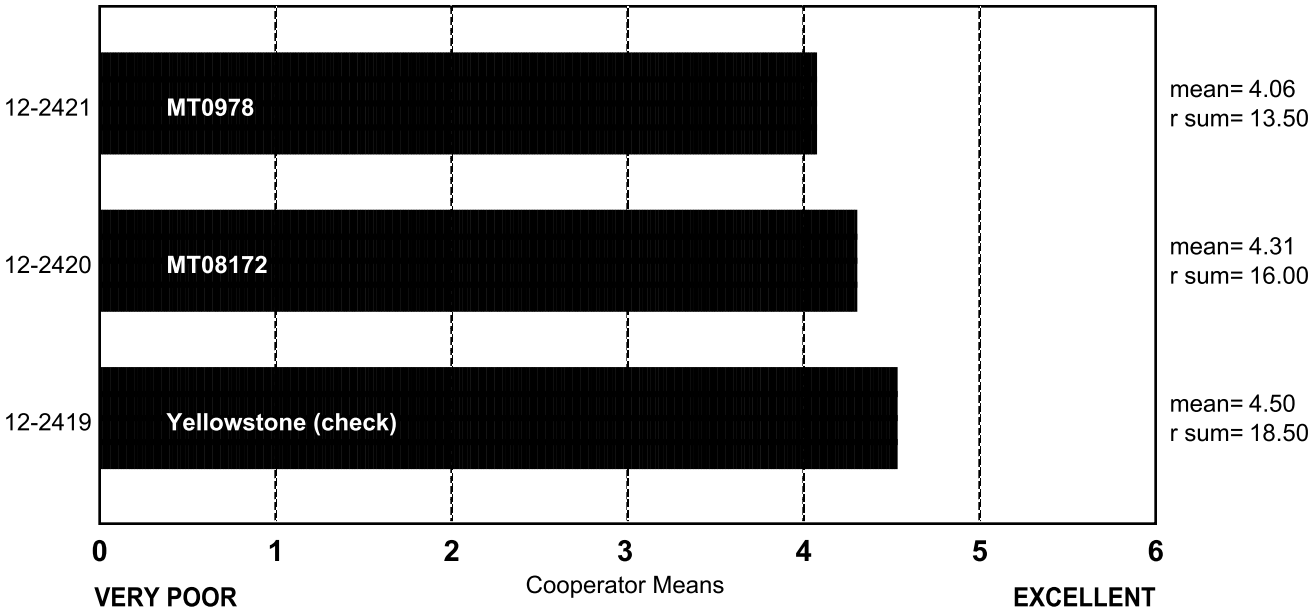
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2421	6487	138.5	3713	0.456	2.225	4.144	1.720	-14.45

SPONGE CHARACTERISTICS

(Small Scale) Montana

ncoop= 8
chisq= 1.56
chisqc= 3.13
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

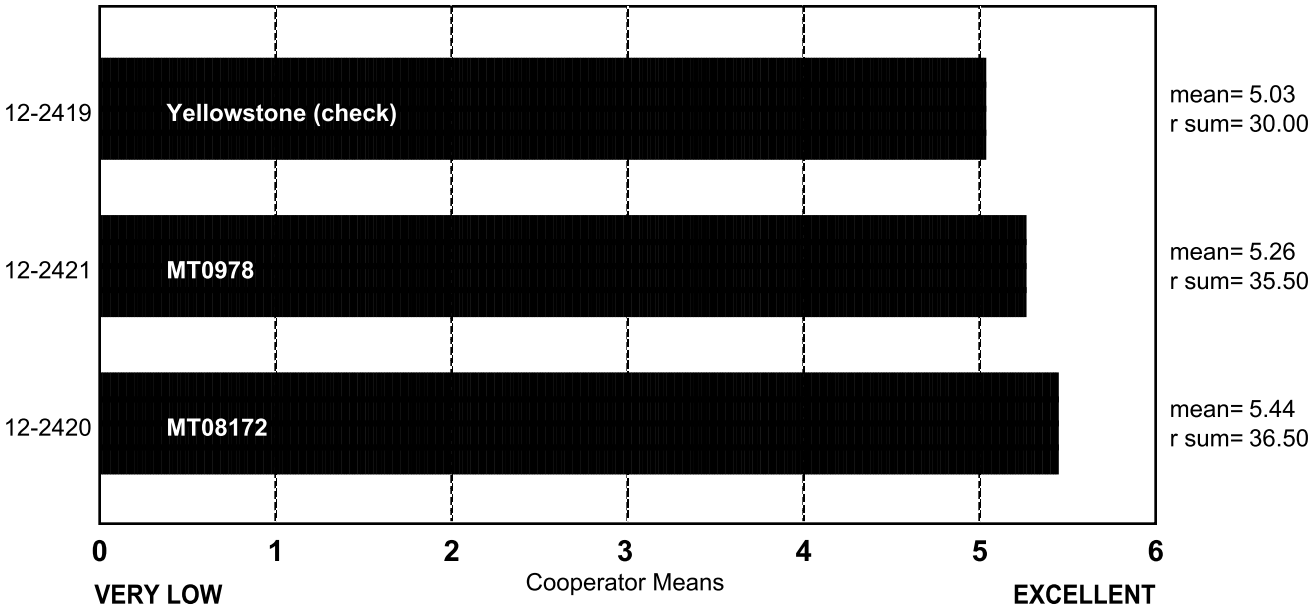


BAKE ABSORPTION

(Small Scale) Montana

ncoop= 17
chisq= 1.44
chisqc= 2.28
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Montana

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2419 Yellowstone (check)	**69.1**	**65.0**	**66.4**	**69.8**	**63.0**	**60.0**	**63.0**	**67.0**	**63.0**	**69.5**	**59.9**	**67.1**	**63.0**	**64.0**	**64.0**	**61.4**	**62.5**
12-2420 MT08172	**68.1**	**70.0**	**67.0**	**68.6**	**65.0**	**60.0**	**65.1**	**67.0**	**65.0**	**68.1**	**61.6**	**66.6**	**65.1**	**65.0**	**64.0**	**64.8**	**65.0**
12-2421 MT0978	**68.1**	**66.0**	**64.5**	**68.2**	**67.5**	**60.0**	**67.7**	**70.9**	**66.0**	**67.6**	**64.2**	**66.2**	**67.7**	**67.0**	**64.0**	**63.4**	**65.0**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Montana

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2419 Yellowstone (check)	**6.0**	**20.0**	**5.8**	**7.2**	**6.5**	**20.0**	**12.0**	**5.3**	**25.0**	**6.7**	**2.8**	**9.1**	**29.0**	**18.0**	**9.0**	**6.2**	**30.0**
12-2420 MT08172	**8.0**	**20.0**	**7.8**	**8.1**	**7.5**	**20.0**	**8.0**	**6.2**	**25.0**	**7.7**	**4.8**	**11.5**	**24.0**	**20.0**	**9.0**	**9.0**	**30.0**
12-2421 MT0978	**3.5**	**7.0**	**3.3**	**3.6**	**7.5**	**11.0**	**8.0**	**3.2**	**25.0**	**4.1**	**2.5**	**4.8**	**6.0**	**5.0**	**3.0**	**4.6**	**15.0**

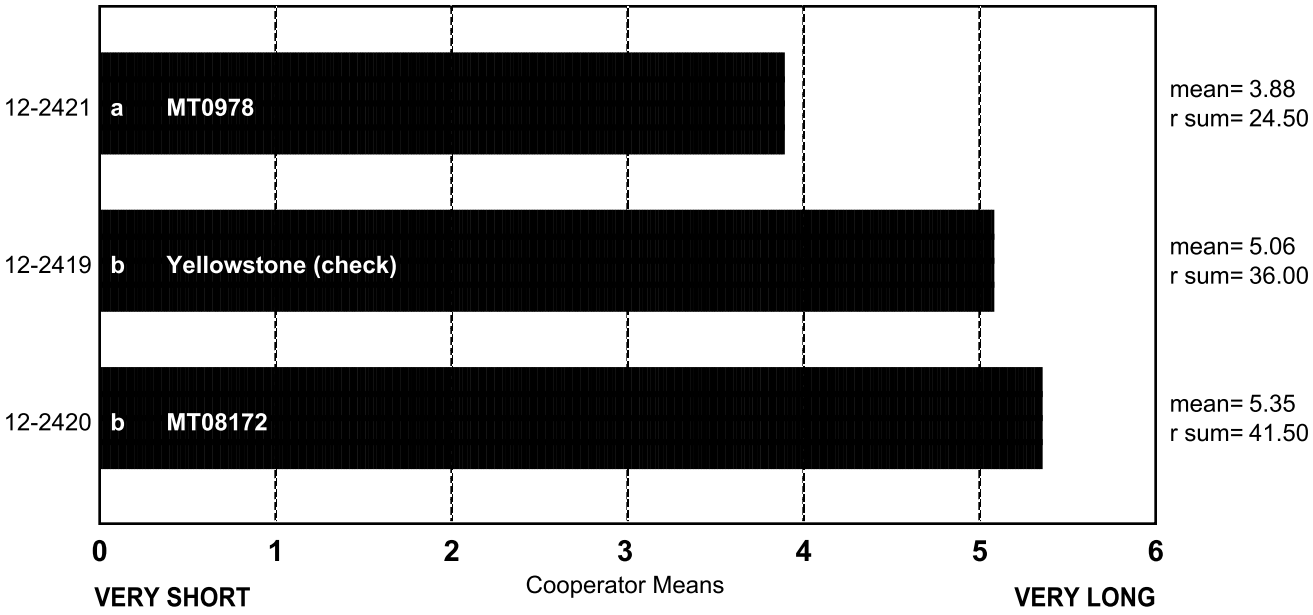
Raw Data

BAKE MIX TIME

(Small Scale) Montana

ncoop= 17
chisq= 8.85
chisqc= 11.58
cvchisq= 5.99
crdiff= 8.69

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

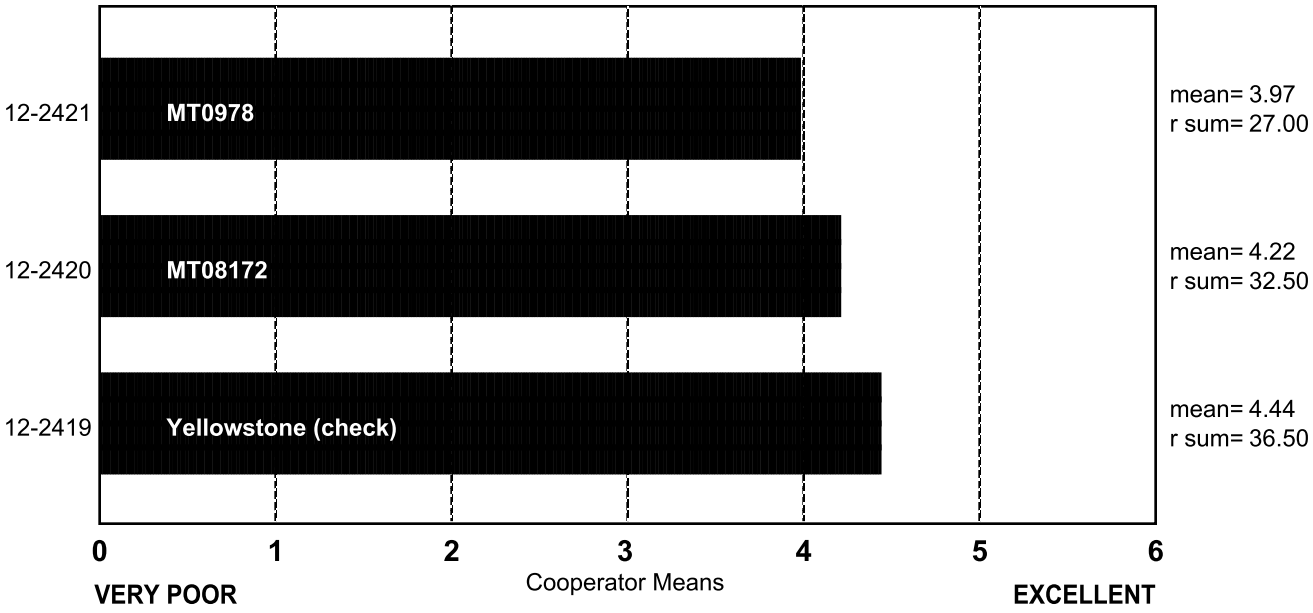


MIXING TOLERANCE

(Small Scale) Montana

ncoop= 16
chisq= 2.84
chisqc= 4.23
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

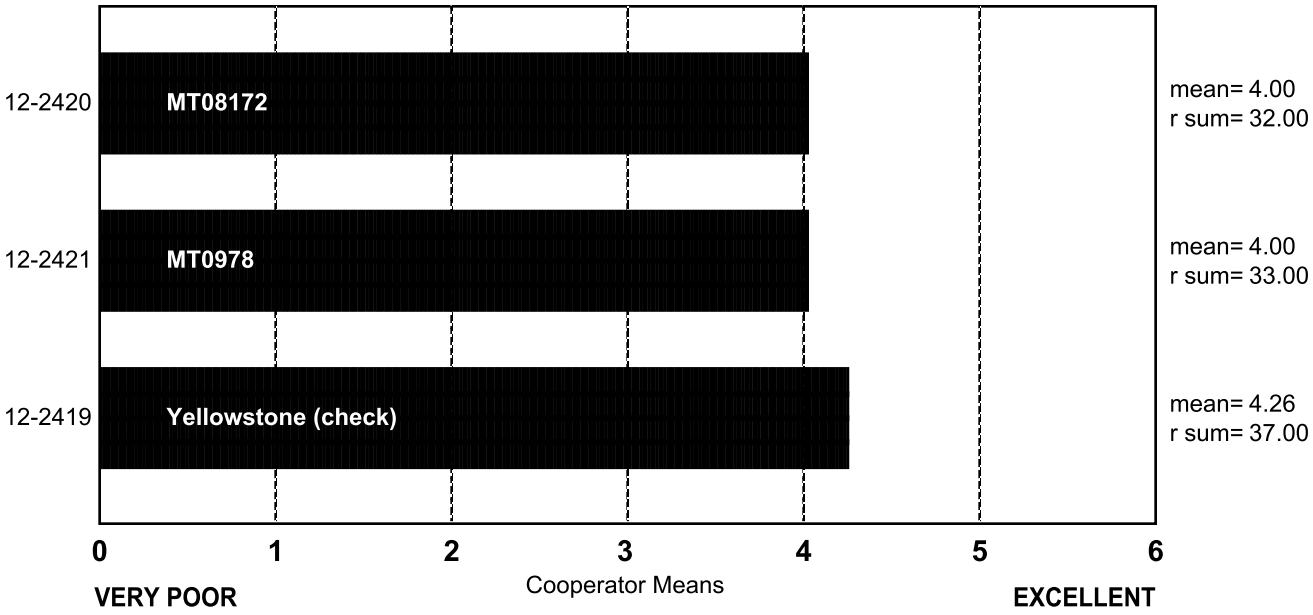


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Montana

ncoop= 17
chisq= 0.82
chisqc= 1.06
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'OUT OF MIXER', DESCRIBED

(Small Scale) Montana

	Sticky	Wet	Tough	Good	Excellent
12-2419 Yellowstone (check)	**1**	**0**	**6**	**8**	**2**
12-2420 MT08172	**2**	**0**	**8**	**6**	**1**
12-2421 MT0978	**2**	**3**	**0**	**12**	**0**

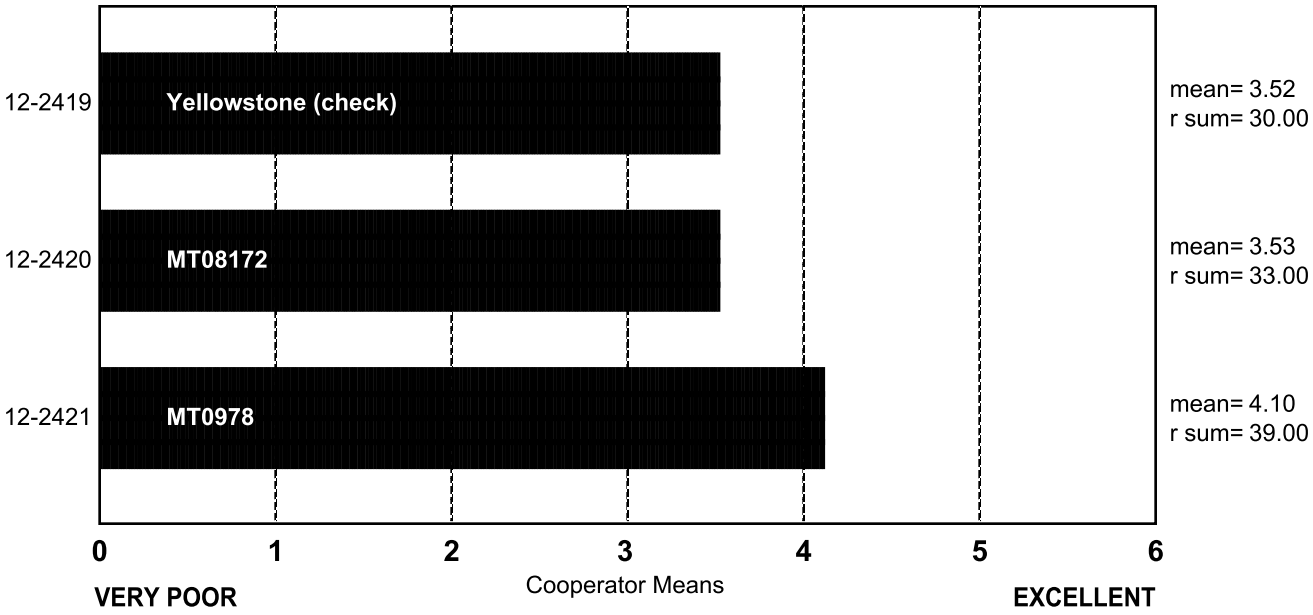
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Montana

ncoop= 17
chisq= 2.47
chisqc= 3.91
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) Montana

	Sticky	Wet	Tough	Good	Excellent
12-2419 Yellowstone (check)	**1**	**0**	**9**	**5**	**2**
12-2420 MT08172	**3**	**0**	**10**	**2**	**2**
12-2421 MT0978	**1**	**3**	**3**	**9**	**1**

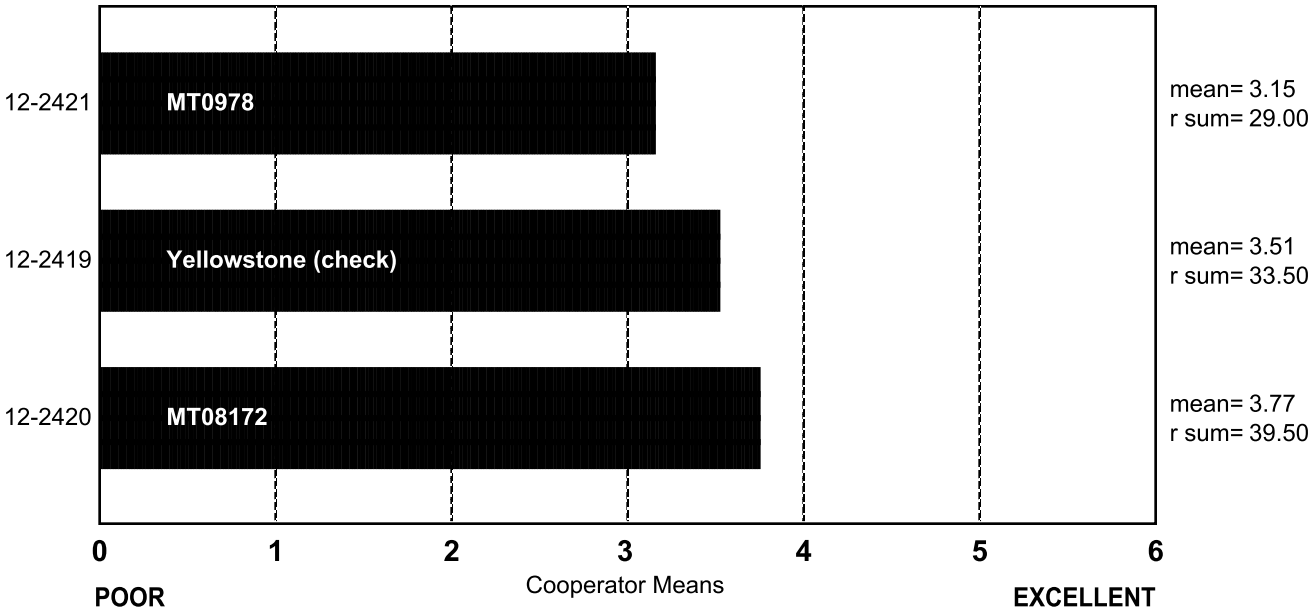
Frequency Table

CRUMB GRAIN

(Small Scale) Montana

ncoop= 17
chisq= 3.26
chisqc= 4.27
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB GRAIN, DESCRIBED

(Small Scale) Montana

	Open	Fine	Dense
12-2419 Yellowstone (check)	**12**	**5**	**0**
12-2420 MT08172	**10**	**7**	**0**
12-2421 MT0978	**12**	**4**	**1**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Montana

	Round	Irregular	Elongated
12-2419 Yellowstone (check)	**5**	**6**	**6**
12-2420 MT08172	**2**	**7**	**8**
12-2421 MT0978	**6**	**9**	**2**

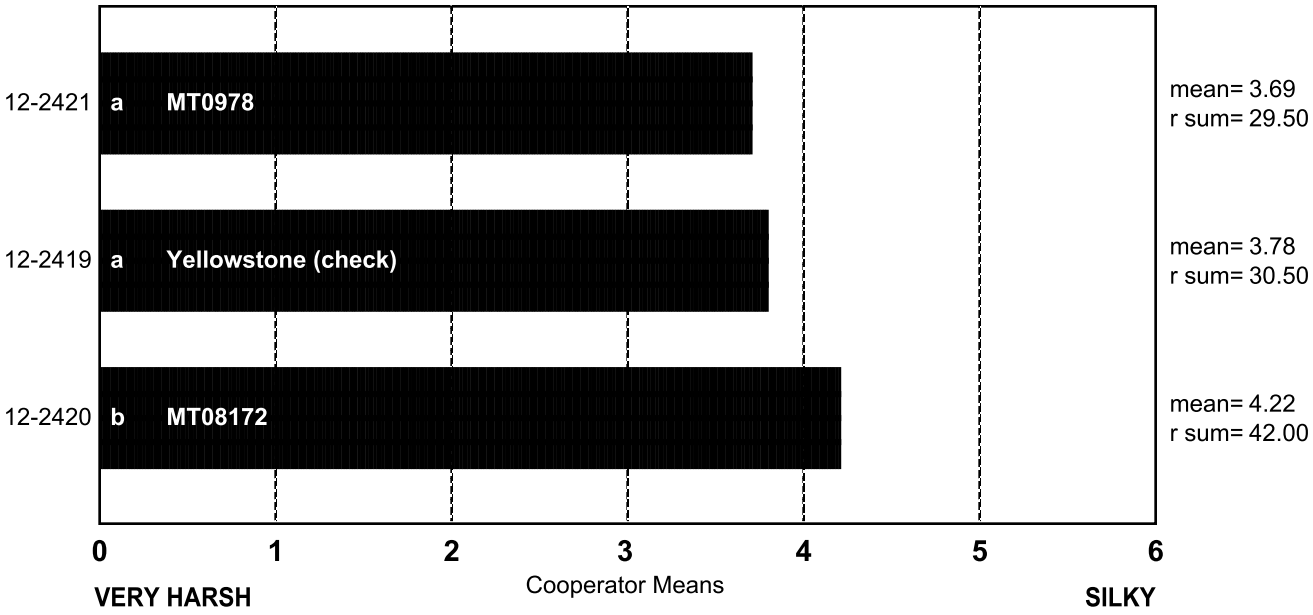
Frequency Table

CRUMB TEXTURE

(Small Scale) Montana

ncoop= 17
chisq= 5.68
chisqc= 8.98
cvchisq= 5.99
crdiff= 8.35

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB TEXTURE, DESCRIBED

(Small Scale) Montana

	Harsh	Smooth	Silky
12-2419 Yellowstone (check)	**3**	**11**	**3**
12-2420 MT08172	**0**	**12**	**5**
12-2421 MT0978	**4**	**10**	**3**

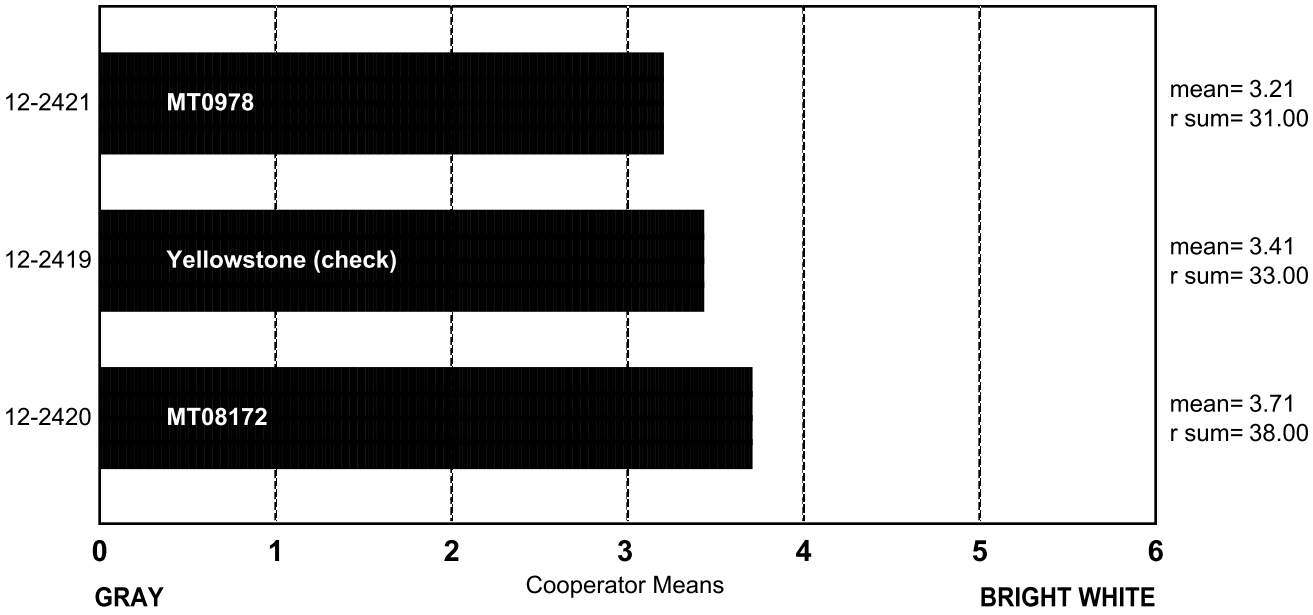
Frequency Table

CRUMB COLOR

(Small Scale) Montana

ncoop= 17
chisq= 1.53
chisqc= 4.52
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB COLOR, DESCRIBED

(Small Scale) Montana

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
12-2419 Yellowstone (check)	**0**	**0**	**3**	**8**	**6**	**0**	**0**
12-2420 MT08172	**0**	**0**	**3**	**5**	**6**	**3**	**0**
12-2421 MT0978	**0**	**0**	**5**	**5**	**6**	**1**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Montana

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2419 Yellowstone (check)	**179.0**	**464.6**	**144.0**	**139.7**	**480.5**	**415.0**	**464.0**	**131.8**	**489.3**	**154.7**	**132.9**	**153.8**	**455.5**	**486.2**	**134.0**	**141.4**	**461.4**
12-2420 MT08172	**179.0**	**462.3**	**140.7**	**138.9**	**476.5**	**415.0**	**467.0**	**131.2**	**484.1**	**153.0**	**130.1**	**152.9**	**451.4**	**486.2**	**134.0**	**142.7**	**466.1**
12-2421 MT0978	**178.0**	**463.1**	**145.6**	**142.1**	**468.0**	**411.0**	**462.0**	**134.3**	**488.8**	**152.7**	**134.2**	**151.7**	**453.3**	**483.0**	**134.0**	**147.0**	**456.5**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Montana

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2419 Yellowstone (check)	**938**	**2500**	**965**	**814**	**2950**	**3100**	**2525**	**945**	**3162**	**958**	**810**	**955**	**2292**	**2400**	**1035**	**850**	**2725**
12-2420 MT08172	**955**	**2500**	**1155**	**850**	**2800**	**3100**	**2350**	**960**	**3162**	**976**	**875**	**1000**	**2375**	**2475**	**1000**	**873**	**2575**
12-2421 MT0978	**965**	**2375**	**850**	**643**	**3200**	**2900**	**2600**	**950**	**3074**	**980**	**845**	**930**	**2400**	**2388**	**975**	**923**	**2625**

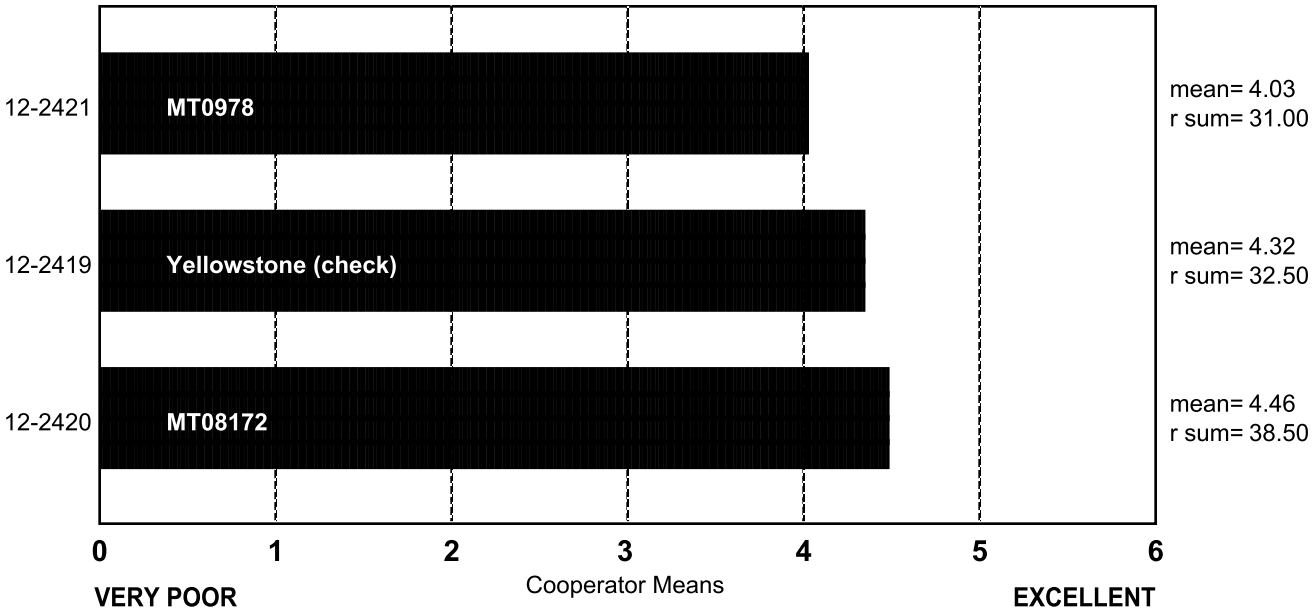
Raw Data

LOAF VOLUME

(Small Scale) Montana

ncoop= 17
chisq= 1.85
chisqc= 2.86
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

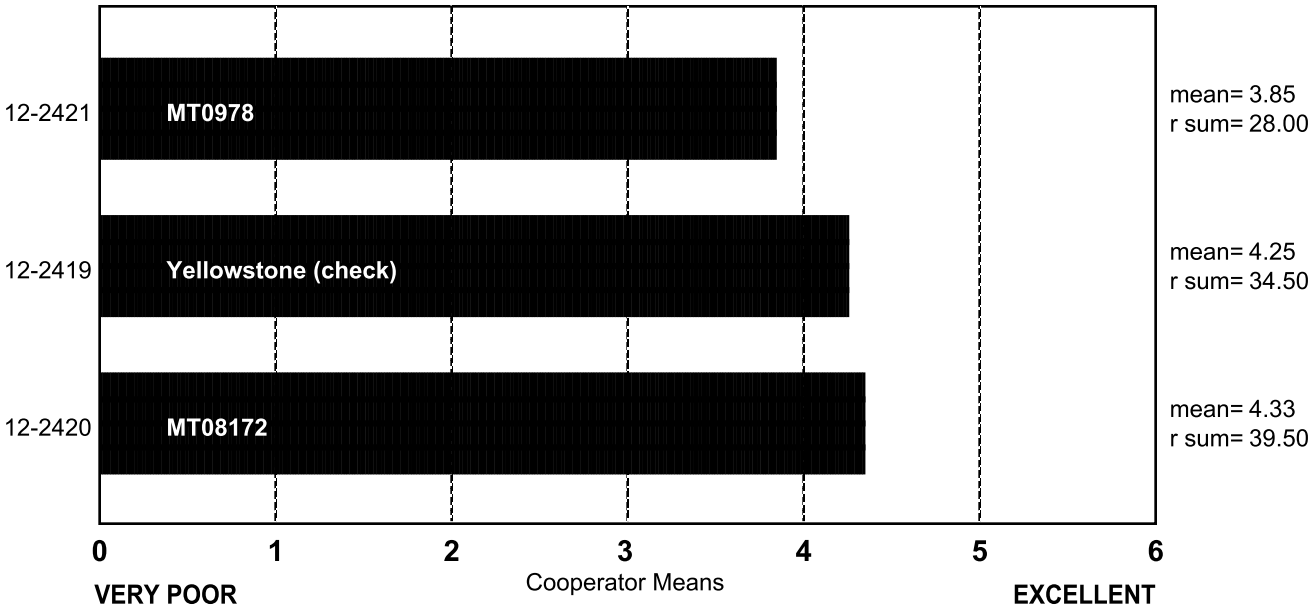


OVERALL BAKING QUALITY

(Small Scale) Montana

ncoop= 17
chisq= 3.91
chisqc= 4.67
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) Montana

COOP. **12-2419 Yellowstone (check)**

A. No comment.
B. High abs, poor/long mix time, low volume, creamy crumb, sl. open grain, sl. flat, good break/shred.
C. Long time to pick-up, very strong out of mixer.
D. No comment.
E. No comment.
F. Very long mix, high protein, very tough dry dough, very open interior, excellent volume.
G. No comment.
H. No comment.
I. Very good absorption, very strong mixing dough, excellent volume, very good internal scores.
J. Long mix time; good overall performance.
K. No comment.
L. 13.6% flour protein, excellent bake absorption, excellent mixing tolerance, very long MT, best crumb grain of series, high LV.
M. Too high of mix time, high protein and stability, low volume and open grain, harsh texture.
N. High absorption, long mix time, tough dough, avg. grain, high volume.
O. Excellent bake quality; strong dough handling, could take more water.
P. Normal Abs & MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, slight yellow crumb, smooth & resilient texture.
Q. No comment.

COOP. **12-2420 MT08172**

A. No comment.
B. Very high abs, poor/long mix time, low volume, creamy crumb, sl. open grain, sl. flat.
C. Long time to pick-up, long mix time, strong/bucky out of mixer, excellent externals.
D. No comment.
E. No comment.
F. Very long mix, high protein, very tough dry dough, very open interior, excellent volume.
G. No comment.
H. Long mixer.
I. Excellent absorption, very strong mixing dough, very good interior scores, excellent volume.
J. Very long mix time; good overall performance.
K. Good loaf volume, long mix time.
L. 13.3% flour protein, excellent bake absorption, excellent mixing tolerance, very long MT, excellent crumb grain, high LV.
M. Too high of mix time, high protein and stability, low volume and open grain.
N. High absorption, very long mix time, tough dough, good grain, creamy, high volume.
O. Great bake quality, strong dough handling, could take more water.
P. Normal Abs, longer MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, slight yellow crumb, silky & resilient texture.
Q. No comment.

COOP. 12-2421 MT0978

A. No comment.
B. High abs, avg. mix time, low volume, tan crumb, open grain, flat.
C. Short mix time.
D. No comment.
E. Wild break & shred.
F. Short mix for high protein, good volume, very open.
G. No comment.
H. No comment.
I. Excellent absorption, above average interior scores, excellent volume.
J. Average performance overall but under performed on loaf volume for the protein level.
K. High bake absorption.
L. 13.7% flour protein, excellent bake absorption, lower mixing tolerance, good bake MT, good LV, questionable crumb grain.
M. Really high protein but good mix time; good volume, grain rating and texture.
N. High absorption, sticky and wet at make-up, open grain, yellow, good volume.
O. Acceptable bake quality; good dough handling but open grain.
P. Normal Abs & MT, slight sticky & strong dough, Hi OS & volume, open & elongated cells, yellow crumb, smooth & resilient texture.
Q. No comment.

Notes: **B, E, F, I, M, N, O and Q** conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

Texas-Amarillo – Jackie Rudd

The Wheat Quality Council samples submitted by Texas A&M AgriLife Research were harvested in June, 2012 from strips planted adjacent to our irrigated yield trials at Bushland (near Amarillo in the Texas Panhandle). We fertilized for a yield goal of 100 bu/a. The grain yields of TAM 111, TX07A001505, and TX03A0563-07 were 79, 82, and 83 bu/a respectively. The crop was flood irrigated four times from early March to early May. Crop development was normal for the Texas Panhandle and there were no significant abiotic or biotic stresses except some post-anthesis heat. Stripe rust appeared late in the season but did not impact on yield.

TAM 111 (CHECK)
TAM 111 (TX95A3091), a hard red winter wheat from the cross TAM 107//TX78V3620/CTK78/3/TX87V1233, was released in 2002 and licensed to AgriPro Wheat. It has good yield under dryland and irrigated conditions and is resistant to stripe rust. The 2010 Texas Wheat Variety Survey indicated that TAM 111 is the most widely grown variety in the state occupying 16% of the total state acreage and 26% of the acreage in the Texas Panhandle.

TX07A001505
This hard red winter wheat experimental was selected from the TAM Wheat Improvement Program in Amarillo from the cross T107//TX98V3620/Ctk78/3/TX87V1233/4/N87V106//TX86V1540/T200. It is resistant to leaf rust and stripe rust, but is susceptible to stem rust race TTKSK (Ug99 of Kenyan origin). It has good yield under a wide range of environments across Texas and the Great Plains, but is particularly suited for the High Plains and Rolling Plains of Texas. TX07A001505 has good test weight (≥60 lbs/bu) and strong dough characteristics.

TX03A0563-07
This hard red winter wheat experimental was selected from the TAM Wheat Improvement Program in Amarillo from the cross X96V107/OGALLALA. It is resistant to leaf rust and stem rust (including race TTKSK/Ug99 of Kenyan origin) and intermediate to stripe rust. It has good yield under a wide range of environments across Texas and the Great Plains, but is particularly suited for the High Plains of Texas. TX03A0563-07 has good test weight (≥60 lbs/bu) and average dough characteristics.

Texas: 2012 (Small-Scale) Samples

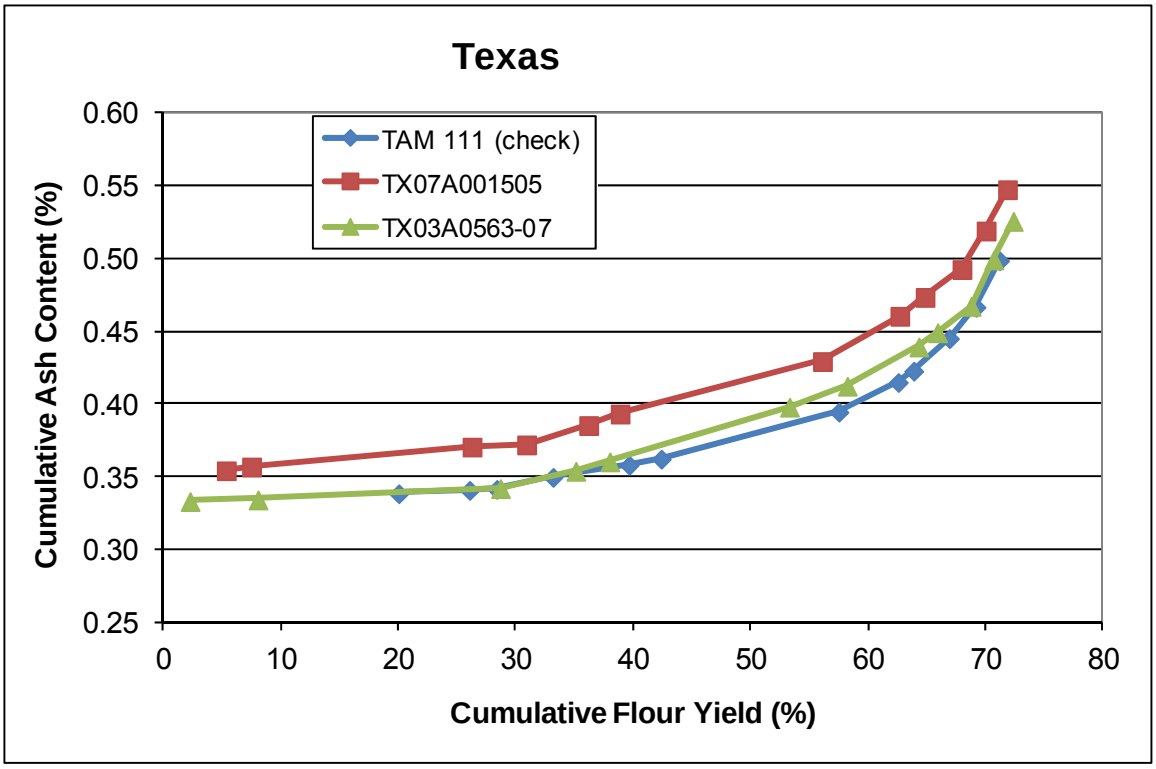
Test entry number	12-2422	12-2423	12-2424
Sample identification	**TAM 111 (check)**	**TX07A001505**	**TX03A0563-07**
Wheat Data			
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	61.1	61.2	61.5
Hectoliter weight (kg/hl)	80.4	80.5	80.9
1000 kernel weight (gm)	28.4	26.2	26.0
Wheat kernel size (Rotap)			
Over 7 wire (%)	66.9	52.0	47.0
Over 9 wire (%)	32.1	46.9	51.3
Through 9 wire (%)	1.1	1.2	1.8
Single kernel (skcs)[a]			
Hardness (avg /s.d)	61.5/16.0	64.0/17.5	63.4/15.9
Weight (mg) (avg/s.d)	28.4/8.6	26.2/7.1	26.0/6.5
Diameter (mm)(avg/s.d)	2.60/0.36	2.56/0.28	2.60/0.28
Moisture (%) (avg/s.d)	9.0/0.8	8.3/1.0	8.7/0.8
SKCS distribution	02-14-27-57-01	03-13-21-63-01	02-13-26-59-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb)	13.4	14.6	14.4
Wheat ash (12% mb)	1.55	1.50	1.49
Milling and Flour Quality Data			
Flour yield (%, str. grade)			
Miag Multomat Mill	71.2	71.8	72.4
Quadrumat Sr. Mill	69.3	68.7	71.5
Flour moisture (%)	12.5	11.8	11.9
Flour protein (14% mb)	12.0	13.1	12.8
Flour ash (14% mb)	0.54	0.54	0.54
Rapid Visco-Analyser			
Peak Time (min)	6.2	6.2	6.1
Peak Viscosity (RVU)	197.8	208.8	160.3
Breakdown (RVU)	52.3	58.0	26.4
Final Viscosity at 13 min (RVU)	272.8	274.4	256.9
Minolta color meter			
L*	92.3	91.7	92.0
a*	-1.01	-1.14	-0.77
b*	8.86	9.79	8.23
PPO	0.694	0.619	0.499
Falling number (sec)	595	608	694
Damaged Starch			
(AI%)	96.72	97.08	97.27
(AACC76-31)	6.84	7.14	7.29

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

Texas: Physical Dough Tests and Gluten Analysis For 2012 (Small-Scale) Samples

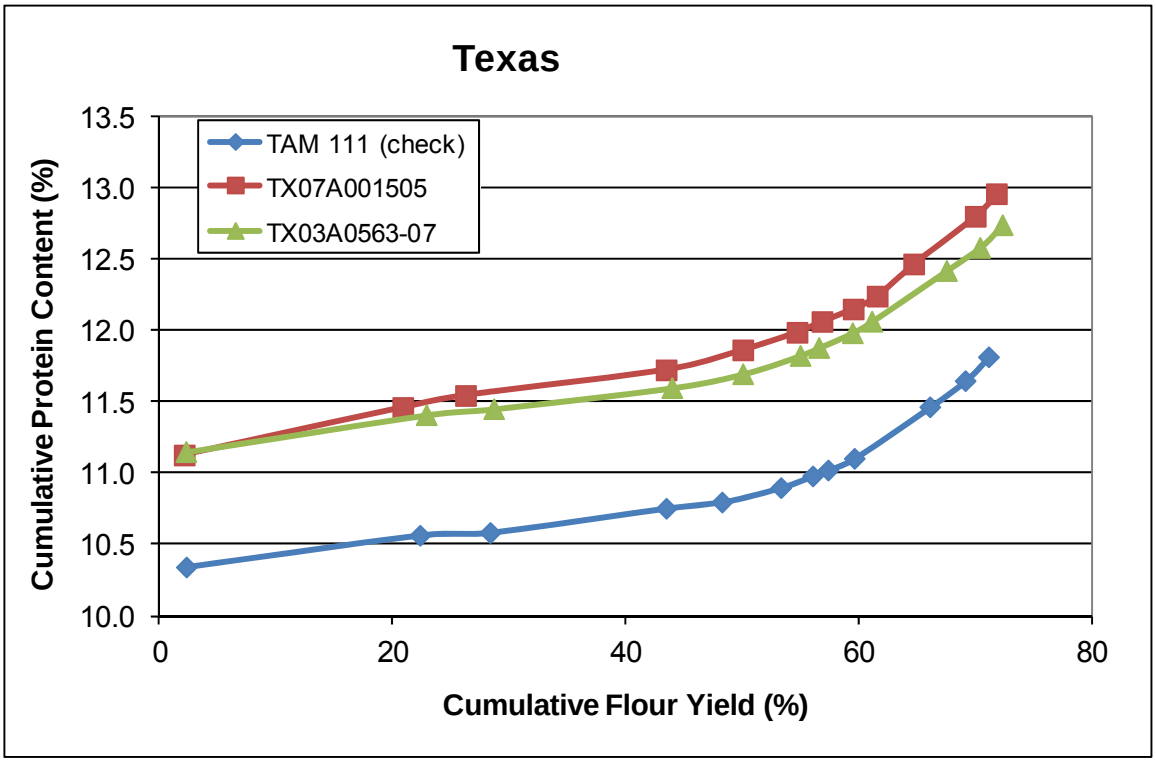
Test Entry Number	12-2422	12-2423	12-2424
Sample Identification	TAM 111 (check)	TX07A001505	TX03A0563-07
MIXOGRAPH			
Flour Abs (% as-is)	65.8	68.5	66.4
Flour Abs (14% mb)	64.0	66.0	64.1
Mix Time (min)	2.5	6.0	2.4
Mix tolerance (0-6)	2	5	2
FARINOGRAPH			
Flour Abs (% as-is)	65.2	65.2	67.2
Flour Abs (14% mb)	63.1	62.7	64.9
Development time (min)	5.5	8.7	5.8
Mix stability (min)	12.6	28.9	13.3
Mix Tolerance Index (FU)	28	16	18
Breakdown time (min)	11.2	19.4	13.9
ALVEOGRAPH			
P(mm): Tenacity	89	125	78
L(mm): Extensibility	113	88	136
G(mm): Swelling index	23.7	20.9	26.0
W(10^{-4} J): strength (curve area)	282	447	281
P/L: curve configuration ratio	0.79	1.42	0.57
Ie(P_{200}/P): elasticity index	50.5	70.6	51.1
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	239/270/295	537/721/694	184/205/233
Extensibility (mm at 45/90/135 min)	176/178/183	154/154/140	188/219/221
Energy (cm^2 at 45/90/135 min)	80/92/106	160/202/169	68/96/109
Resist $_{max}$ (BU at 45/90/135 min)	327/379/426	826/997/989	259/318/356
Ratio (at 45/90/135 min)	1.36/1.51/1.61	3.49/4.69/4.95	0.98/0.94/1.05
PROTEIN ANALYSIS			
HMW-GS Composition	2*, 7+8, 2+12	2*, 7+9, 5+10	2*, 20a+20b, 5+10
%IPP	47.74	59.72	43.78
SEDIMENTATION TEST			
Volume (ml)	44.2	58.5	56.6

Texas: Cumulative Ash Curves



TAM 111 (check)					TX07A001505					TX03A0563-07				
Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash	Mill Streams	Strm-yld (14%mb)	Ash	Cumul (14%) Yield	Ash
2M	20.0	0.34	20.1	0.34	1M	5.4	0.35	5.4	0.35	1M Red	2.3	0.33	2.3	0.33
1M	6.0	0.35	26.1	0.34	1M Red	2.2	0.36	7.5	0.36	1M	5.8	0.34	8.1	0.33
1M Red	2.3	0.35	28.4	0.34	2M	18.8	0.38	26.3	0.37	2M	20.6	0.35	28.7	0.34
1BK	4.8	0.40	33.2	0.35	1BK	4.7	0.38	30.9	0.37	2BK	6.4	0.41	35.1	0.35
2BK	6.5	0.40	39.7	0.36	2BK	5.3	0.46	36.2	0.39	Grader	2.9	0.44	38.0	0.36
Grader	2.7	0.42	42.4	0.36	Grader	2.7	0.50	38.9	0.39	3M	15.3	0.49	53.3	0.40
3M	15.1	0.49	57.5	0.40	3M	17.2	0.51	56.1	0.43	1BK	4.9	0.57	58.2	0.41
4M	5.1	0.65	62.6	0.42	4M	6.6	0.73	62.7	0.46	4M	6.1	0.70	64.3	0.44
FILTER FLR	1.3	0.79	63.9	0.42	FILTER FLR	2.2	0.85	64.8	0.47	FILTER FLR	1.6	0.84	65.9	0.45
3BK	3.0	0.92	66.9	0.45	3BK	3.1	0.89	68.0	0.49	3BK	2.9	0.88	68.8	0.47
5M	2.3	1.10	69.2	0.47	5M	2.1	1.39	70.0	0.52	BRAN FLR	1.9	1.64	70.7	0.50
BRAN FLR	2.0	1.60	71.2	0.50	BRAN FLR	1.8	1.64	71.9	0.55	5M	1.7	1.65	72.4	0.53
Break Shorts	3.6	3.21	74.8	0.63	Break Shorts	4.0	2.97	75.9	0.68	Break Shorts	3.5	2.98	75.8	0.64
Red Dog	3.4	2.44	78.2	0.71	Red Dog	3.2	2.59	79.1	0.75	Red Dog	2.7	2.81	78.5	0.71
Red Shorts	0.3	4.11	78.5	0.72	Red Shorts	0.4	3.77	79.5	0.77	Red Shorts	0.3	4.03	78.8	0.72
Filter Bran	0.9	1.46	79.5	0.73	Filter Bran	0.9	1.85	80.4	0.78	Filter Bran	1.2	1.58	80.0	0.74
Bran	20.5	4.81	100.0	1.57	Bran	19.6	4.40	100.0	1.49	Bran	20.0	4.72	100.0	1.53
Wheat		1.51			Wheat		1.46			Wheat		1.45		
St. Grd. Fl.		0.54			St. Grd. Fl.		0.54			St. Grd. Fl.		0.54		

Texas: Cumulative Protein Curves

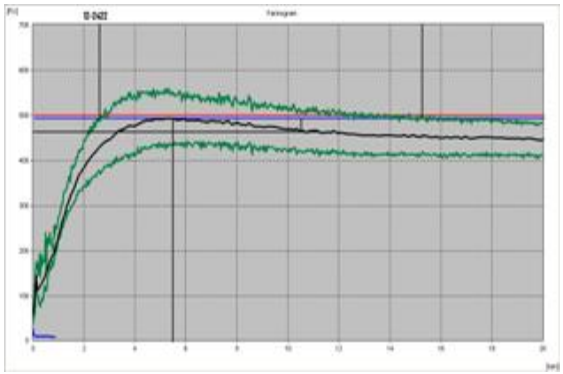


TAM 111 (check)					TX07A001505					TX03A0563-07				
Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein	Mill Streams	Strm-yld (14%mb)	Protein	Cumulative (14%) Yield	Protein
1M Red	2.3	10.3	2.3	10.3	1M Red	2.2	11.1	2.2	11.1	1M Red	2.3	11.1	2.3	11.1
2M	20.0	10.6	22.4	10.6	2M	18.8	11.5	20.9	11.5	2M	20.6	11.4	22.9	11.4
1M	6.0	10.7	28.4	10.6	1M	5.4	11.9	26.3	11.5	1M	5.8	11.6	28.7	11.4
3M	15.1	11.1	43.5	10.8	3M	17.2	12.0	43.5	11.7	3M	15.3	11.9	44.0	11.6
1BK	4.8	11.2	48.3	10.8	4M	6.6	12.8	50.1	11.9	4M	6.1	12.4	50.1	11.7
4M	5.1	11.9	53.4	10.9	1BK	4.7	13.3	54.7	12.0	1BK	4.9	13.1	55.0	11.8
Grader	2.7	12.6	56.1	11.0	FILTER FLR	2.2	14.0	56.9	12.1	FILTER FLR	1.6	13.8	56.6	11.9
FILTER FLR	1.3	12.8	57.4	11.0	Grader	2.7	14.0	59.6	12.1	Grader	2.9	14.0	59.5	12.0
5M	2.3	13.2	59.7	11.1	5M	2.1	14.9	61.6	12.2	5M	1.7	15.0	61.2	12.1
2BK	6.5	14.8	66.1	11.5	3BK	3.1	16.9	64.8	12.5	2BK	6.4	15.8	67.6	12.4
3BK	3.0	15.6	69.2	11.6	2BK	5.3	16.9	70.0	12.8	3BK	2.9	16.4	70.4	12.6
BRAN FLR	2.0	17.6	71.2	11.8	BRAN FLR	1.8	19.1	71.9	13.0	BRAN FLR	1.9	18.6	72.4	12.7
Break Shorts	3.6	15.0	74.8	12.0	Break Shorts	4.0	15.5	75.9	13.1	Break Shorts	3.5	15.4	75.8	12.9
Red Dog	3.4	14.6	78.2	12.1	Red Dog	3.2	15.6	79.1	13.2	Red Dog	2.7	15.2	78.5	12.9
Red Shorts	0.3	14.6	78.5	12.1	Red Shorts	0.4	14.8	79.5	13.2	Red Shorts	0.3	15.2	78.8	12.9
Filter Bran	0.9	12.2	79.5	12.1	Filter Bran	0.9	13.1	80.4	13.2	Filter Bran	1.2	13.1	80.0	13.0
Bran	20.5	18.4	100.0	13.4	Bran	19.6	17.9	100.0	14.1	Bran	20.0	18.1	100.0	14.0
Wheat		13.1			Wheat		14.2			Wheat		14.0		
St. Grd. Fl.		12.0			St. Grd. Fl.		13.1			St. Grd. Fl.		12.8		

Physical Dough Tests

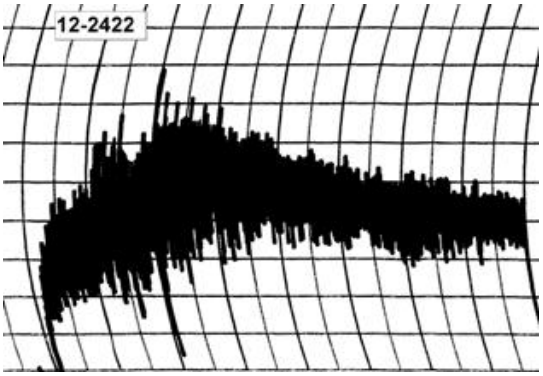
2012 (Small Scale) Samples – Texas

Farinograms



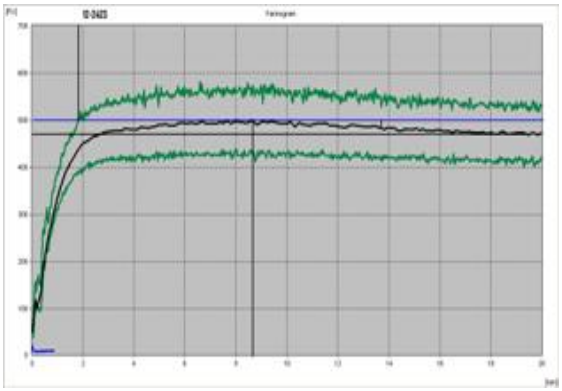
Water abs = 63.1%, Peak time = 5.5 min,
Mix stab = 12.6 min, MTI = 28 FU

Mixograms

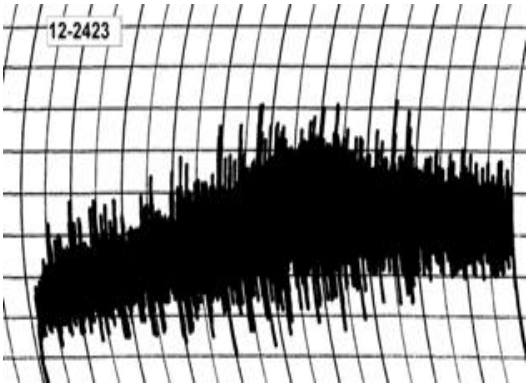


Water abs = 64.0%
Mix time = 2.5 min

12-2422, TAM 111 (check)



Water abs = 62.7%, Peak time = 8.7 min,
Mix stab = 28.9 min, MTI = 16 FU



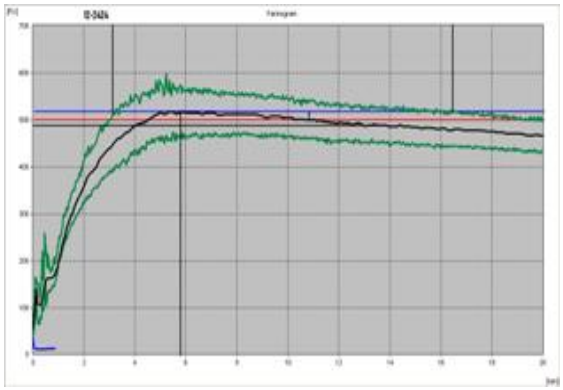
Water abs = 66.0%
Mix time = 6.0 min

12-2423, TX07A001505

Physical Dough Tests

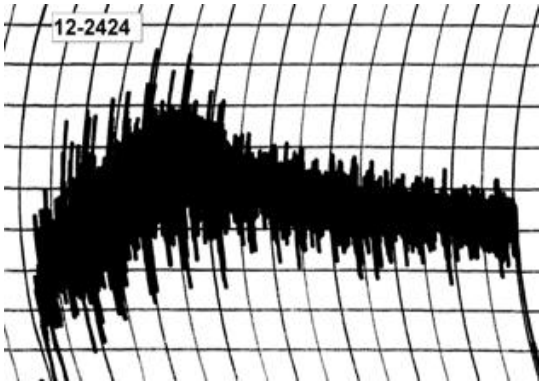
2012 (Small Scale) Samples – Texas (continued)

Farinograms



Water abs. = 64.9%, Peak time = 5.8 min,
Mix stab = 13.3 min, MTI = 18 FU

Mixograms

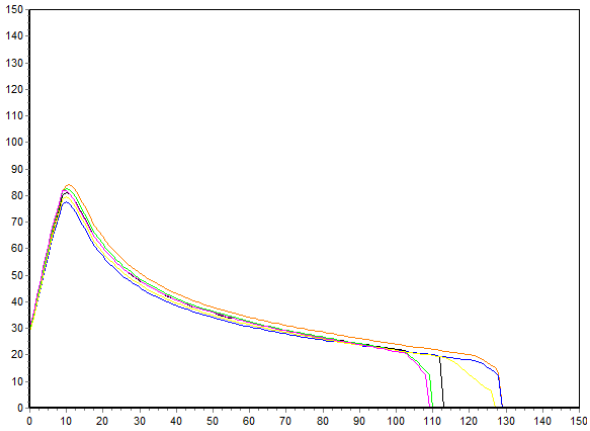


Water abs = 64.1%
Mix time = 2.4 min

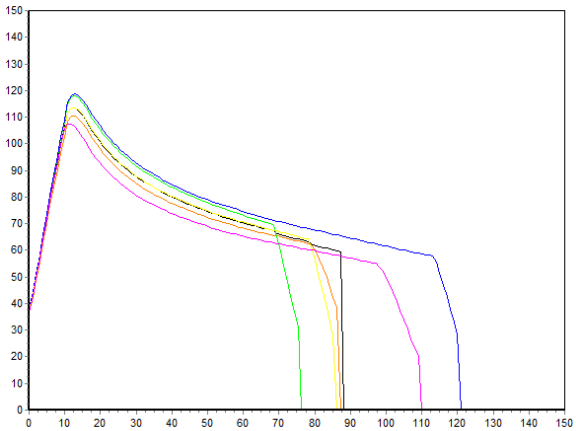
12-2424, TX03A0563-07

Physical Dough Tests - Alveograph

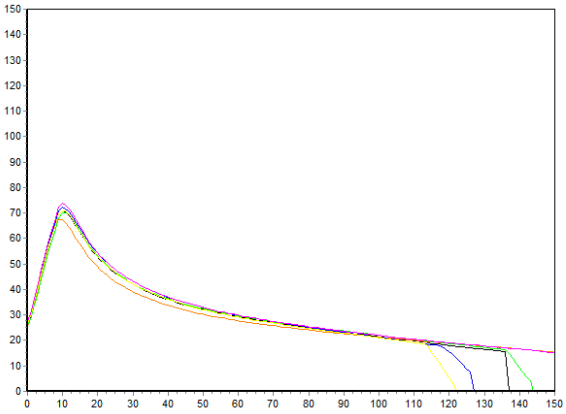
2012 (Small Scale) Samples – Texas



12-2422, TAM 111 (check)
P (mm H_20) = 89, L (mm) = 113, W ($10E^{-4}J$) = 282



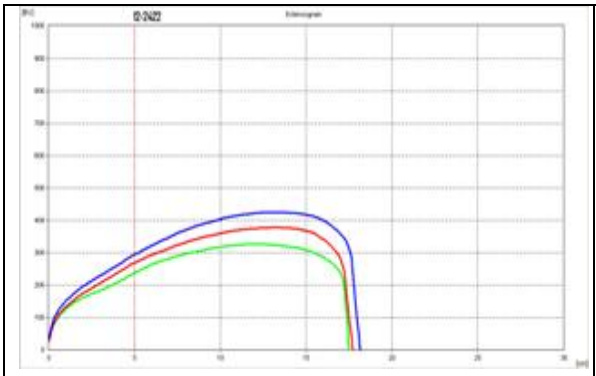
12-2423, TX07A001505
P (mm H_20) = 125, L (mm) = 88, W ($10E^{-4}J$) = 447



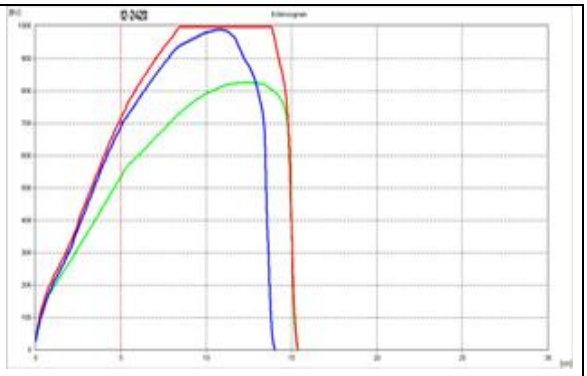
12-2424, TX03A0563-07
P (mm H_20) = 78, L (mm) = 136, W ($10E^{-4}J$) = 280

Physical Dough Tests - Extensigraph

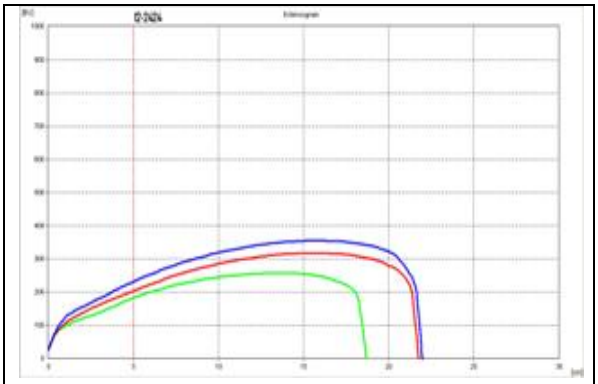
2012 (Small Scale) Samples – Texas



TAM 111 (check) - 2422
R (BU) = 270, E (mm) = 178, W (cm^2) = 92
Rmax (BU) = 379, Ratio = 1.5 at 90 min



TX07A001505 - 2423
R (BU) = 721, E (mm) = 154, W (cm^2) = 202
Rmax (BU) = 997, Ratio = 4.7 at 90 min



TX03A0563 - 2424
R (BU) = 205, E (mm) = 219, W (cm^2) = 96
Rmax (BU) = 318, Ratio = 0.94 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.

Texas: C-Cell Bread Images and Analysis for 2012 (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})
2422	5391	140.6	3753	0.428	1.813	1.393	1.655	-3.55
2423	6186	134.3	3955	0.436	1.912	4.316	1.755	-10.75

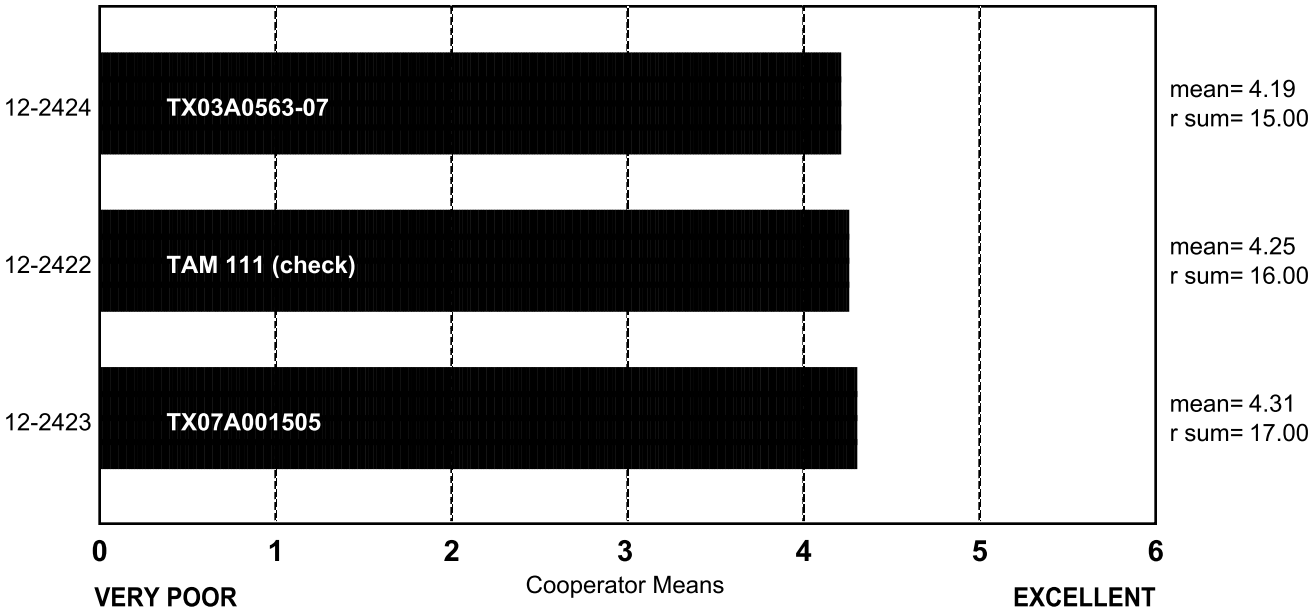
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2424	6004	139.8	3693	0.447	2.084	1.999	1.720	-12.50

SPONGE CHARACTERISTICS

(Small Scale) Texas-Amarillo

ncoop= 8
chisq= 0.25
chisqc= 0.44
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

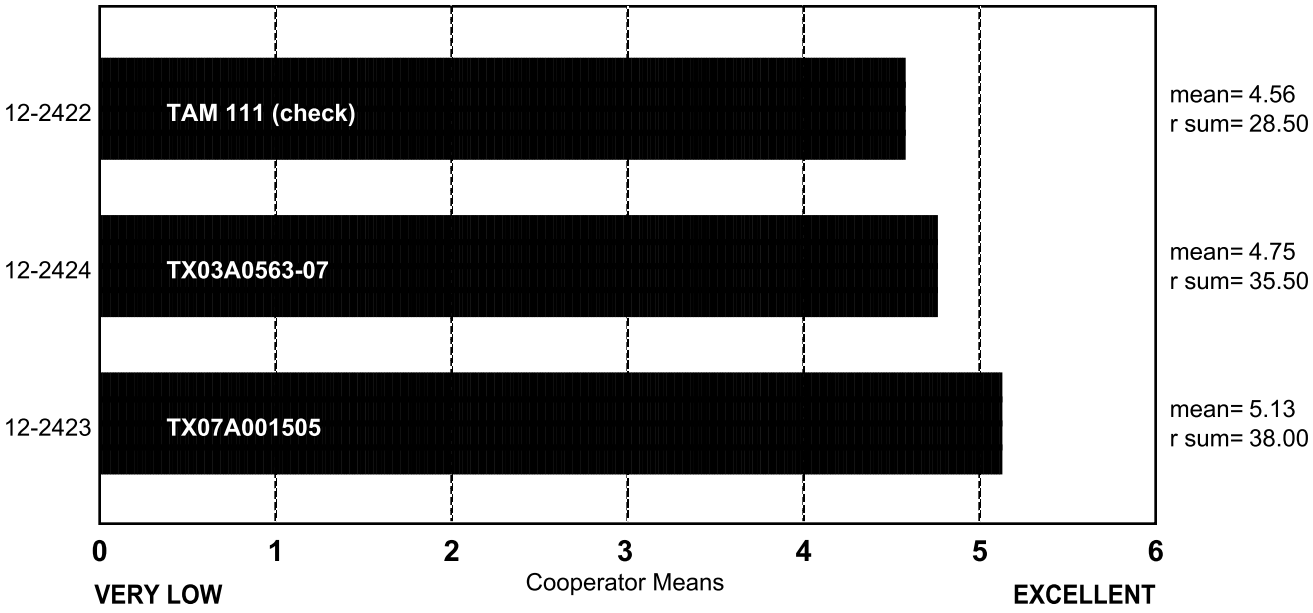


BAKE ABSORPTION

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 2.85
chisqc= 4.62
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Texas-Amarillo

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2422 TAM 111 (check)	**66.1**	**61.0**	**63.3**	**66.6**	**63.0**	**58.0**	**63.1**	**66.9**	**63.0**	**68.5**	**59.4**	**63.9**	**63.1**	**63.0**	**52.0**	**63.5**	**61.5**
12-2423 TX07A001505	**68.1**	**66.0**	**64.5**	**68.7**	**62.5**	**59.0**	**72.7**	**67.4**	**63.0**	**69.6**	**59.2**	**67.2**	**62.7**	**64.0**	**64.0**	**65.1**	**64.0**
12-2424 TX03A0563-07	**66.1**	**63.0**	**63.6**	**66.6**	**65.0**	**59.0**	**64.9**	**68.4**	**65.0**	**67.8**	**61.0**	**63.4**	**64.9**	**64.0**	**63.0**	**65.7**	**63.0**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Texas-Amarillo

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2422 TAM 111 (check)	**2.8**	**6.0**	**3.3**	**2.9**	**5.5**	**20.0**	**12.0**	**2.3**	**25.0**	**3.1**	**1.5**	**3.4**	**5.0**	**5.0**	**3.0**	**3.0**	**16.0**
12-2423 TX07A001505	**6.5**	**11.0**	**6.5**	**7.0**	**8.5**	**20.0**	**8.0**	**5.0**	**25.0**	**7.0**	**3.5**	**10.0**	**9.0**	**10.0**	**9.0**	**6.1**	**30.0**
12-2424 TX03A0563-07	**2.5**	**7.0**	**2.8**	**2.6**	**6.0**	**8.0**	**8.0**	**2.2**	**22.0**	**3.1**	**1.5**	**3.5**	**5.0**	**5.0**	**3.0**	**3.3**	**20.0**

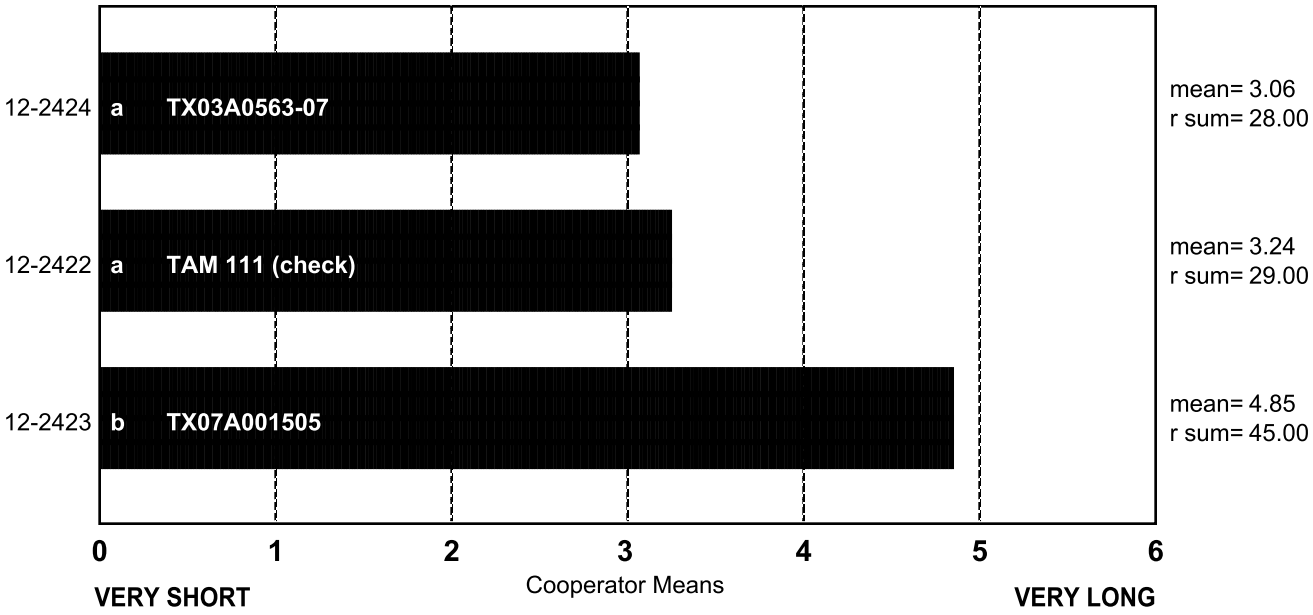
Raw Data

BAKE MIX TIME

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 10.71
chisqc= 13.48
cvchisq= 5.99
crdiff= 8.48

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

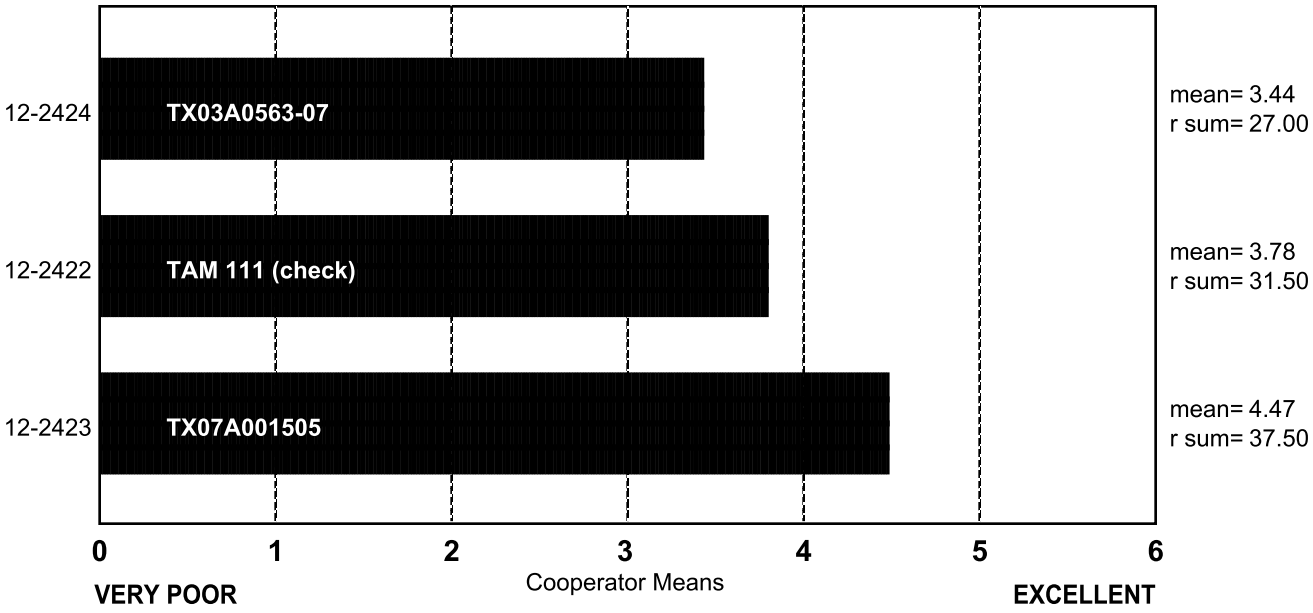


MIXING TOLERANCE

(Small Scale) Texas-Amarillo

ncoop= 16
chisq= 3.47
chisqc= 5.16
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.

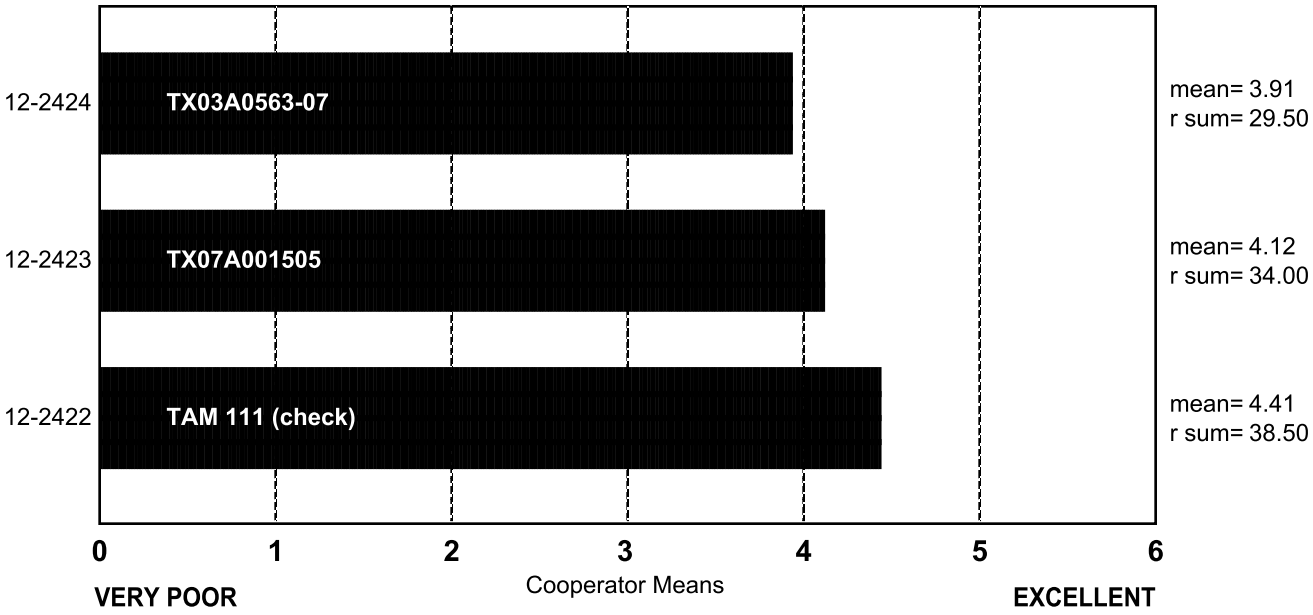


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 2.38
chisqc= 3.77
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'OUT OF MIXER', DESCRIBED

(Small Scale) Texas-Amarillo

	Sticky	Wet	Tough	Good	Excellent
12-2422 TAM 111 (check)	**0**	**2**	**1**	**12**	**2**
12-2423 TX07A001505	**2**	**0**	**8**	**6**	**1**
12-2424 TX03A0563-07	**4**	**1**	**2**	**10**	**0**

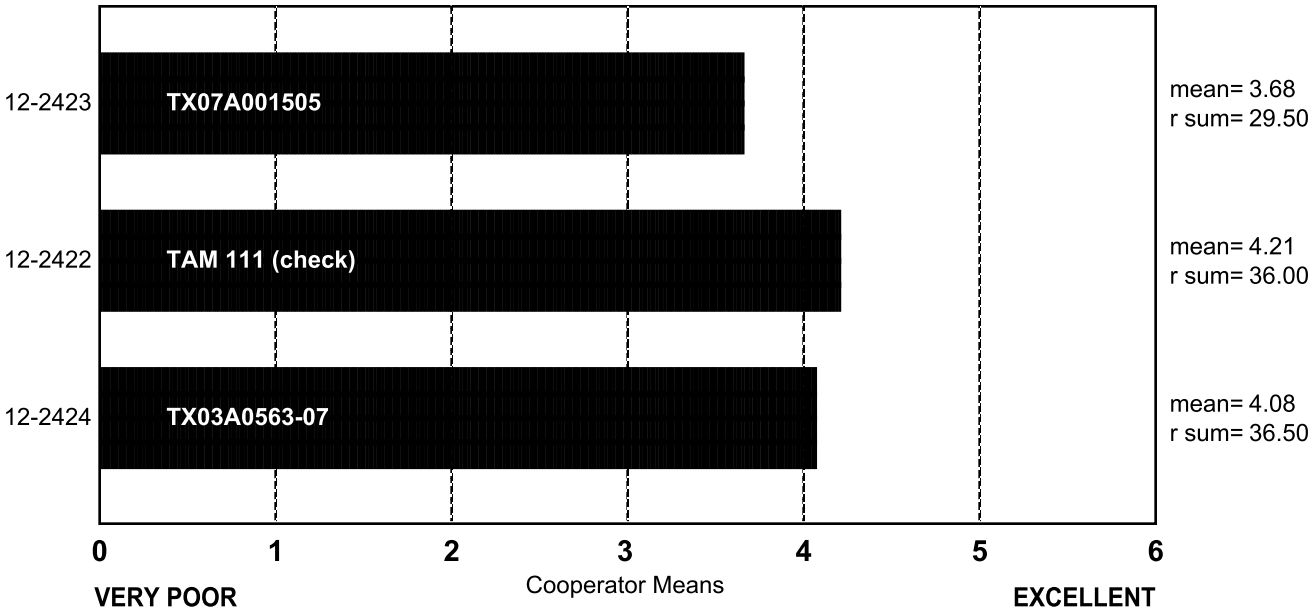
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 1.79
chisqc= 2.54
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) Texas-Amarillo

	Sticky	Wet	Tough	Good	Excellent
12-2422 TAM 111 (check)	**0**	**3**	**1**	**12**	**1**
12-2423 TX07A001505	**2**	**0**	**7**	**4**	**4**
12-2424 TX03A0563-07	**4**	**1**	**0**	**10**	**2**

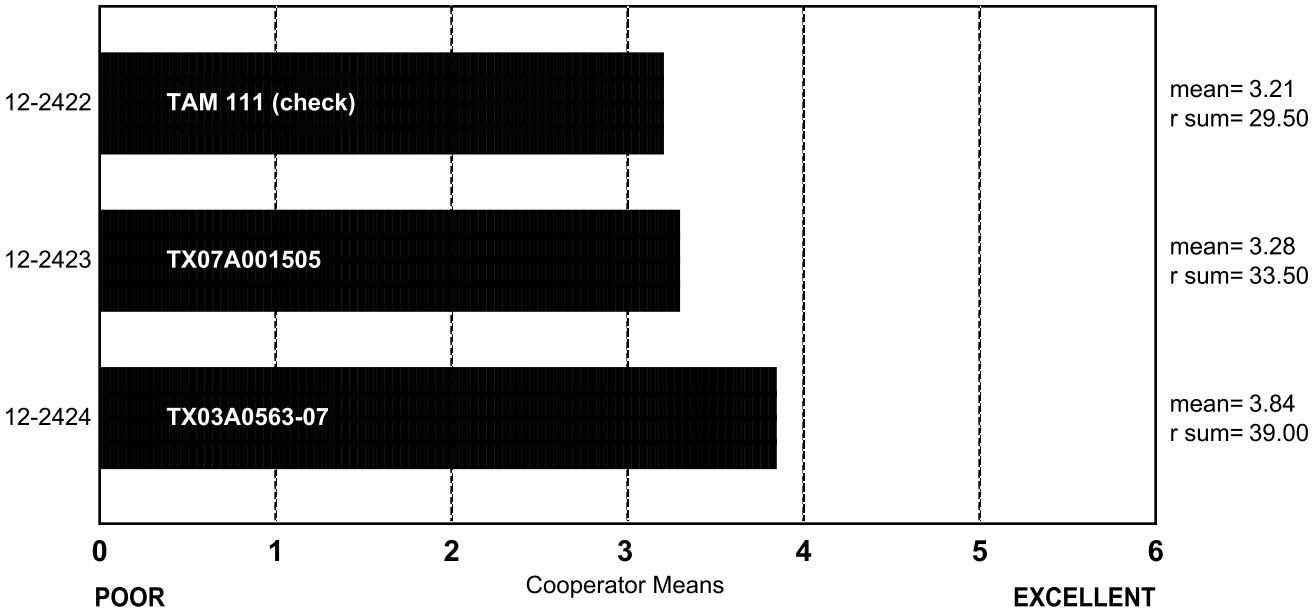
Frequency Table

CRUMB GRAIN

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 2.68
chisqc= 3.25
cvchisq= 5.99
crdiff=

Variety order by rank sum.
No samples different at 5.0% level of significance.



CRUMB GRAIN, DESCRIBED

(Small Scale) Texas-Amarillo

	Open	Fine	Dense
12-2422 TAM 111 (check)	**9**	**4**	**4**
12-2423 TX07A001505	**8**	**6**	**3**
12-2424 TX03A0563-07	**7**	**9**	**1**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Texas-Amarillo

	Round	Irregular	Elongated
12-2422 TAM 111 (check)	**7**	**8**	**2**
12-2423 TX07A001505	**3**	**9**	**5**
12-2424 TX03A0563-07	**3**	**10**	**4**

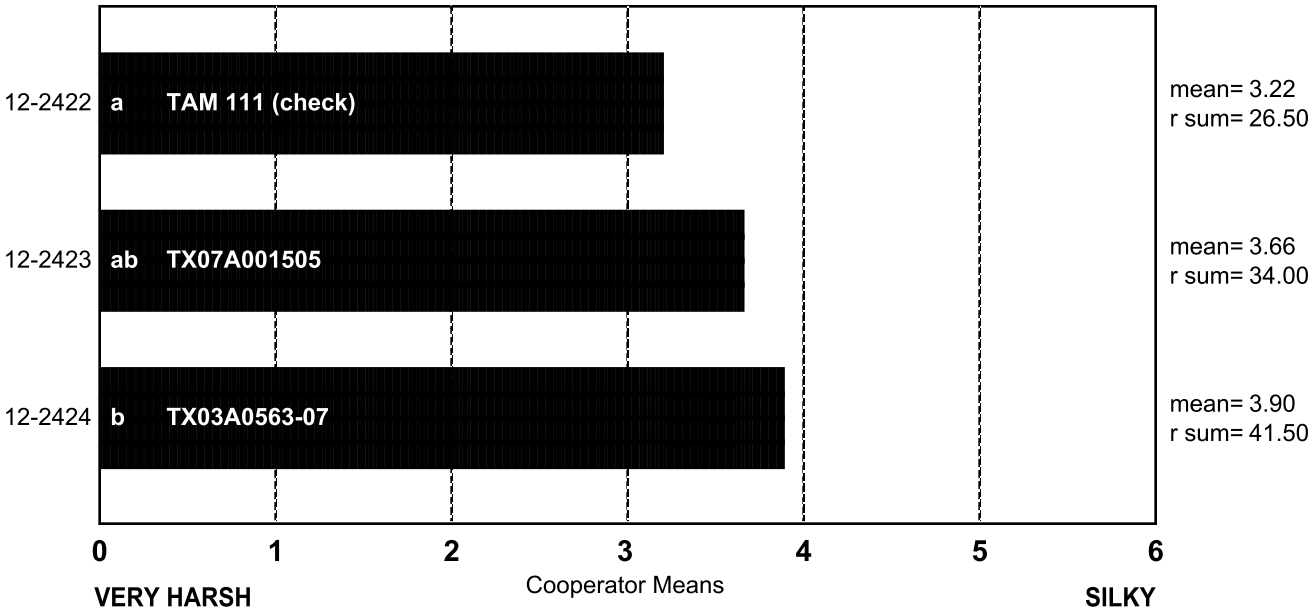
Frequency Table

CRUMB TEXTURE

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 6.62
chisqc= 9.18
cvchisq= 5.99
crdiff= 8.37

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB TEXTURE, DESCRIBED

(Small Scale) Texas-Amarillo

	Harsh	Smooth	Silky
12-2422 TAM 111 (check)	**8**	**7**	**2**
12-2423 TX07A001505	**6**	**5**	**6**
12-2424 TX03A0563-07	**3**	**9**	**5**

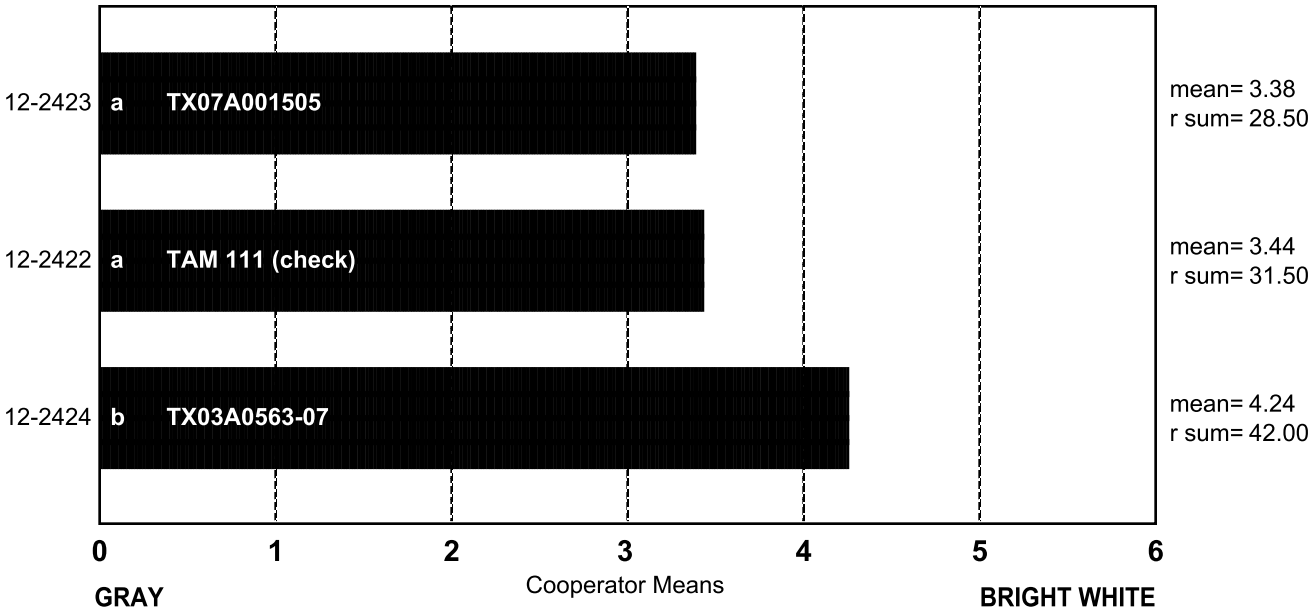
Frequency Table

CRUMB COLOR

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 5.91
chisqc= 9.14
cvchisq= 5.99
crdiff= 8.42

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



CRUMB COLOR, DESCRIBED

(Small Scale) Texas-Amarillo

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
12-2422 TAM 111 (check)	**0**	**0**	**3**	**6**	**6**	**2**	**0**
12-2423 TX07A001505	**0**	**0**	**5**	**5**	**5**	**2**	**0**
12-2424 TX03A0563-07	**0**	**0**	**3**	**1**	**5**	**7**	**1**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Texas-Amarillo

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2422 TAM 111 (check)	**178.0**	**465.4**	**141.0**	**142.0**	**471.0**	**416.0**	**461.0**	**132.7**	**488.1**	**159.3**	**131.1**	**154.8**	**451.9**	**489.5**	**134.0**	**145.1**	**461.0**
12-2423 TX07A001505	**178.0**	**464.1**	**140.4**	**139.2**	**479.0**	**417.0**	**458.0**	**128.9**	**488.7**	**156.9**	**129.7**	**152.7**	**451.5**	**487.2**	**134.0**	**145.6**	**462.2**
12-2424 TX03A0563-07	**178.0**	**465.2**	**141.0**	**141.6**	**466.0**	**411.0**	**461.0**	**132.3**	**480.1**	**153.1**	**131.7**	**153.6**	**451.4**	**486.4**	**134.0**	**143.7**	**463.3**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Texas-Amarillo

	Coop. A	Coop. B	Coop. C	Coop. D	Coop. E	Coop. F	Coop. G	Coop. H	Coop. I	Coop. J	Coop. K	Coop. L	Coop. M	Coop. N	Coop. O	Coop. P	Coop. Q
12-2422 TAM 111 (check)	**763**	**2263**	**850**	**724**	**2850**	**2500**	**2450**	**835**	**2868**	**983**	**715**	**725**	**2450**	**2125**	**860**	**763**	**2475**
12-2423 TX07A001505	**875**	**2450**	**1090**	**816**	**2800**	**2800**	**2000**	**885**	**3045**	**951**	**860**	**895**	**2458**	**2188**	**935**	**695**	**2675**
12-2424 TX03A0563-07	**815**	**2575**	**1040**	**687**	**3200**	**2950**	**2700**	**915**	**3074**	**955**	**825**	**870**	**2500**	**2375**	**963**	**848**	**2700**

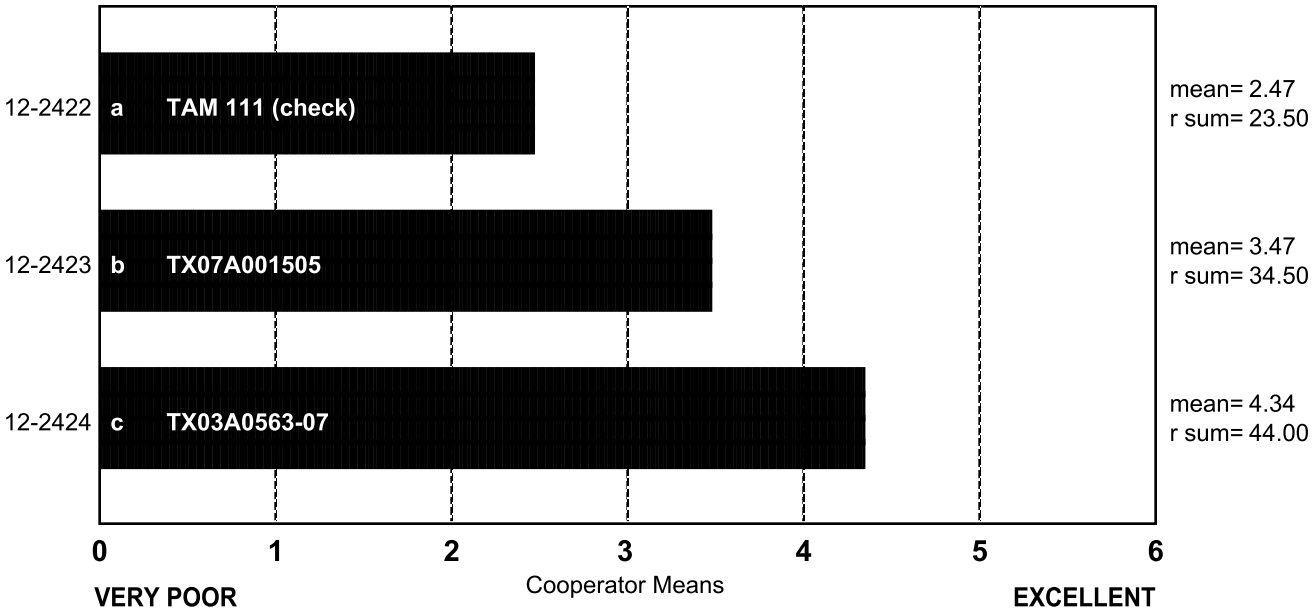
Raw Data

LOAF VOLUME

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 12.38
chisqc= 13.37
cvchisq= 5.99
crdiff= 9.18

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.

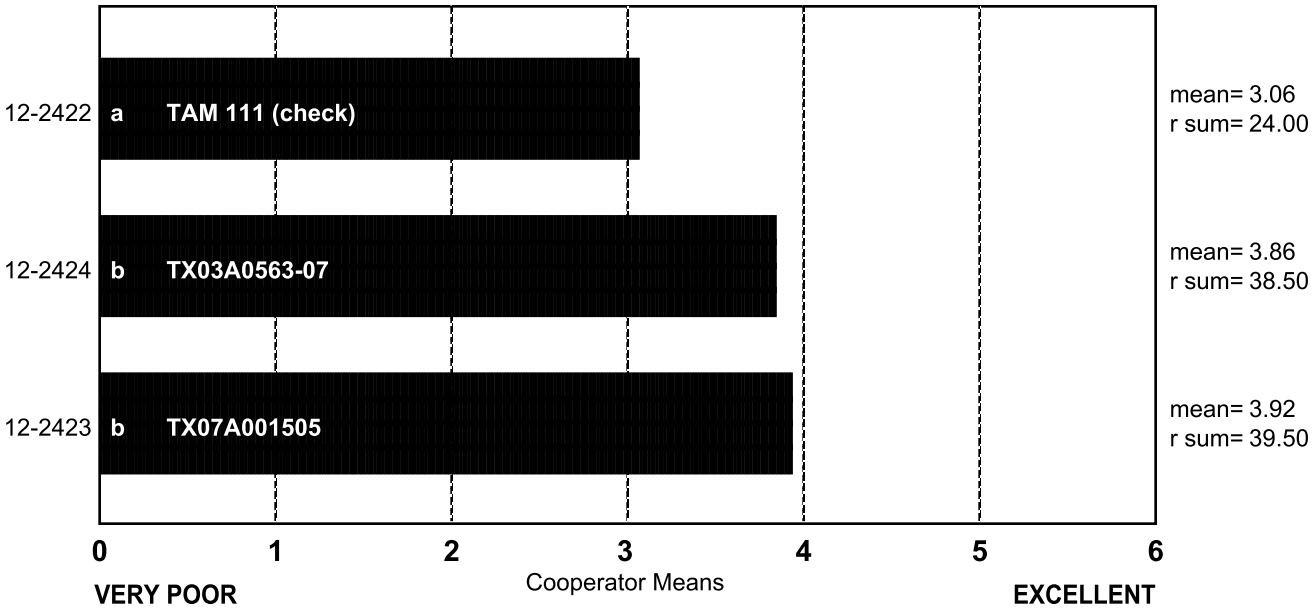


OVERALL BAKING QUALITY

(Small Scale) Texas-Amarillo

ncoop= 17
chisq= 8.85
chisqc= 9.71
cvchisq= 5.99
crdiff= 9.88

Variety order by rank sum.
Samples with the same letter not different at 5.0% level of significance.



COOPERATOR'S COMMENTS
(Small Scale) Texas-Amarillo

COOP. **12-2422 TAM 111 (check)**

A. No comment.
B. Avg. abs, avg. mix time, very low volume, tan crumb, open grain, harsh, flat.
C. Short mix time.
D. No comment.
E. No comment.
F. Very long mix, tough & bucky, dead, putty like, low loaf volume, very open grain.
G. No comment.
H. No comment.
I. Very good absorption, good mixing strength, sl. above average interiors and average volume.
J. Weaker dough properties and crumb grain; good volume performance.
K. Low loaf volume, short mix time.
L. 11.7% flour protein, Questionable tolerance, short MT, good absorption, questionable crumb grain and low LV.
M. Good volume, excellent grain rating, good protein, abs, and stability.
N. Good absorption, dense grain, yellow, low volume.
O. Poor bake quality, soft dough handling and poor mix tolerance.
P. Normal Abs, shorter MT, slight sticky & strong dough, low OS & volume, open & round cells, yellow crumb, slight harsh & resilient texture.
Q. No comment.

COOP. **12-2423 TX07A001505**

A. No comment.
B. Very high abs, sl. long mix time, low volume, creamy crumb, sl. open grain, sl. flat.
C. Long mix time, excellent externals.
D. No comment.
E. Shelled break and shred.
F. Very long mix, tough & bucky, dead, putty like, avg. volume, very open grain.
G. No comment.
H. No comment.
I. Sl. open, streaky grain, good absorption, very good volume.
J. Bucky dough, long mixing, adequate overall performance.
K. Good loaf volume.
L. 13.0% flour protein, excellent mixing tolerance & absorption, long MT, Q-S crumb grain, better than check.
M. Good volume, excellent grain rating, good protein, abs and stability.
N. High absorption, long mix time, tough dough, fine grain, yellow, low volume.
O. Good bake quality, long mixing requirement, very strong dough handling, could take more water.
P. Normal Abs & MT, slight sticky & weak dough, very low OS & volume, dense & round cells, yellow crumb, harsh & tight texture.
Q. No comment.

COOP. 12-2424 TX03A0563-07

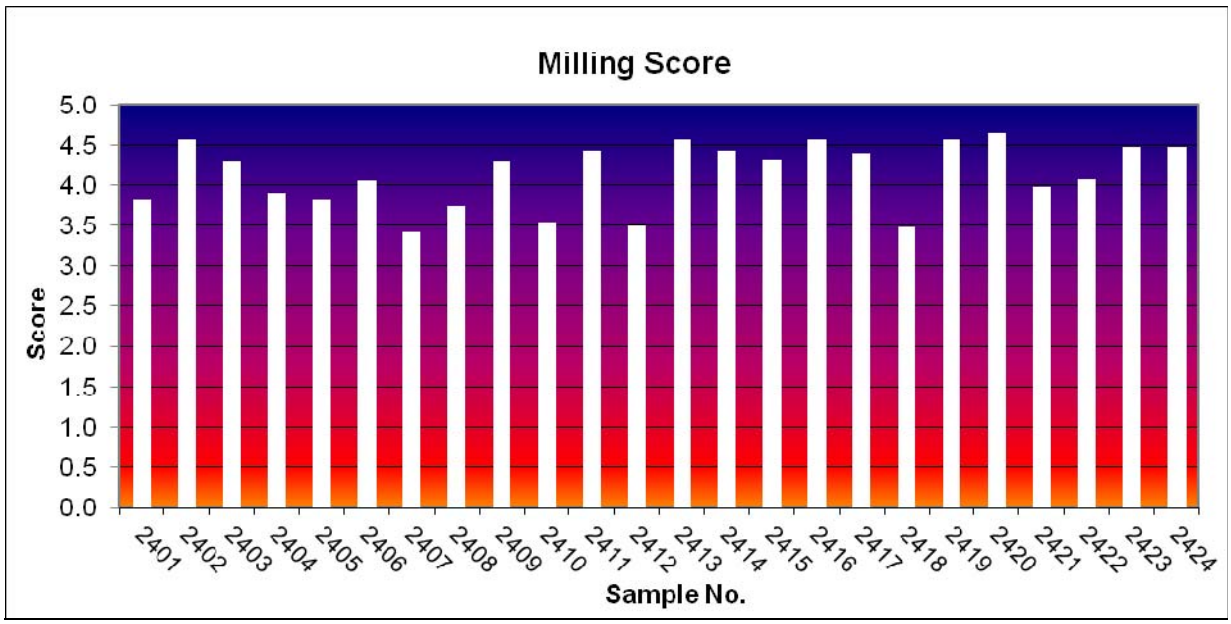
A. No comment.
B. Above avg. abs, avg. mix time, avg. volume, white crumb, sl. open grain, good symmetry.
C. Short mix time, excellent externals, much better loaf than mixograph, and dough out of mixer and at pan would have indicated.
D. No comment.
E. No comment.
F. Short mix, excellent volume, sl. sticky out of mixer, good recovery, very open grain, sl. creamy.
G. No comment.
H. Average grain, texture, crumb grain and color.
I. Sl. open, variable grain, excellent absorption, and excellent volume.
J. Very weak dough properties; overall bread performance average.
K. Short mix time.
L. 12.7% flour protein, questionable tolerance, short MT, Q-S crumb grain, better than check.
M. Excellent volume, great grain rating, white color, good texture, excellent mix time, good abs.
N. High absorption, sticky and wet out of mix, good grain, creamy, good volume.
O. Acceptable bake quality, soft dough handling.
P. Normal Abs, shorter MT, slight sticky & strong dough, Hi OS & volume, fine & elongated cells, slight yellow crumb, smooth & resilient texture.
Q. No comment.

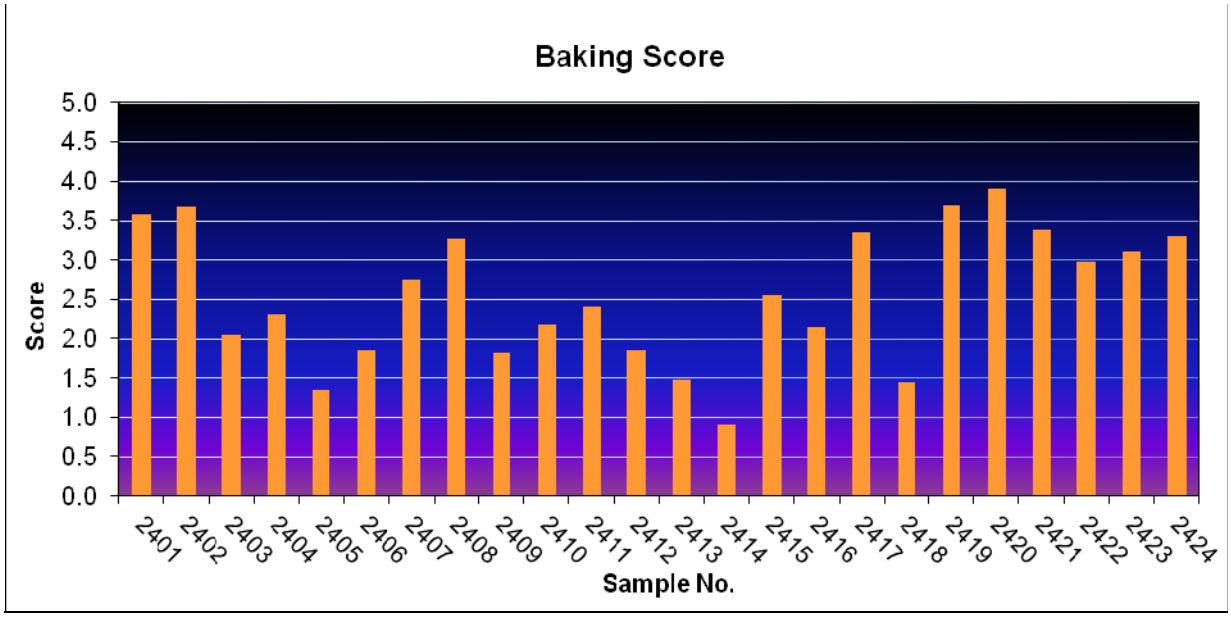
Notes: **B, E, F, I, M, N, O and Q** conducted sponge and dough bake tests

2012 WQC Milling and Baking Scores

2012 WQC Milling & Baking Scores

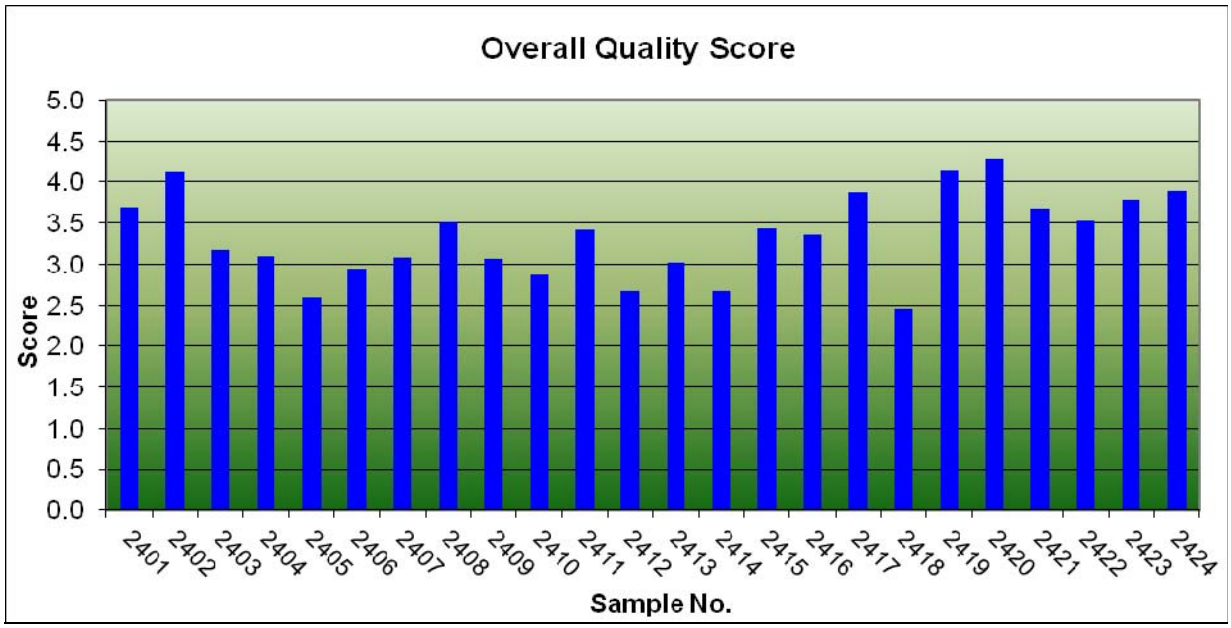
(Based upon HWWQL Quality Data and KSU Milling Data)





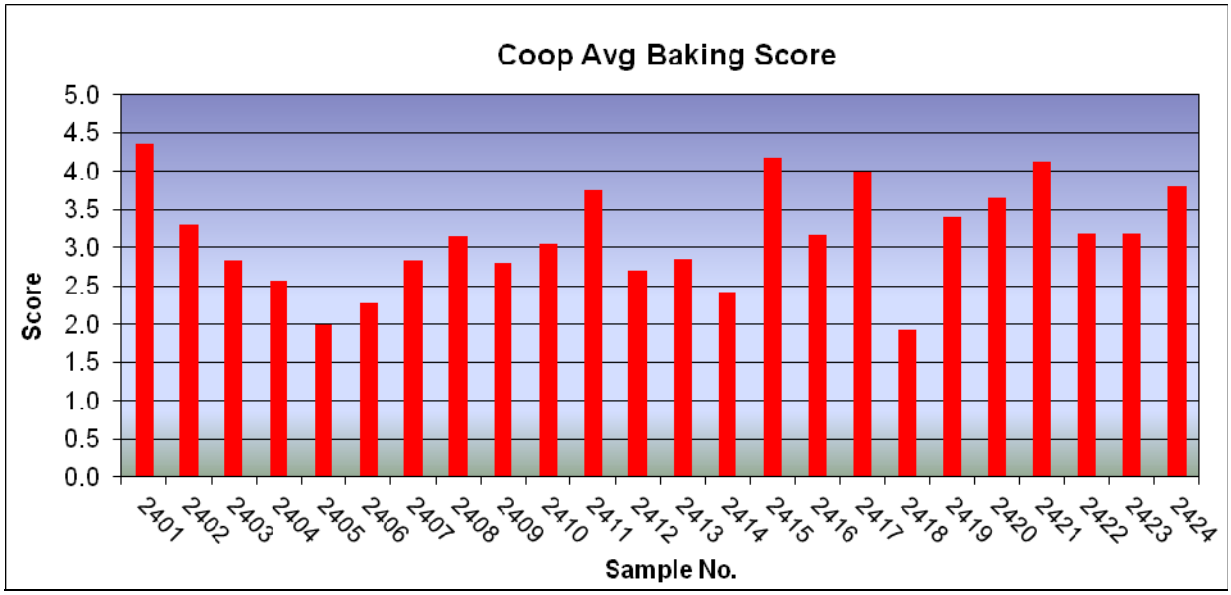
2012 WQC Milling & Baking Scores

(Based upon HWWQL Quality Data and KSU Milling Data)



2012 WQC Baking 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
2012 WQC Hard Winter Wheat Samples

USDA-ARS Hard Winter Wheat Quality Laboratory
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Richard Chen, **richard.chen@ars.usda.gov**

Alkaline Noodle Quality Report of 2012 WQC Samples

Objectives: Evaluate alkaline noodle color and cooking characteristics.

Materials: 24 WQC hard winter wheat samples harvested in 2012.

Methods:

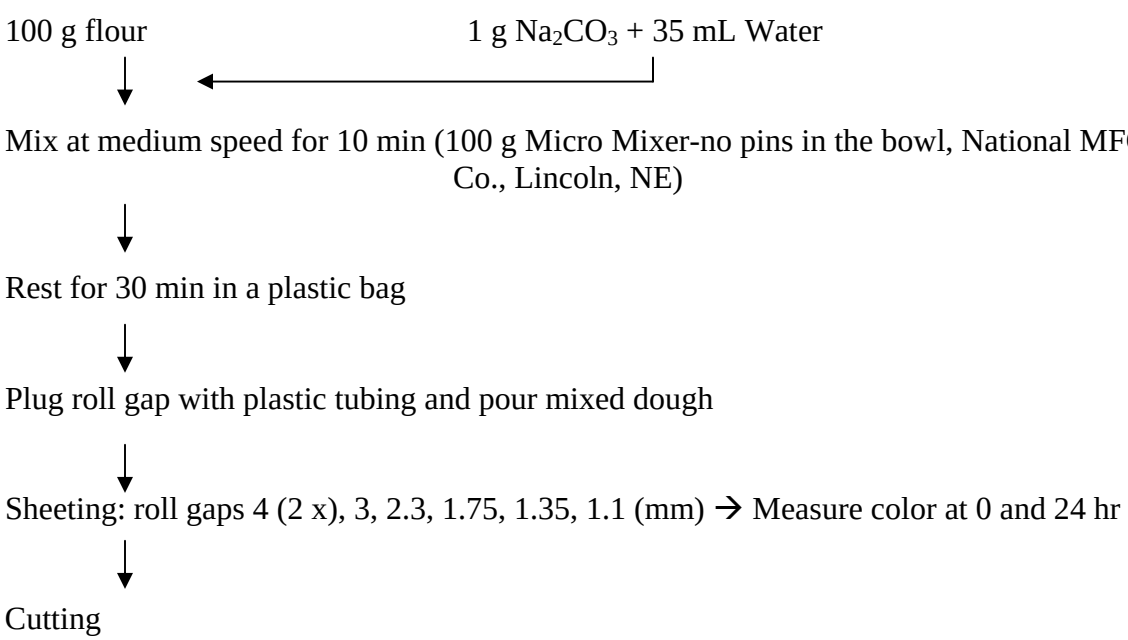
PPO (Polyphenol Oxidase) Test:
The PPO level in wheat meal was determined using a method modified from AACCI Approved Method 22-85.

1. Grind wheat using a Udy Mill and blend the sample thoroughly on a 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:



Measurement of Noodle Dough Color:

Noodle dough color (*L**, lightness; *a**, redness-greenness; *b**, yellowness-blueness) was measured by Minolta Colorimeter (Model CR-300) at 0 and 24 hr.

Cooking Noodles:

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

Measurement of Cooking Loss and Water Uptake:

Cooking Loss:

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

Water Uptake:

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

Texture Profile Analysis (TPA) of Noodle:

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

- **Hardness (N):** maximum peak force during the first compression cycle (first bite) and often substituted by the term “firmness”.

- **Springiness (elasticity, ratio):** ratio related to the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite.

- **Chewiness:** hardness x cohesiveness x springiness.

- **Resilience (ratio):** measurement of how the sample recovers from deformation both in terms of speed and forces derived.

- **Cohesiveness (ratio):** ratio of the positive force area during the second compression to that during the first compression.

Results:

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

Table I shows the following:

Noodle Color (*L* value, Higher is better.) ***at 0 hr***: 2413 (84.53), 2411(83.34), 2412 (83.26)

Noodle Color (*L* value, Higher is better.) ***at 24 hr***: 2413 (72.65), 2411 (72.19), 2412 (67.92)

Delta L (Change of *L* value, Lower absolute value is better.)
2411 (-11.15), 2413 (-11.88), 2421 (-13.03)

PPO (Lower is better.): 2413 (0.194), 2411 (0.195), 2410 (0.197)

Table II shows the following:

Hardness: 2424 (2.994), 2405(2.631), 2402 (2.586)

Springiness: 2417 (0.986), 2403 (0.984), 2412(0.982)

Chewiness: 2424 (1.880), 2412 (1.666), 2404 (1.648)

Resilience: 2423 (0.425), 2420 (0.423), 2415 (0.418)

Cohesiveness: 2420 (0.684), 2408 (0.681), 2415 (0.680)

Water Uptake: 2405 (89.28), 2415 (88.76), 2414 (87.52)

Cooking Loss: 2413 (9.80), 2414 (9.04), 2416 (8.48)

Discussion

The sample 2413 showed the highest brightness at 0 hr and at 24 hr respectively, the lowest PPO level, and the second delta *L** and highest delta *b**. The bright yellow noodle color after 24 hr production is considered desirable characteristics for alkaline noodles. Thus, the sample 2413 would be the most favorable for alkaline noodle quality. The sample 2411 showed the second

brightness at 0 hr and at 24 hr respectively, and the lowest delta *L**. The Sample 2412 showed the third brightest noodle color at 0 hr and at 24 hr respectively, and the third Springiness and the second Chewiness after cooking.

The sample 2415 showed the third Resilience and Cohesiveness after cooking and higher water uptake. Therefore, sample 2415 would be a good noodle flour for white salted noodles (Japanese Udon-type), which are preferred to have a bright, creamy white color, and smooth, soft texture.

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
12-2401	*80.03*	*65.72*	*-0.71*	*0.92*	*22.41*	*25.87*	-14.31	1.63	3.46	0.402
12-2402	*78.86*	*61.96*	*-0.65*	*1.69*	*22.40*	*26.88*	-16.90	2.34	4.48	0.421
12-2403	*79.11*	*61.69*	*-0.27*	*2.05*	*18.59*	*23.37*	-17.42	2.32	4.78	0.669
12-2404	*81.84*	*65.64*	*-1.03*	*0.91*	*19.80*	*24.31*	-16.20	1.94	4.51	0.541
12-2405	*80.13*	*63.21*	*-0.62*	*1.78*	*19.20*	*24.77*	-16.93	2.40	5.57	0.590
12-2406	*82.04*	*67.77*	*-0.73*	*0.81*	*18.76*	*23.90*	-14.27	1.53	5.14	0.644
12-2407	*74.74*	*58.21*	*-0.56*	*1.83*	*25.36*	*26.34*	-16.53	2.39	0.98	0.590
12-2408	*77.90*	*61.66*	*-1.61*	*1.15*	*25.36*	*28.01*	-16.24	2.76	2.66	0.693
12-2409	*80.12*	*62.66*	*-1.38*	*1.09*	*24.79*	*27.43*	-17.47	2.47	2.65	0.569
12-2410	*80.77*	*64.71*	*-0.98*	*1.16*	*25.31*	*29.81*	-16.06	2.14	4.50	0.197
12-2411	*83.34*	*72.19*	*-0.76*	*0.27*	*19.30*	*24.81*	-11.15	1.03	5.51	0.195
12-2412	*83.38*	*67.92*	*-0.60*	*1.16*	*17.25*	*23.43*	-15.46	1.75	6.18	0.508
12-2413	*84.53*	*72.65*	*-1.06*	*0.01*	*18.36*	*26.19*	-11.88	1.07	7.83	0.194
12-2414	*80.99*	*66.84*	*-0.57*	*1.36*	*20.60*	*26.46*	-14.15	1.93	5.86	0.490
12-2415	*80.71*	*67.02*	*-0.58*	*0.90*	*20.72*	*25.93*	-13.70	1.48	5.22	0.199
12-2416	*77.74*	*62.53*	*-0.18*	*2.19*	*22.14*	*26.15*	-15.21	2.37	4.01	0.529
12-2417	*78.18*	*63.32*	*-0.04*	*2.44*	*22.40*	*24.04*	-14.87	2.48	1.64	0.555
12-2418	*80.04*	*63.62*	*-0.24*	*2.23*	*19.11*	*23.88*	-16.42	2.47	4.78	0.550
12-2419	*77.14*	*62.58*	*0.10*	*2.03*	*24.41*	*26.65*	-14.57	1.93	2.25	0.370
12-2420	*80.09*	*63.85*	*-0.15*	*1.67*	*21.75*	*25.25*	-16.24	1.82	3.51	0.433
12-2421	*76.96*	*63.93*	*-0.02*	*1.86*	*26.08*	*29.07*	-13.03	1.88	2.99	0.222
12-2422	*80.14*	*65.90*	*-1.19*	*1.01*	*23.63*	*27.03*	-14.24	2.19	3.40	0.694
12-2423	*79.18*	*65.00*	*-0.83*	*0.88*	*23.55*	*26.92*	-14.18	1.71	3.37	0.619
12-2424	*78.71*	*64.02*	*-0.71*	*1.22*	*20.82*	*24.60*	-14.70	1.92	3.79	0.499
Avg	*79.86*	*64.77*	*-0.64*	*1.36*	*21.75*	*25.88*	-15.09	2.00	4.13	0.474

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

Sample ID	Springiness	Hardness	Chewiness	Resilience	Cohesiveness	Water Uptake (%)	Cooking Loss(%)
12-2401	0.959	2.496	1.573	0.371	0.657	85.92	7.08
12-2402	0.951	2.586	1.639	0.400	0.667	84.12	7.00
12-2403	0.984	2.551	1.611	0.354	0.642	86.88	7.44
12-2404	0.975	2.513	1.648	0.406	0.672	84.88	7.16
12-2405	0.975	2.631	1.613	0.352	0.629	87.12	8.32
12-2406	0.965	2.425	1.509	0.370	0.645	89.28	7.56
12-2407	0.963	2.506	1.611	0.392	0.668	77.84	6.36
12-2408	0.947	2.352	1.516	0.410	0.681	72.96	8.36
12-2409	0.963	2.546	1.599	0.375	0.652	85.44	7.52
12-2410	0.951	2.552	1.556	0.366	0.641	80.40	8.40
12-2411	0.961	2.454	1.568	0.415	0.665	84.36	7.60
12-2412	0.982	2.551	1.666	0.403	0.665	83.48	7.52
12-2413	0.965	2.391	1.489	0.382	0.645	82.88	9.80
12-2414	0.967	2.444	1.410	0.325	0.597	87.52	9.04
12-2415	0.980	2.278	1.517	0.418	0.680	88.76	7.24
12-2416	0.982	2.568	1.637	0.370	0.649	81.88	8.48
12-2417	0.986	2.424	1.590	0.384	0.665	82.08	7.36
12-2418	0.973	2.485	1.503	0.348	0.621	85.20	8.32
12-2419	0.975	2.466	1.617	0.416	0.672	76.32	7.56
12-2420	0.975	2.385	1.591	0.423	0.684	77.28	7.60
12-2421	0.961	2.403	1.500	0.377	0.650	82.16	7.36
12-2422	0.975	2.471	1.565	0.399	0.649	81.32	7.80
12-2423	0.980	2.304	1.521	0.425	0.674	79.28	8.20
12-2424	0.957	2.994	1.880	0.373	0.656	80.20	5.60

TORTILLA BAKING TEST of 2012 WQC SAMPLES

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(January 2012)

Introduction

Flour tortillas continue to expand into the mainstream of consumers' eating habits. For example, breakfast burritos are continuing to increase in popularity as a portable convenience food that can be eaten on the way to work.

The quality of the tortilla used for wrapping the fillings is of major importance. A tortilla must not crack or break and allow the salsa to create a mess. In many cases, people use tortilla wraps instead of bread because the hot-press type resists moisture uptake, and the wrap can be eaten without worrying about crumbs.

Thus we are trying to understand essential properties of flour for hot-press tortillas with long term storage stability. This will take some time to work out details. So the work described is an attempt to summarize some of the research that has been done related to flour tortillas and the attributes of wheat flour.

This report includes information on the procedure for production and evaluation, and data of the 2012 WQC samples. Towards the end are general observations on the relationship between flour properties and tortilla quality. It is not all inclusive, but is a start toward better understanding.

Procedures to Produce and Evaluate Wheat Flour Tortillas Using a Commercial Hot Press Baking Procedure

Tortilla Formulation

Ingredients	Amount
Wheat flour	100%
Salt	1.5%
Sodium Stearoyl Lactylate	0.5%
Sodium Propionate	0.4%
Potassium Sorbate	0.4%
All purpose Shortening	6.0%
Sodium Bicarbonate	0.6%
Fumaric Acid - encapsulated	0.33%
Sodium Aluminum Sulfate	0.58%
Cysteine	0.003%

Tortilla Processing

MIX

Dry ingredients - 1 min, low speed, paddle
Add shortening - 3 min, low speed, paddle
Add water (35°C) - 1 min, low speed, hook, then mix at variable time at medium speed.

Subjective Dough Evaluation

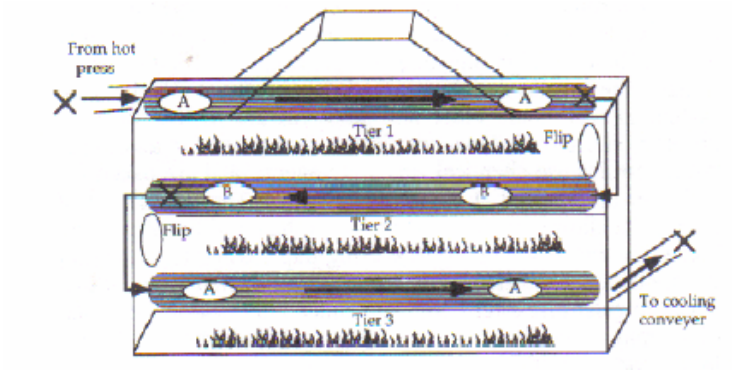
PROOF
5 min, 32°C, 70% RH

DIVIDE and ROUND
Obtain 43-g dough balls

PROOF
10 min, 32°C, 70% RH

Top and bottom of press platen = 395°F; pressure = 1100 psi; press time = 1.4 sec

HOT-PRESS



Oven temperature = 390°F; baking time = 30 sec

BAKE

COOL and PACKAGE

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

Subjective Dough Evaluation

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

Smoothness refers to the appearance and texture of the dough surface, and gives an idea how cohesive the dough is.
Softness refers to the viscosity or firmness of the dough when compressed. It is obtained by pressing the dough with the fingers.
Force to extend refers to the elasticity of the dough when pulled apart. It is obtained by pulling the dough at the same point where softness is ranked.
Extensibility refers to the length the dough extends when pulled apart. It is obtained by pulling the dough.
Press rating refers to the force required to press the dough on the stainless steel round plate before dividing and rounding.

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

BOLD values = desired dough properties.

Evaluation of Tortilla Properties

First day after processing, tortillas are evaluated for weight, diameter, thickness and opacity.

1. Weight
Ten tortillas are weighed on an analytical balance. The weight of one tortilla is calculated by dividing total weight by 10. This ranges from 40 to 46 g.

2. Diameter
Ten tortillas are measured by using a ruler at two points across the tortilla: the larger diameter and the smaller diameter. Values from measurements of ten tortillas are averaged. This varies widely among wheat samples depending on flour quality; desired values are > 165 mm.

3. Thickness
Ten tortillas are stacked and a digital caliper is used to measure their height. The thickness of one tortilla is calculated by dividing the height of the stack by 10. This ranges from 2.5 to 3.5 mm.

4. Moisture
Moisture is determined using a two-stage procedure (AACC, Method 44-15A, 2000). This ranges from 30 to 34%.

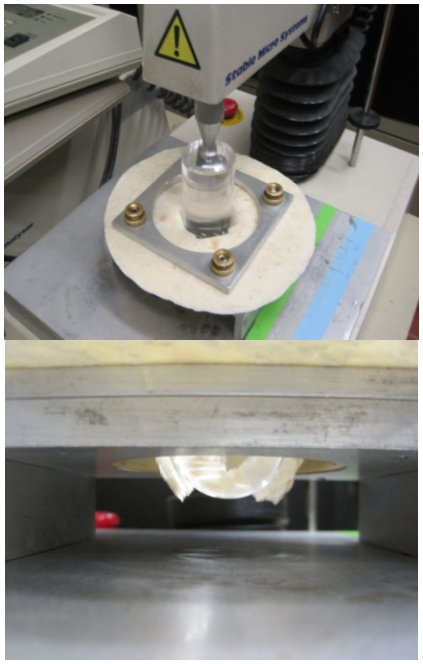
5. Color Values
The color values of lightness (L*), +a* (redness and greenness) and +b* (yellowness and blueness) of tortillas are determined using a handheld colorimeter (model CR-300, Minolta Camera Co., Ltd., Chuo-Ku, Osaka, Japan). L*-values correlate with opacity and are usually greater than 80.

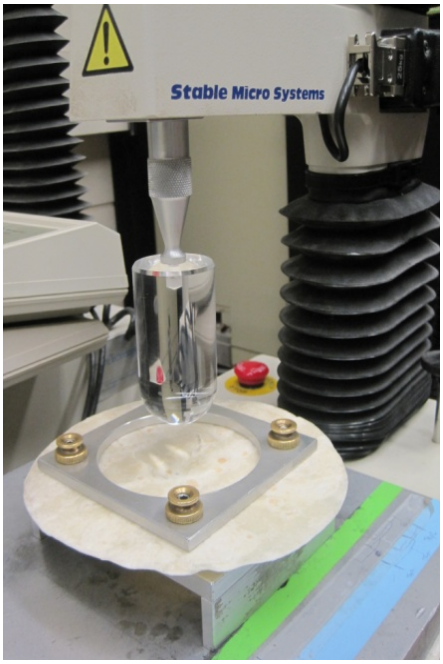
6. Specific Volume
Specific volume (cm^3/g) is calculated: $= \pi * (Diameter/2)^2 * height * 1000 / weight$. This corresponds to fluffiness of the tortilla; desired value is > 1.5 cm^3/g.

7. Tortilla Rollability Score
Two tortillas are evaluated on 4, 8, 12, and 16 days of storage by wrapping a tortilla around a dowel (1.0 cm diameter). The cracking and breakage of the tortilla is rated using a continuous scale of 1-5 (5 = no cracking, 4 = signs of cracking, but no breaking, 3 = cracking and breaking beginning on the surface, 2 = cracking and breaking imminent on both sides, 1 = unrollable, breaks easily). This measures shelf-stability, and the desired value is > 3 on the 16^{th} day.

8. Objective rheological test

Extensibility of two tortillas is measured on 0, 4, 8, 12 and 16 days of storage using a texture analyzer (model TA XT2, Texture Technologies Corp., Scarsdale, NY/Stable Micro Systems, Godalming, Surrey, UK). The tortilla is mounted on the circular frame and a rounded nose probe (The TA-33: 1.5 inch diameter, 3 inch tall rounded end acrylic probe) pushes into the tortilla during the test. Deformation modulus, force, work and distance required to rupture are measured.





WHEAT QUALITY COUNCIL - 2012 DATA WORKSHEET

COOPERATOR NAME:	T.O. Jondiko, J.M. Awika and L.W. Rooney
COOOPERATOR TYPE: MILLER, BAKER, QUALITY LAB	University, Quality Lab
MIXING TOLERANCE METHOD: FARINOGRAPH, MIXOGRAPH, MIXING SERIES, OTHER	
BAKE TEST METHOD: STRAIGHT DOUGH, SPONGE & DOUGH, OTHER	Tortilla Bake Test
DOUGH WEIGHT:	43 gram
Cysteine	30 ppm
Resting TIME:	10 min
Hot-Press Temp (top/bottom):	395 / 395 F
Hot-Press Time:	1.40 sec
Hot-Press Pressure:	1100 psi
OVEN TEMPERATURE:	390 F
BAKE TIME:	30 sec

Table 1. Protein content, and mixograph and farinograph data of the wheat samples.*

TEST No.	Protein	Mix Time	Mix Tolerance	Devt. Time	Stability	Tolerance Index	Breakdown
	(%, 14% mb)	(min)	(scale of 1-6)	(min)	(min)	(FU)	(min)
2401	12.35	3.0	3	5.8	11.2	19	12.5
2402	12.83	5.0	5	7.2	16.1	20	13.3
2403	11.46	3.1	2	5.5	9.0	39	9.1
2404	11.40	5.0	5	5.2	12.7	25	11.6
2405	11.08	3.5	3	5.5	14.8	28	10.6
2406	10.65	3.8	3	6.5	12.7	27	12.0
2407	13.74	4.9	5	7.8	28.5	14	17.2
2408	13.64	7.6	5	37.9	42.9	16	46.0
2409	12.69	3.0	2	8.0	15.9	16	17.4
2410	12.76	4.3	4	6.9	18.1	14	16.6
2411	11.30	3.3	3	5.5	11.2	32	9.6
2412	10.69	3.5	4	5.8	14.8	24	12.0
2413	10.65	4.1	3	6.0	12.2	25	11.9
2414	10.05	3.6	2	5.2	8.9	37	8.6
2415	12.10	3.5	3	6.2	16.4	21	14.0
2416	12.33	3.1	3	7.2	16.9	19	17.0
2417	12.76	3.8	4	8.2	18.1	28	13.3
2418	10.48	4.4	4	5.8	17.3	23	12.7
2419	13.77	6.3	5	6.7	21.2	21	14.0
2420	13.58	8.5	5	7.7	18.8	28	13.2
2421	13.96	3.6	3	7.7	13.8	17	15.6
2422	12.01	2.5	2	5.5	12.6	28	11.2
2423	13.10	6.0	5	8.7	28.9	16	19.4
2424	12.80	2.4	2	5.8	13.3	18.0	13.9

*All data in this table were provided together with the flour samples.

Table 2. Water absorption, mixing time and subjectively evaluated dough properties

TEST No.	Dough Absorp*	Mix time at medium speed**	Mixo TM	Dough Temp	Smooth-ness	Soft-ness	Force to Extend	Extensi-bility	Press Rating
	%	(min)	(min)	(°C)	(Rating)	(Rating)	(Rating)	(Rating)	(Rating)
Tortilla Ref.	52	8	6.0	29.6	2.0	2.0	3.5	2.5	2.0
2401	60	8	3.0	28.9	2.0	2.5	3.0	2.5	2.5
2402	57	13	5.0	29.9	3.0	3.0	2.5	3.0	3.0
2403	54	10	3.1	29.7	2.5	3.0	3.0	2.0	3.0
2404	57	15	5.0	30.4	3.0	3.5	2.0	3.5	3.5
2405	52	12	3.5	28.7	3.5	3.5	2.0	3.5	4.5
2406	55	12	3.8	30.1	2.0	2.0	2.5	2.0	4.5
2407	54	8	4.9	30.2	2.5	2.0	3.5	1.5	3.5
2408	59	8	7.6	30.7	3.0	3.0	3.5	4.0	3.5
2409	58	6	3.0	29.7	2.0	2.0	3.5	2.0	2.0
2410	59	10	4.3	29.1	2.5	3.0	2.5	3.5	3.0
2411	62	8	3.3	30.1	2.5	2.5	3.0	2.5	3.0
2412	57	10	3.5	29.8	3.0	3.0	4.0	3.5	4.0
2413	57	8	4.1	30.3	2.5	3.5	3.0	3.0	4.0
2414	55	6	3.6	29.3	3.0	2.5	2.5	3.5	3.5
2415	58	8	3.5	30.3	3.5	3.0	3.0	3.5	4.0
2416	58	3	3.1	31.6	2.5	3.0	4.0	2.5	2.0
2417	58	8	3.8	31.1	2.5	2.0	3.5	2.5	3.5
2418	54	8	4.4	29.9	3.0	3.0	2.0	3.5	3.5
2419	57	7	6.3	29.7	3.0	3.0	4.0	3.0	4.0
2420	58	9	8.5	20.5	3.0	3.0	3.5	3.0	3.5
2421	60	9	3.6	30.5	3.0	2.0	3.5	2.5	2.5
2422	58	4	2.5	30.2	2.0	2.0	4.0	2.0	2.5
2423	58	9	6.0	30.7	3.5	3.5	3.5	3.5	4.5
2424	59	2	2.4	30.8	1.5	1.5	4.5	1.5	1.5
Descriptors or Scale	record actual absorption	Adjusted Mix time	Actual Mixo Peak time	record actual tempe-rature	*from* 1 = satin smooth *to* 5 = very rough	*from* 1 = very soft *to* 5 = very hard	*from* 1 = less force *to* 5 = extreme force	*from* 1 = breaks immediately *to* 5 = extends readily	*from* 1 = less force *to* 5 = extreme force

* Tortilla dough water absorption was the percent absorption from Farinograph analysis minus 10 units, e.g., if Farinograph absorption was 61% then the tortilla dough absorption was 51%.
** Dough was mixed at medium speed at variable mixing times based on mixograph peak times. However, we had to increase/ decrease the mixing time to ensure complete gluten formation.

Most of the doughs were generally easy to process (i.e., no excessive stickiness or firmness). Doughs from sample 2402 and 2424 were had the highest extensibility scores. Samples 2412, 2416, 2419, 2422 and 2424 required more force to extend. Samples 2405, 2406, 2412, 2413 and 2419 required more force to flatten and hard to press (to the stainless steel plate) and round.

Table 3. **Physical properties of tortillas.**

TEST No.	Moisture	Weight	Thickness	Diameter	Sp. Volume	Lightness*
	%	g	mm	mm	cm^3/g	L-value
Tortilla Ref.	31.7	40.4	2.84	172	1.6	82.1
2401	34.6	40.2	3.04	157	1.5	81.0
2402	33.0	43.2	3.08	133	1.0	76.7
2403	30.3	41.8	3.31	153	1.5	80.4
2404	32.5	43.1	2.92	137	1.0	77.7
2405	30.3	42.3	3.03	135	1.0	77.2
2406	33.7	39.4	2.94	156	1.4	81.3
2407	33.2	44.0	3.11	143	1.1	77.7
2408	35.4	40.7	3.35	127	1.0	76.8
2409	33.9	41.9	2.93	167	1.5	83.4
2410	33.6	43.5	2.98	149	1.2	81.9
2411	34.6	41.0	2.77	159	1.3	81.5
2412	34.1	41.8	2.82	152	1.2	79.8
2413	34.1	40.9	2.80	165	1.5	82.3
2414	32.7	41.6	2.84	162	1.4	80.8
2415	34.6	41.2	2.95	153	1.3	80.4
2416	34.3	41.5	2.96	165	1.5	81.3
2417	33.6	38.6	2.55	152	1.2	78.4
2418	32.5	41.5	3.00	142	1.1	77.3
2419	34.7	42.8	2.96	141	1.1	77.8
2420	34.4	43.8	3.28	132	1.0	77.4
2421	35.2	41.1	2.93	165	1.5	81.5
2422	33.9	38.6	3.01	160	1.6	82.6
2423	34.9	40.0	2.88	149	1.3	80.4
2424	36.8	40.4	3.00	167	1.6	83.3
Descriptors or Scale	Calculate using two-step method	Record actual weight	Record actual thickness	Record actual diameter	Calculate as = π(radius)^2 *thickness *1000/wt	Record actual L-value; 0 = black to 100 = white

*L-value measured from twice-baked side of tortilla

Five samples produced tortillas of good diameter (at least 165 mm). However, these were inferior to control tortillas (172 mm). Samples with >165 mm tortilla diameter had lightness scores >80 and >1.5 cm^3/g specific volume indicating that the dough discs did not shrink back during hot-pressing. Generally, small diameter tortillas (samples 2402, 2408, 2404. 2405, 2420) had corresponding low specific volume averagely 1.0 cm^3/g and were less fluffy, darker and dense.

Table 4. **Texture profile of tortillas measured on day of processing and after 12 days of storage.**

TEST No.	*Modulus day 0*	*Force day 0*	*Distance day 0*	*Work day 0*	*Modulus day 16*	*Force day 16*	*Distance day 16*	*Work day 16*
	(N/mm)	(N)	(mm)	(N.mm)	(N/mm)	(N)	(mm)	(N.mm)
Tortilla Ref.	0.78	10.5	22	80	1.0	7.0	12	31
2401	0.66	11.1	28	116	0.9	8.7	18	50
2402	1.01	20.6	30	230	1.3	18.4	22	180
2403	0.72	11.7	29	123	Mold	Mold	Mold	Mold
2404	1.08	18.5	27	198	1.3	15.7	17	114
2405	1.04	19.2	30	231	1.2	11.0	16	75
2406	0.64	9.3	26	73	0.8	6.8	15	35
2407	0.77	15.8	32	235	1.0	15.7	26	176
2408	0.62	14.2	35	179	0.9	13.6	26	137
2409	0.55	8.1	26	81	0.7	5.6	15	30
2410	0.72	12.6	30	138	0.9	9.8	16	61
2411	0.66	10.4	29	118	0.9	7.9	15	41
2412	0.74	10.8	26	83	1.1	9.0	15	48
2413	0.66	9.3	25	85	0.7	5.1	14	25
2414	0.64	9.4	25	76	0.9	6.6	13	33
2415	0.72	12.8	28	124	1.0	9.0	16	60
2416	0.53	9.4	30	105	0.7	6.6	15	36
2417	0.72	12.8	32	156	1.1	11.3	16	74
2418	0.80	15.4	30	192	1.2	9.6	14	52
2419	0.67	15.9	35	205	1.1	15.7	25	163
2420	0.71	17.5	35	220	1.2	18.7	22	201
2421	0.51	8.7	29	93	0.7	7.1	17	44
2422	0.55	9.8	30	92	0.7	5.8	15	32
2423	0.70	12.6	30	163	1.0	9.5	17	62
2424	0.62	9.7	29	105	0.7	6.6	16	36
HSD (α = 0.05)	0.15	3.8	6.1	70.0	0.25	2.9	3.6	40.0
Descriptors or Scale	Determine parameters using texture analyzer on day of processing				Determine parameters using texture analyzer after 16 days of storage			

Tortillas from all the samples had a significant reduction in extensibility (>10 mm) reduction in distance from day 0 to day 16. Samples 2402, 2419 and 2420 had consistently the highest force, distance and work needed to rupture the tortillas especially after 16 days of storage at room temperature. These were the most extensible (less prone to break) compared to the other samples.

Table 5. Subjective rollability scores, tortilla diameter and sample ratings.

TEST No.	*Rollability Scores (RS)*				*Diameter*	Rating*
	4 days	8 days	12 days	16 days+	mm	
Tortilla Ref.	4.8	4.0	3.5	3.3	172	Good
2401	4.8	4.5	4.3	3.8	157	Fair
2402	5.0	4.8	4.3	3.8	133	Poor
2403	4.8	3.5	.	.	153	Poor
2404	4.8	4.5	4.0	3.8	137	Poor
2405	4.5	4.3	4.0	3.5	135	Poor
2406	4.0	3.5	3.3	2.8	156	Poor
2407	4.5	4.5	4.3	4.0	143	Poor
2408	5.0	4.8	4.5	3.8	127	Poor
2409	5.0	4.8	3.8	2.8	167	Poor
2410	4.3	4.0	3.8	3.3	149	Poor
2411	4.3	4.0	3.5	3.3	159	Fair
2412	4.0	3.8	3.3	2.8	152	Poor
2413	4.0	3.5	3.0	2.5	165	Poor
2414	3.8	3.5	3.0	2.3	162	Poor
2415	4.3	4.0	4.0	3.8	153	Poor
2416	4.3	4.0	3.5	2.8	165	Poor
2417	4.3	4.0	4.0	3.8	152	Poor
2418	4.0	3.8	3.3	2.8	142	Poor
2419	5.0	4.8	4.3	3.8	141	Poor
2420	5.0	4.8	4.5	4.0	132	Poor
2421	5.0	4.8	4.3	3.8	165	Good
2422	4.5	3.8	3.5	3.3	160	Fair
2423	5.0	4.8	4.3	3.8	149	Poor
2424	4.5	4.0	3.3	3.0	167	Good
Descriptors or Scale	*from* 1 = breaks when rolled to 5 = rolls easily				Record actual diameter	

+ 16 days rollability score is based on one replicate (Second Replicate evaluation is underway)
*Subjective rating based mainly on diameter and rollability scores (day 16):
Good = rollability score >3 on day 16, ≥165 mm
Fair = rollability score >3 on day 16, 157-164 mm
Poor = rollability score <3 on day 16, any diameter

Only sample 2421 and 2424 tortillas had the acceptable diameter and day-16 rollability scores. Samples 2401, 2411 and 2422 had "fair" ratings (acceptable rollability score but relatively small diameter). Other samples either had very good rollability scores but small diameters (typical of strong flours that give doughs that shrink when hot-pressed) or acceptable diameter but break after 16 days of storage (typical of weak flours) (Figure 1). Between the two, the former is easier to 'tweak' to create acceptable tortillas. Reducing agents like L-cysteine can

be added to the formulation to reduce elasticity, lessen shrinking back, and result in tortillas with bigger diameters (Figure 2). It is important, however, that a balance between decreasing dough elasticity and maintaining the desired tortilla flexibility be met (i.e., too much reducing agent results in a tortilla that breaks easily).

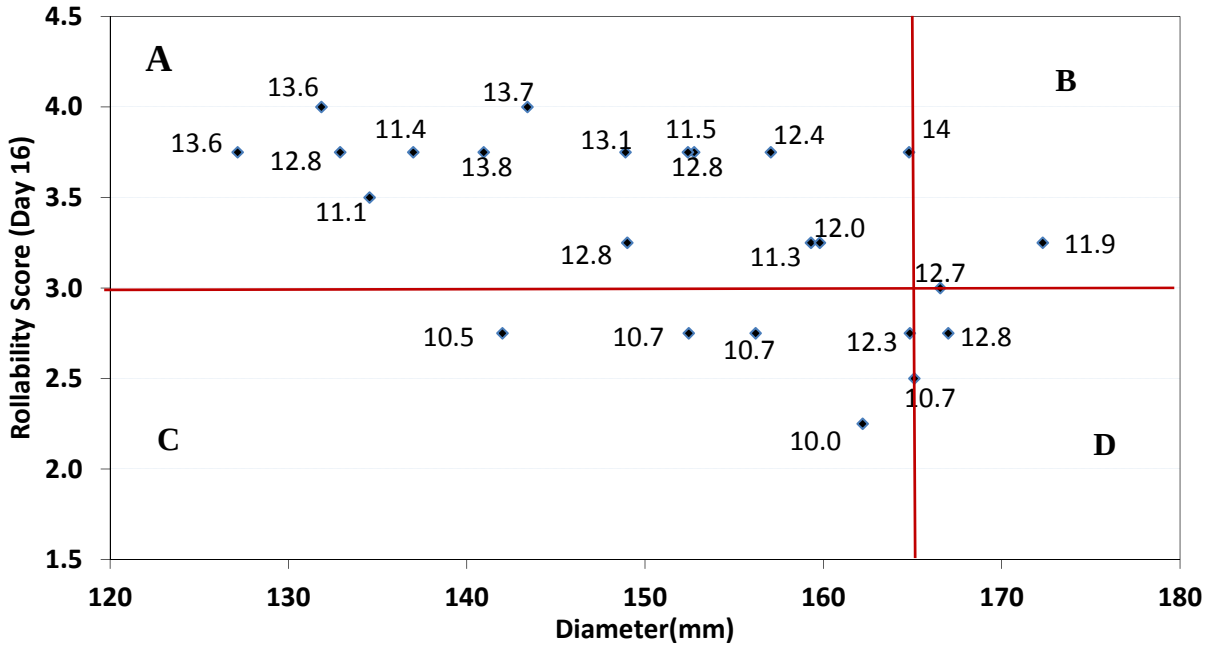


Fig. 1. Relationship of tortilla diameter, rollability score (day 16) and flour protein content (14% mb; shown as numbers inside the box). Quadrant A: good shelf-stability, poor diameter; B: acceptable diameter and shelf-stability; D: good diameter, poor shelf-stability.

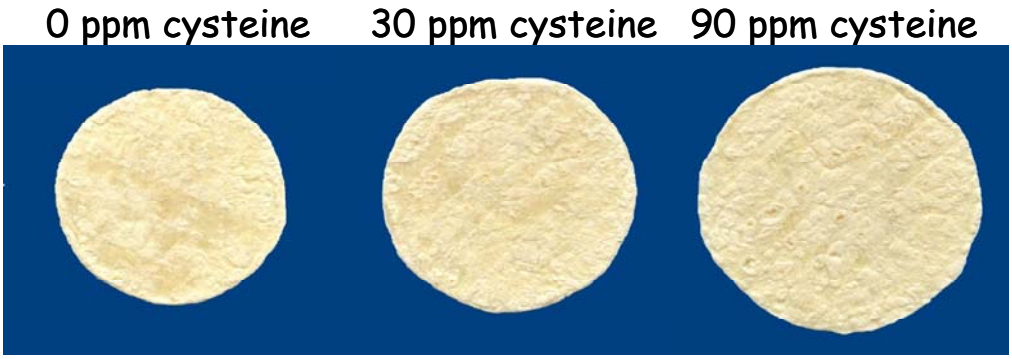


Fig. 2. Tortillas from commercial bread flour (13.3% protein) with and without L-cysteine.

Currently, the characteristics of flour that will give excellent tortilla quality are not completely understood. Waniska et al. (2004) stated that the list of flour properties should include intermediate protein content (10-12%), intermediate protein quality and low levels of starch damage. Sample 2414, which gave the best tortilla quality, does not fall into this category (i.e., has 14.21% protein and is relatively weak) and seems to be an outlier.

For this year's samples (as also observed before), protein content (PC) alone cannot determine the tortilla quality. In Figure 1, all shelf-stable samples (rollability score >3) have PC of about 12%, but not all samples with 12% PC gave shelf-stable tortillas. Protein quality, on the other hand, seems to be a better (but still not perfect) predictor of tortilla quality. Figure 3 shows that samples with at least 3.5 min mixograph mixing time generally gave small diameters and good shelf-stability, while those with less than 4 min mixing time had tortillas with good diameter but poor shelf-stability. Further studies on specific protein and/or gluten components that affect tortilla quality are required to improve the current understanding of the relationships involved.

We are completing extensive measurements of rheological properties of dough and tortillas produced from the 2011 crop year along with the current 2012 samples. Colleagues at the Grain Marketing Laboratory are conducting protein fractionation of these samples which hopefully will assist in determining more about essential factors affecting tortilla quality.

The work to establish the attributes required for optimum tortilla production will require significant efforts. Bread baking quality has been evaluated for more than 100 years. We think that excellent progress is being made to understand the tortilla baking system, which differs significantly from bread baking.

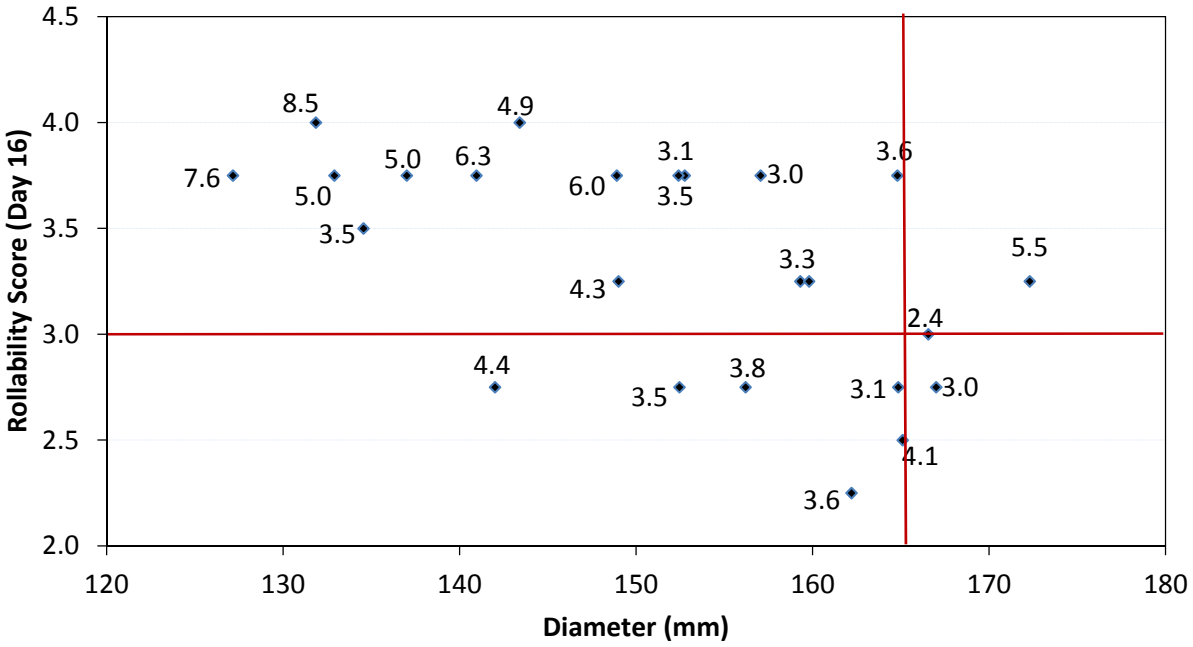


Fig. 3. Relationship of tortilla diameter, rollability score (day 16) and mixograph mixing time (shown as numbers inside the box).

References:

Serna-Saldivar, S.O., Rooney, L.W., Waniska, R.D. 1988. Wheat flour tortilla production. Cereal Foods World. 33: 855-864.

Waniska, R.D., Cepeda, M., King, B.S., Adams, J.L., Rooney, L.W., Torres, P.I., Lookhart, G.L., Bean, S.R., Wilson, J.D., Bechtel, D.B. 2004. Effects of flour properties on tortilla qualities. Cereal Food World. 49 (4): 237-244.

Waniska, R.D. 1999. Perspectives on flour tortillas. Cereal Foods World. 44:471-473.

2012 WQC HARD WINTER WHEAT FLOUR PROTEIN ANALYSIS

Michael Tilley

USDA, CGAHR, Manhattan, KS

Procedures

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

Sequential protein extraction:

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

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

- Protein extraction (Bean et al, 1998): 100 mg flour + 1 ml 50% 1-propanol- vortex for 5 min, centrifuge for 5 min at 12,000 x g. Discard supernatant.
- Repeat this procedure two more times and discard the supernatants (the supernatants contain the monomeric and soluble polymeric proteins).
- Lyophylize the pellet, which contains the insoluble polymeric proteins.
- Determine pellet protein content by Nitrogen combustion (LECO analysis).
- Insoluble polymeric protein percentage (%IPP) is calculated by multiplying nitrogen values by a conversion factor of 5.7 and dividing by total flour protein.

References

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

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

Naeem, H.A.; Sapirstein, H.D. 2007. Ultra-fast separation of wheat glutenin subunits by reversed-phase HPLC using a superficially porous silica-based column. *Journal of Cereal Science* 46:157-168.

Results of Flour Protein Analysis

Sample	HMW-GS composition	Polymeric/ monomeric pr	IPP (%)
12-0002401	2*, 7 + 8, 5 + 10	0.75	45.35
12-0002402	2*, 7 + 8, 5 + 10	0.85	45.40
12-0002403	2*, 7 + 9, 5 + 10	0.72	44.84
12-0002404	2*, 7 + 8, 5 + 10	1.00	44.07
12-0002405	2*, 7 + 9, 5 + 10	0.88	42.73
12-0002406	2*, 7 + 8, 5 + 10	0.87	42.24
12-0002407	2*, 7 + 8, 5 + 10	0.78	46.43
12-0002408	2*, 7^{OE} + 8, 5 + 10	0.86	51.48
12-0002409	2*, 7 + 9, 5 + 10	0.74	37.97
12-0002410	2*, 7 + 9, 5 + 10	0.66	42.86
12-0002411	1, 7 + 9, 5 + 10	0.99	46.19
12-0002412	2*, 7 + 8, 2 + 12	1.09	41.15
12-0002413	2*, 7 + 9, 5 + 10	0.77	37.94
12-0002414	2*, 7 + 9, 5 + 10	0.89	39.47
12-0002415	2*, 17 + 18, 5 + 10	0.88	35.46
12-0002416	2*, 7 + 9, 5 + 10	0.79	47.62
12-0002417	2*, 7 + 9, 5 + 10	0.84	47.58
12-0002418	2*, 7 + 8, 5 + 10	0.99	53.89
12-0002419	1, 7 + 8, 5 + 10	0.76	55.10
12-0002420	1, 7 + 9, 5 + 10	0.68	58.07
12-0002421	2*, 7 + 8, 5 + 10	0.65	49.00
12-0002422	2*, 7 + 8, 2 + 12	0.75	47.74
12-0002423	2*, 7 + 9, 5 + 10	0.87	59.72
12-0002424	2*, 20a + 20b, 5 + 10	0.87	43.78

APPENDIX A
Credits and Methods

CREDITS

Milling, Sample Analysis, Ingredients and Report Preparation

Single Kernel Analysis, Kernel Size Distribution, Test Weight, and Quadrumatic Sr. Mill	USDA/ARS/HWWQL Manhattan, KS
Flour Milling (Miag Multomat)	KSU Dept. Grain Science & Ind. Manhattan, KS
Wheat Grading	Federal Grain Inspection Service 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	Caravan Ingredients Company 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

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Bay State Milling Co. P.O. Box 188 55 Franklin Street Winona, MN 55987	Miller	**Terry A. Selleck** (507)452-1770 terry.wn@bsm.com
Cargill Inc. 3794 Williston, Rd., Minnetonka, MN 55345	Miller	**Brian Walker** (952)238-4886 Brian_walker@cargill.com
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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 1000 kernels of wheat, determined with an electronic seed counter using a 40g sample from which all foreign material and broken kernels have been removed (reported on 12% moisture basis).

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.

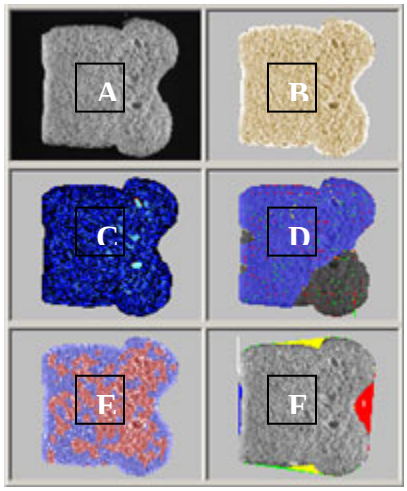
Similarly, cumulative protein curves are determined by arranging millstreams in ascending order of protein content, and tabulating the protein content of the total flour produced with the addition of successive millstreams. Wheat that gives high protein content at low extraction, and a fast rate of protein 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

2012 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	Pup-loaf straight dough	100 g		90 min	401	22
B	2	Sponge and dough	700 g, 524 g dough	Mixing series	240 min (sponge time) and 60 min (fermentation)	420	20
C	3	Pup-loaf straight dough	100 g, approx 170 g	Mixograph	90 min	400	25
D	4	Pup-loaf straight dough	200g, 170 g dough	Mixograph	180 min	419	24
E	5	Sponge and dough	700 g flour, 19 oz	Farinograph	180 min (sponge) and 70 min (fermentation)	420	20
F	6	Sponge and dough	600 g flour, 480 g dough	Other	240 min (sponge time) and 45 min (fermentation)	420	20
G	7	Straight dough	700 g flour, 525 g dough	Mixing series	120 min	400	25
H	8	Pup-loaf straight dough	100 g flour, approx 160 g dough	Farinograph	120 min	425	20
I	9	Sponge and dough	540 g dough	Mixing series	210 min	430	23
J	10	Pup-loaf straight dough	100 g flour, approx 175 g dough	Mixograph	90 min	425	21
K	11	Pup-loaf straight dough	100 g flour	Farinograph	120 min	390	25
L	12	Pup-loaf straight dough	100 g flour, approx 170 g dough	Mixograph	120 min	420	18
M	13	Sponge and dough	1000 g flour, 500 g dough	Farinograph	240 min	425	20
N	14	Sponge and dough	700 g flour, 524 g dough	Farinograph with mixing evalu	240 min (sponge time) and 60 min (fermentation)	420	20
O	15	Sponge and dough	600 g flour, 160 g dough	Mixing series	240 min	425	16
P	16	Straight dough	100 g flour, approx. 175 g dough	Farinograph and Mixograph	180 fermentation and 60 min proof time	400	25
Q	17	Sponge and dough	520 g dough		270 min	400	18

APPENDIX B

Hard Winter Wheat Quality Council
Goals for Hard Winter Wheat Breeders

Hard Winter Wheat Quality Council

2012 Technical Board Officers

CHAIR:	**Craig Warner**, BIMBO Bakeries USA
VICE CHAIR:	**Theresa Sutton,** USDA/ARS/CGAHR
SECRETARY:	**Justin Turner**, Horizon Milling
MEMBER:	**Ron Lindgren**, Foss North America
MEMBER:	**Ron Hobbs,** ADM Milling

2012 Quality Evaluation & Advisory Committee

Brad Seabourn, USDA/ARS/HWWQL

Allan Fritz, Kansas State University

Brian Strouts, American Institute of Baking

Ken Ulbrich, Bay State Milling

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’, not 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

by **Theresa Sutton**

Feb. 15-16, 2012

Hard Winter Wheat Quality Council Meeting Minutes
Annual Meeting February 15, 2012

Sid Perry, Chair (WestBred/Monsanto) called the meeting to order. The minutes from last year's meeting (Feb. 2011) had been posted to the WQC website. A motion to accept the minutes was made by Hayden Wands (Bimbo Bakeries), seconded by Craig Warner (Bimbo Bakeries), voted on and approved.

Slate of Officers for 2012-2013

Chair: Craig Warner (Bimbo Bakeries USA)
Vice Chair: Theresa Sutton (USDA/ARS/CGAHR)
Secretary: Justin Turner (Horizon Milling)
Member: Ron Lindgren (Foss North America)
Member: Ron Hobbs (ADM Milling), nominated from the floor
Randy Englund (SD Wheat Commission) moved to accept the nomination from the floor; it was seconded by Laura McLaughlin (USDA), voted on and approved.

Wheat Quality Council Book Report by Richard Chen (USDA)

- 21 samples from 7 collaborating breeders.
- The report was out late due to milling issues
- A history of WQC Hard Winter Wheat Entries was added to the book.
- 2011 WQC Milling and Baking Score diagrams were also added to the book based on a suggestion from Tim Aschbrenner (Cereal Food Processors).
- Reprocessed flour supplemental baking data was added as Appendix F.

Overview of 2011 Milling by Quenten Allen (KSU)

- KSU conducted an in depth look at the history of the Miag Multomat flow. The Miag was purchased in 1958 for $14,500.00. Updated copy recorded 9/29/1961.
- 2011 was a "check" year in determining items needed for correction. Standard Operating Procedures were identified for future technician training and included a sieve check, warm-up validation, spare parts inventory, etc.
- There are exciting developments happening at KSU Milling department including extended capabilities at the Hal Ross Pilot Mill.
- Film of the Miag in operation was shown.

2011 Hard Winter Wheat Key Quality Indicators by Praveen Jella (ConAgra)

- 2011 crop was 25% lower compared to last year due to less acreage and yield.
- Texas, Oklahoma and Southwest Kansas had lower production due to dry and extremely hot conditions.
- Lower test weight and KWT.
- Protein content was higher but Falling Number values were comparable.

Update on Crop Conditions in the Hard Winter Wheat States:
Montana – Jim Berg

- Acreage planted was down
- Not much snow cover, average
- 25% good to excellent crop condition
- 25 – 30% crop had some wind damage
- May get more moisture in Feb. and March

Colorado – Scott Haley

- Acreage planted was up
- Good planting conditions in the Fall
- Nice snows in December
- Looking good now

South Dakota – Bill Berzonsky

- Very wet spring and in general wet and humid
- Higher than normal incidence for diseases
- Hot spots for scab in central and south central SD
- Approx. 1.59M acres harvested
- Wesley, Overland & Expedition are the top 3 varieties grown
- Lyman is the best variety for scab resistance
- Poor snow depth, less than 1 inch

Nebraska – Richard Little (Univ of NE) and Janet Lewis (Bayer CropScience)

- Similar to Colorado
- Very little snow
- Eastern part of the state is looking good

Kansas – Allan Fritz

- Acreage planted was up, especially in western KS
- Decent moisture but concerns for Southwest part of the state
- Worried about late spring freezes
- In good shape now but there are warm weather concerns

Oklahoma – Mark Hodges

- In 2011, Oklahoma had the hottest July and the coldest winter on record, the largest earthquake and only the second worst drought.
- 2012 crop has a good start, acreage is up
- Unusual rainfall but in good shape, there is still a moisture deficit
- Southwest part of the state and pan handle region are a D4 condition for drought

Texas – Sid Perry for Jackie Rudd

- Tough conditions, there is need for moisture

Other Business

Ben Handcock announced that the Council had 3 new members: Pepperidge Farm, Snyder's – Lance and ABA. Sara Lee is now a part of Bimbo Bakeries. Lee Sanders (ABA) was voted to the Board of Trustees. Glen Weaver (ConAgra) will be the new Chair of the Executive Committee.

Brad Seabourn (USDA) reminded the baking collaborators that there would be a planning meeting after the sessions ended for the day. He also thanked Ben Handcock for 20 years (1992 – 2012) of dedicated service to the Wheat Quality Council.

A motion to adjourn the meeting was made by Brian Walker (Horizon Milling), seconded by Glen Weaver (ConAgra), voted on and approved. Meeting adjourned.

Respectfully submitted: Theresa Sutton, Secretary, USDA HWWQL

APPENDIX F

Historical WQC Hard Winter Wheat Entries Since 2001

A History of WQC Hard Winter Wheat Entries

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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	no			Kansas-Manhattan
KS020633M-13	11-2409	HRW	no			Kansas-Manhattan
McGill (check)	11-2410	HRW				Nebraska
NE05496	11-2411	HRW	no			Nebraska
NE05548	11-2412	HRW	no			Nebraska
NI08708	11-2413	HRW	no			Nebraska
Jagalene (check)	11-2414	HRW				Westbred
HV9W06-509	11-2415	HWW	yes	WB-Grainfield	2012	Westbred
Yellowstone (check)	11-2416	HRW				Montana
MTS0808	11-2417	HRW	no			Montana
MT0871	11-2418	HRW	no			Montana
Lyman (check)	11-2419	HRW				South Dakota
SD06158	11-2420	HRW	no			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	no			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	no			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

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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	no			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
Yellowstone (check)	09-2414	HRW				MSU
MT06103	09-2415	HRW	no			MSU
MTS0713	09-2416	HRW	yes	Judee	2011	MSU
TAM 111 (check)	09-2417	HRW				TAMU
TX02A0252	09-2418	HRW	yes	TAM 113	2010	TAMU
Millennium (check)	09-2419	HRW				NU
NE01481	09-2420	HRW	yes	McGill	2010	NU
NI04421	09-2421	HRW	yes	Robidoux	2010	NU
2008						
Jagalene (check)	08-2401	HRW				AgriPro
Art	08-2402	HRW	yes			AgriPro
Hawken	08-2403	HRW	yes			AgriPro
NuDakota	08-2404	HRW	yes			AgriPro
Hatcher (check)	08-2405	HRW				CSU
Thunder CL	08-2406	HWW	yes			CSU
CO03W054	08-2407	HWW	yes	Snowmass		CSU
CO03064	08-2408	HRW	no			CSU
Danby (check)	08-2409	HWW				KSU-Hays
Tiger	08-2410	HWW	yes			KSU-Hays
Karl 92 (check)	08-2411	HRW				KSU-Manhattan
KS970093-8-9-#1	08-2412	HRW	yes	Everest	2009	KSU-Manhattan
OK Bullet (check)	08-2413	HRW				OSU
OK03305	08-2414	HRW	yes	Pete	2009	OSU
OK03522	08-2415	HRW	yes	Billings	2009	OSU
OK03825-5403-6	08-2416	HRW				OSU
Tandem (check)	08-2417	HRW	yes	STARS0601W	2006	SDSU
SD05W030	08-2418	HWW	no			SDSU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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	no			SDSU
SD01273	07-2416	HRW	no			SDSU
Genou (check)	07-2417	HRW				MSU
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

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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
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

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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
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

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
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 very much for reviewing the 2012 WQC Hard Winter Wheat milling and baking report. 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@ars.usda.gov