Milling and Baking Test Results for Hard Winter Wheat

Harvested in 2008

59th 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 of AgriPro Wheat and Westbred, LLC, and laboratories of milling, baking, grain trade and other firms and research organizations. This report was completed by USDA-ARS, Hard Winter Wheat Quality Laboratory. 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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Downloading or printing this report can be obtained from Wheat Quality Council webpage if you are a member of WQC. Otherwise, please contact:

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2008

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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 2008 Testing Program

2008 was the 59th year for the Hard Winter Wheat Milling and Baking Evaluation Program sponsored by the Wheat Quality Council. Wheat experimental lines and check varieties were submitted by public and private breeding programs. This report includes FGIS market classification, physical grain testing, milling, analytical, rheological, and bread baking results. Alkaline noodle data generated by the USDA, Hard Winter Wheat Quality Lab in Manhattan, KS and tortilla data generated by Texas A&M University as well as the USDA-ARS-GMPRC Grain Quality and Structure Research Unit are also included in the report. Methods used to evaluate wheat lines are listed in Appendix A.

All entries this year were grown in special locations and submitted for small-scale testing by participating wheat breeders. Wheat samples were milled on the Miag Multomat Mill at Kansas State University (Methods, Appendix A). The flours were distributed to nineteen cooperators (16 for bread baking, 2 for tortilla and 1 for noodle), with all returning bread baking, tortilla, and noodle test results.

Identity of 2008 Wheat Samples

	Test Entry Number	Sample Identification
AGRIPRO	08-2401	Jagalene (Check)
	08-2402	Art
	08-2403	Hawken
	08-2404	NuDakota
COLORADO		
	08-2405	Hatcher (Check)
	08-2406	Thunder CL
	08-2407	CO03W054
	08-2408	CO03064
KANSAS-HAYS		
	08-2409	Danby (Check)
	08-2410	Tiger
KANSAS-MANHATTAN		
	08-2411	Karl 92 (Check)
	08-2412	KS970093-8-9-#1
OKLAHOMA		
	08-2413	OK Bullet (Check)
	07-2414	OK03305
	07-2415	OK03522
	07-2416	OK03825-5403-6
SOUTH DAKOTA		
	08-2417	Tandem (Check)
	08-2418	SD05W030

Wheat Classification Results from FGIS

FGIS Market Classification

ID	Program	CL	DKG	TW	M	ODOR	HT	DKT	FM	SHBN	DEF	CCL	WOCL	GRADE
08-2401	**Agripro**	HRW	0.00	60.6	11.1	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.0	U. S. NO. 1 HRW, DKG 0.0%
08-2402	**Agripro**	HRW	0.00	61.3	10.9	OK	0.0	0.3	0.0	0.1	0.4	0.0	0.0	U. S. NO. 1 HRW, DKG 0.0%
08-2403	**Agripro**	HRW	0.00	61.3	11.0	OK	0.0	0.1	0.0	0.2	0.3	0.0	0.0	U. S. NO. 1 HRW, DKG 0.0%
08-2404	**Agripro**	HDWH	0.00	59.7	10.8	OK	0.0	0.6	0.0	0.1	0.7	0.0	0.0	U. S. NO. 2 HDWH, DKG 0.0%
08-2405	**Colorado**	HRW	0.00	61.1	10.2	OK	0.0	0.0	0.0	0.8	0.8	0.0	0.2	U. S. NO. 1 HRW, DKG 0.0%
08-2406	**Colorado**	HDWH	0.00	60.8	9.7	OK	0.0	0.0	0.0	0.7	0.7	0.0	0.0	U. S. NO. 1 HDWH, DKG 0.0%
08-2407	**Colorado**	HDWH	0.00	60.8	9.9	OK	0.0	0.1	0.0	0.4	0.5	0.0	0.0	U. S. NO. 1 HDWH, DKG 0.0%
08-2408	**Colorado**	HRW	0.00	57.6	10.1	OK	0.0	0.1	0.0	0.2	0.3	0.0	0.4	U. S. NO. 3 HRW, DKG 0.0%
08-2409	**Kansas-Hays**	HDWH	0.01	63.3	12.1	OK	0.0	0.0	0.0	0.7	0.7	0.0	0.0	U. S. NO. 1 HDWH, DKG 0.0%
08-2410	**Kansas-Hays**	HDWH	0.01	59.6	11.5	OK	0.0	0.1	0.0	0.4	0.5	0.7	0.7	U. S. NO. 2 HDWH, DKG 0.0%
08-2411	**Kansas-Man**	HRW	0.00	60.0	11.9	OK	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U. S. NO. 1 HRW, DKG 0.0%
08-2412	**Kansas-Man**	HRW	0.00	59.3	12.4	OK	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U. S. NO. 2 HRW, DKG 0.0%
08-2413	**Oklahoma**	HRW	0.03	58.2	11.5	OK	0.0	0.0	0.0	0.5	0.5	0.0	3.2	U. S. NO. 2 HRW, DKG 0.0%
08-2414	**Oklahoma**	HRW	0.00	60.8	11.8	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.0	U. S. NO. 1 HRW, DKG 0.0%
08-2415	**Oklahoma**	HRW	0.01	59.9	11.6	OK	0.0	0.0	0.0	0.1	0.1	0.0	0.2	U. S. NO. 2 HRW, DKG 0.0%
08-2416	**Oklahoma**	HRW	0.01	59.2	11.5	OK	0.0	0.2	0.0	0.2	0.4	0.0	0.0	U. S. NO. 2 HRW, DKG 0.0%
08-2417	**South Dakota**	HRW	0.00	63.2	12.0	OK	0.0	0.1	0.0	0.2	0.3	0.0	0.0	U. S. NO. 1 HRW, DKG 0.0%
08-2418	**South Dakota**	HDWH	0.00	63.5	12.1	OK	0.0	0.0	0.0	0.2	0.2	5.0	5.0	U. S. NO. 4 HDWH, DKG 0.0%

CL = Class, DKG = Dockage (%), TW = Test weight (lb/bushels), M = Moisture (%), HT = Heat damage (%), 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

AgriPro – Reported by Rollin Sears

Growing Location

The plots were grown in a farmer's field approximately 10 miles south of Salina along the Smokey Hill river. The field was planted to soybeans the previous year.

Jagalene (Check) (08-2401)

It is the check and was the leading variety planted in Kansas in 2008

Art (08-2402)

Art is a new variety available to growers for fall planting in 2008. It is best adapted to central Kansas.

Hawken (08-2403)

Hawken is a new variety available to growers for fall planting 2008. It is best adapted to northern Kansas, Nebraska, Colorado and South Dakota.

NuDakota (08-2404)

NuDakota is a hard white wheat that is best adapted to Colorado, western Nebraska and western South Dakota.

AgriPro: 2008 (Small-Scale) Samples [a]

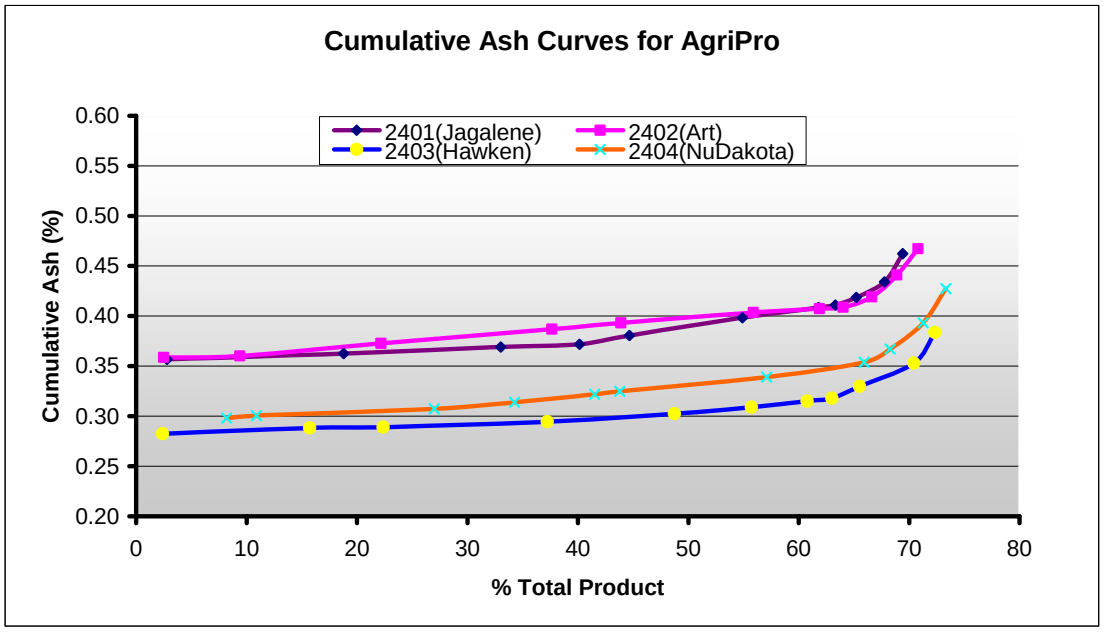
Test entry number	08-2401	08-2402	08-2403	08-2404
Sample identification	**Jagalene (check)**	**Art**	**Hawken**	**NuDakota**
Wheat Data				
FGIS classification	1 HRW	1 HRW	1HRW	2HDWH
Test weight (lb/bu)	60.6	61.3	61.3	59.7
Hectoliter weight (kg/hl)	79.7	80.6	80.6	78.6
1000 kernel weight (gm)	27.4	26.7	28.8	29.4
NIR hardness	80	61	71	64
Wheat kernel size (Rotap)				
Over 7 wire (%)	47.4	49.9	55.9	66.5
Over 9 wire (%)	52.5	50.1	44.0	33.5
Through 9 wire (%)	0.1	0.0	0.1	0.0
Single kernel (skcs)				
Hardness (avg /s.d)	73.1/14.7	69.1/14.1	68.2/13.7	61.7/13.8
Weight (mg) (avg/s.d)	26.8/6.7	25.5/5.8	27.6/5.8	29.2/6.3
Diameter (mm)(avg/s.d)	2.62/0.27	2.60/0.23	2.66/0.25	2.68/0.26
SKCS distribution	00-03-14-83	01-03-21-75	02-02-15-81	01-12-27-60
Classification	Hard	Hard	Hard	Hard
Wheat moisture (%)	10.0	9.88	10.1	9.6
Wheat protein (12% mb)	14.2	13.8	14.3	13.0
Wheat ash (12% mb)	1.52	1.71	1.52	1.59
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	69.5	70.8	72.4	73.3
Quadrumat Sr. Mill	72.6	68.7	70.4	69.9
NIR flour moisture (%)	11.7	11.7	12.0	12.6
NIR flour protein (14% mb)	12.7	12.2	12.4	11.2
Flour ash (14% mb)	0.49	0.49	0.44	0.46
Glutomatic				
Wet gluten (%)	35.6	35.0	33.6	34.5
Dry gluten (%)	14.0	11.7	12.2	11.5
Gluten index	96.6	70.8	97.2	86.2
Rapid Visco-Analyser				
Peak time (min)	6.2	6.3	6.3	6.2
Peak viscosity (RVU)	202.6	210.6	207.5	217.6
Breakdown (RVU)	65.4	63.9	69.7	76.0
Final viscosity at 13 min (RVU)	249.7	262.7	248.9	261.2
Minolta color meter				
L*	92.20	92.86	92.75	92.84
a*	-1.48	-1.72	-1.30	-1.45
b*	10.00	10.05	8.70	9.08
Falling number (sec)	536	429	426	469
Flour particle size (avg)				
Fisher sub sieve sizer	23.3	18.9	20.5	21.3

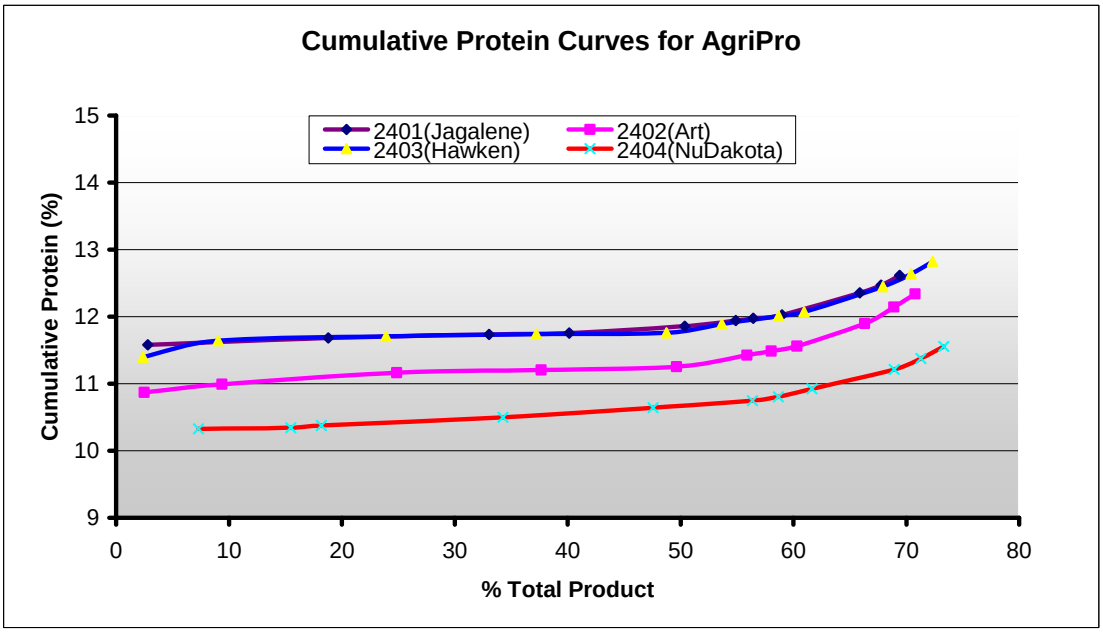
[a] s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

AgriPro: Physical Dough Tests and Gluten Analysis For 2008 (Small-Scale) Samples

Test Entry Number	08-2401	08-2402	08-2403	08-2404
Sample Identification	Jagalene (check)	Art	Hawken	NuDakota
MIXOGRAPH				
Flour Abs (% as-is)	65.7	60.8	64.9	63.2
Flour Abs (14% mb)	63.1	58.2	62.6	61.6
Mix Time (min)	3.88	2.38	4.75	2.88
Mix tolerance (0-6)	3	2	5	2
FARINOGRAPH				
Flour Abs (% as-is)	62.0	60.8	62.1	58.8
Flour Abs (14% mb)	59.4	58.2	59.8	57.2
Development time (min)	7.1	6.5	6.3	4.0
Mix stability (min)	17.9	13.1	15.8	10.5
Mix Tolerance Index (FU)	15	20	28	25
Breakdown time (min)	16.2	13.8	11.4	9.8
ALVEOGRAPH				
P(mm. H2O): Tenacity	94	81	91	60
L(mm): Extensibility	107	69	97	96
G($mm_{0.5}$): Swelling index	23	18.5	21.9	21.8
W(10^{-4} J): strength (curve area)	375	208	336	174
P/L: curve configuration ratio	0.88	1.17	0.94	0.62
Ie(P_{200}/P): elasticity index	66.6	57.4	66.7	50
EXTENSIGRAPH				
Resist (BU at 30/60/90 min)	320/476/513	290/448/498	327/440/459	214/258/289
Extensibility (mm at 30/60/90 min)	201/186/166	140/130/121	199/183/168	179/178/179
Energy (cm2 at 30/60/90 min)	150/187/179	75/99/97	147/171/153	71/89/100
Resist $_{max}$ (BU at 30/60/90 min)	576/781/858	423/604/639	567/726/721	276/367/405
Ratio (at 30/60/90 min)	1.6/2.6/3.1	2.1/3.4/4.1	1.6/2.4/2.7	1.2/1.5/1.6
PROTEIN ANALYSIS				
HMW-GS Composition	1/2*, 5, 10, 17, 18	2*, 5, 10, 7, 9	Null, 5, 10, 7, 9	1, 2, 12, 7, 9
Glu/Gli	0.53	0.44	0.41	0.59
HMW/LMW	0.35	0.40	0.23	0.38
%IPP	54.74	47.01	50.78	47.56
SEDIMENTATION TEST				
Volume (ml at 14% mc)	55.0	39.0	64.0	41.8

AgriPro: Cumulative Ash and Protein Curves

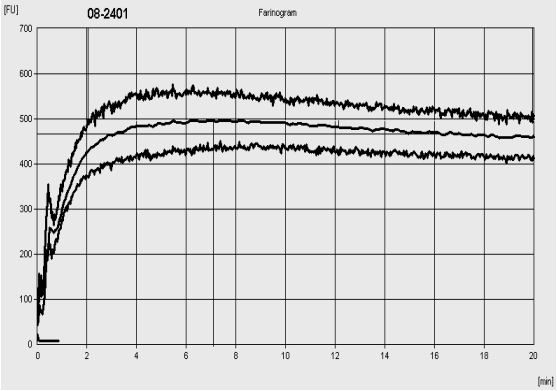




Physical Dough Tests

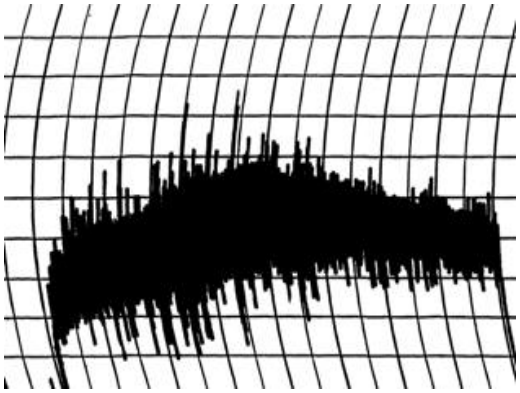
2008 (Small Scale) Samples – AgriPro

Farinograms



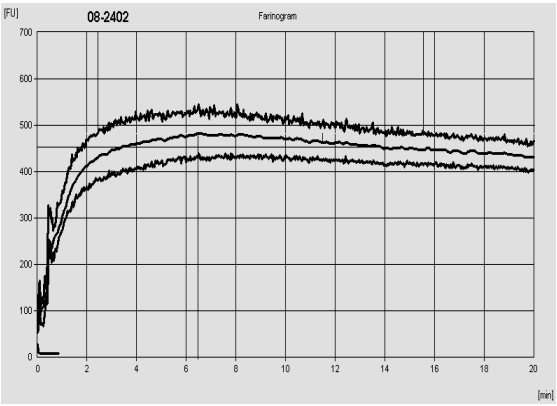
Water Abs.= 59.4%, Peak time = 7.1 min,
Mix Stab.= 17.9 min, MTI = 15 FU

Mixograms

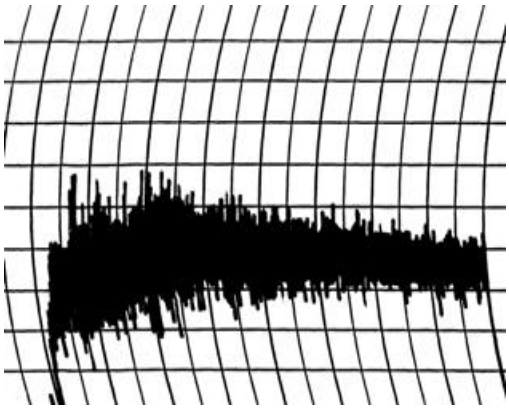


Abs. = 63.1%, Mix time = 3.9 min,
Mix tolerance = 3

08-2401, Jagalene (check)



Water Abs. = 58.24%, Peak time = 6.5 min,
Mix Stab. = 13.1 min, MTI = 20 FU

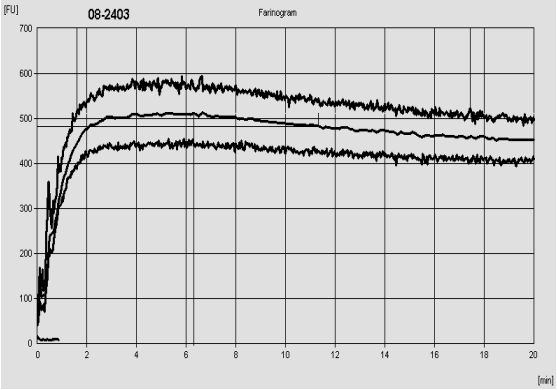


Abs. = 58.2%, Mix time = 2.4 min,
Mix tolerance = 2

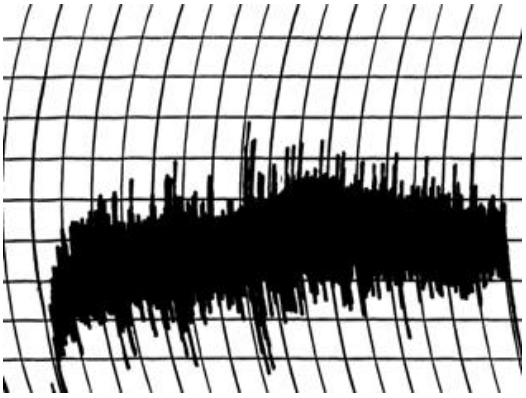
08-2402, Art

Physical Dough Tests
2008 (Small Scale) Samples – AgriPro (continued)

Farinograms **Mixograms**

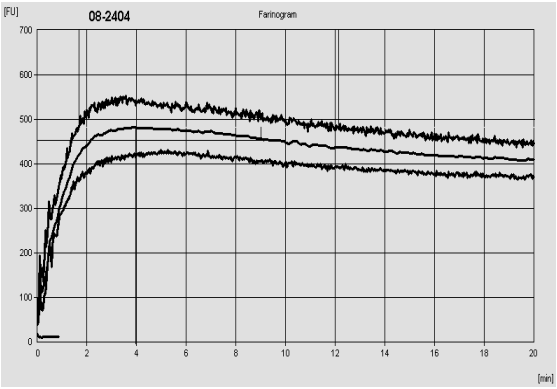


Water Abs. = 59.8%, Peak time = 6.3 min,
Mix Stab. = 15.8 min, MTI = 28 FU

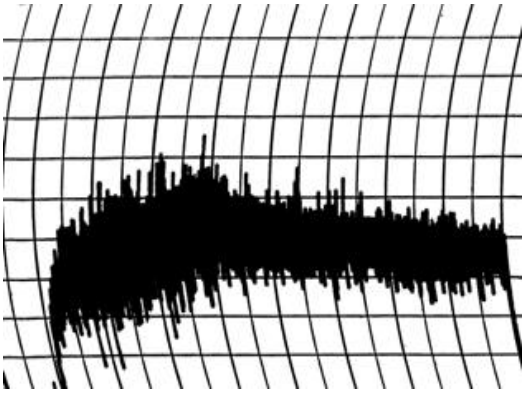


Abs. = 62.6%, Mix time = 4.8 min,
Mix tolerance = 5

08-2403, Hawken



Water Abs. = 57.2%, Peak time = 4.0 min,
Mix Stab. = 25 FU, MTI = 25 FU

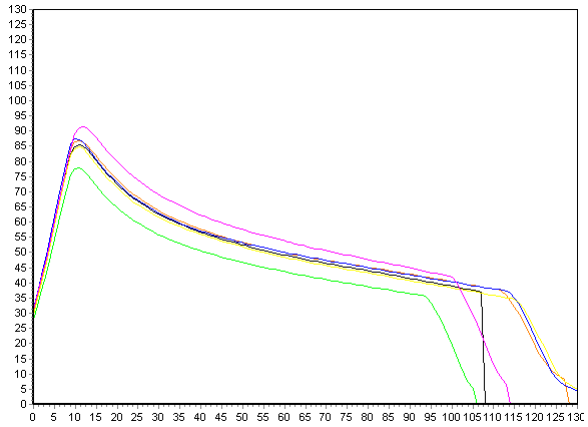


Abs. = 61.6 %, Mix time 2.9 min,
Mix tolerance = 2

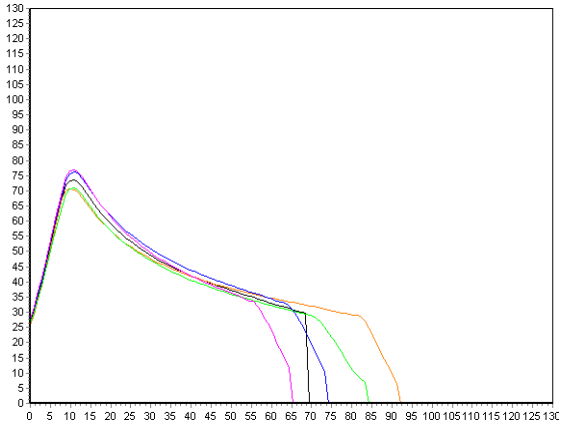
08-2404, NuDakota

Physical Dough Tests - Alveograph

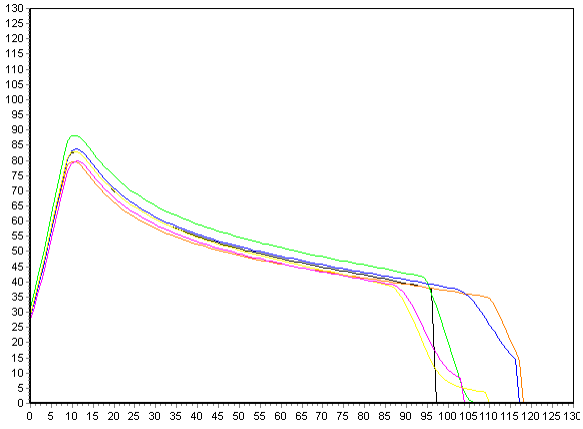
2008 (Small Scale) Samples – AgriPro



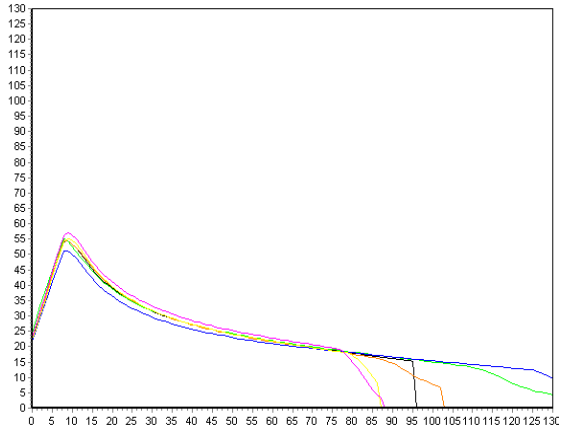
08-2401 (Jagalene)
P (mm $_{H2O}$)=94, L(mm) =107, W(10^{-4} J) =375



08-2402 (Art)
P (mm $_{H2O}$)=81, L(mm) =69, W(10^{-4} J) =208



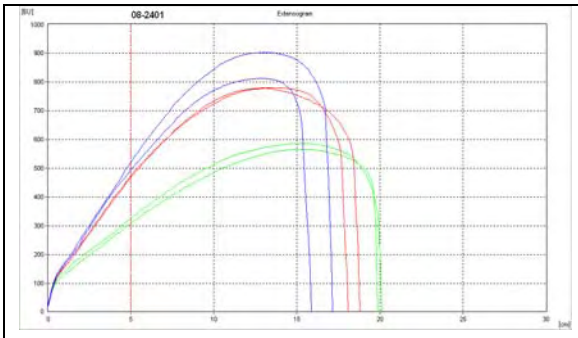
08-2403 (Hawken)
P (mm $_{H2O}$)=91, L(mm) =97, W(10^{-4} J) =336



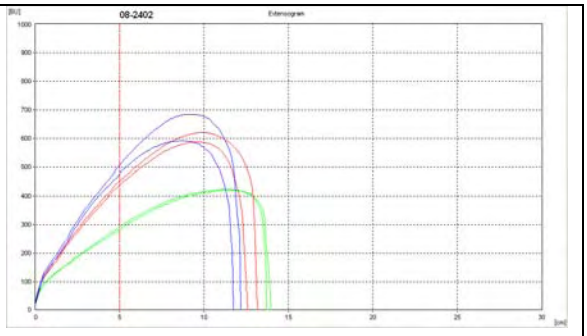
08-2404 (NuDakota)
P (mm $_{H2O}$)=60, L(mm) =96, W(10^{-4} J) =174

Physical Dough Tests - Extensigraph

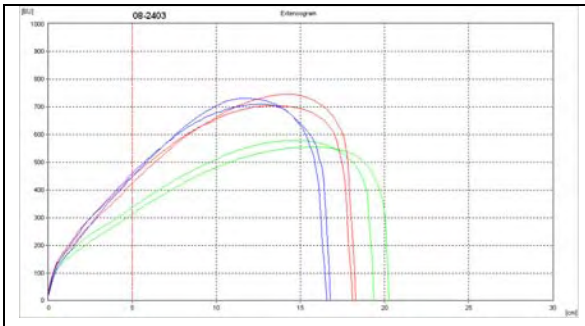
2008 (Small Scale) Samples – AgriPro



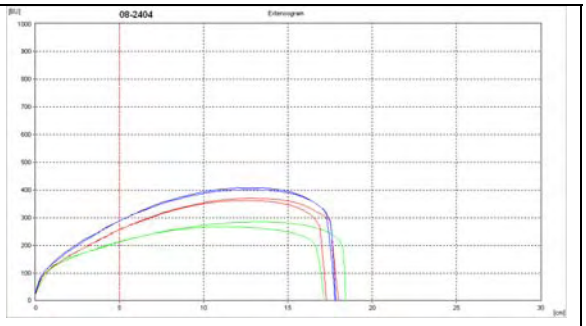
08-2401 (Jagalene)
R (BU) = 320, E (mm) =201, W (cm^2) = 150
Rmax (BU) = 576, Ratio = 1.6 at 30 min



08-2402 (Art)
R (BU) = 290, E (mm) =140, W (cm^2) = 75
Rmax (BU) = 423, Ratio = 2.1 at 30 min



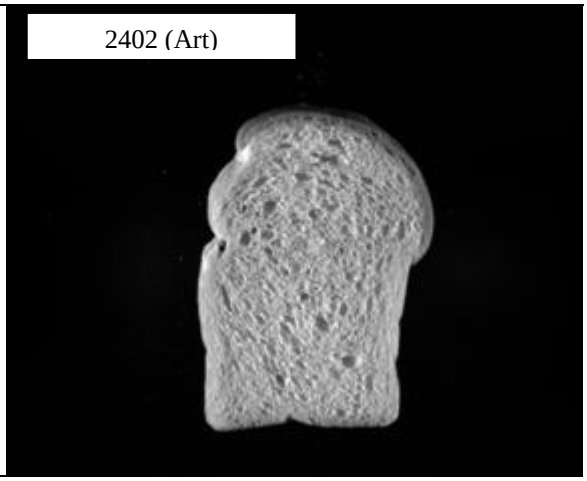
08-2403 (Hawken)
R (BU) = 327, E (mm) =199, W (cm^2) = 147
Rmax (BU) = 567, Ratio = 1.6 at 30 min



08-2404 (NuDakota)
R (BU) = 214, E (mm) =179, W (cm^2) = 71
Rmax (BU) = 276, Ratio = 1.2 at 30 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm2) = Energy; Rmax (BU) = Maximum resistance. Green = test at 30 min, Red = test at 60 min, and Blue =a test at 90 min.

AgriPro: C-Cell Bread Images and Analysis for 2008 (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	6335	145.4	3998	0.441	1.935	2.01	1.79	-19.7
2402	5708	153.2	3797	0.432	1.842	0.65	1.70	-15.9

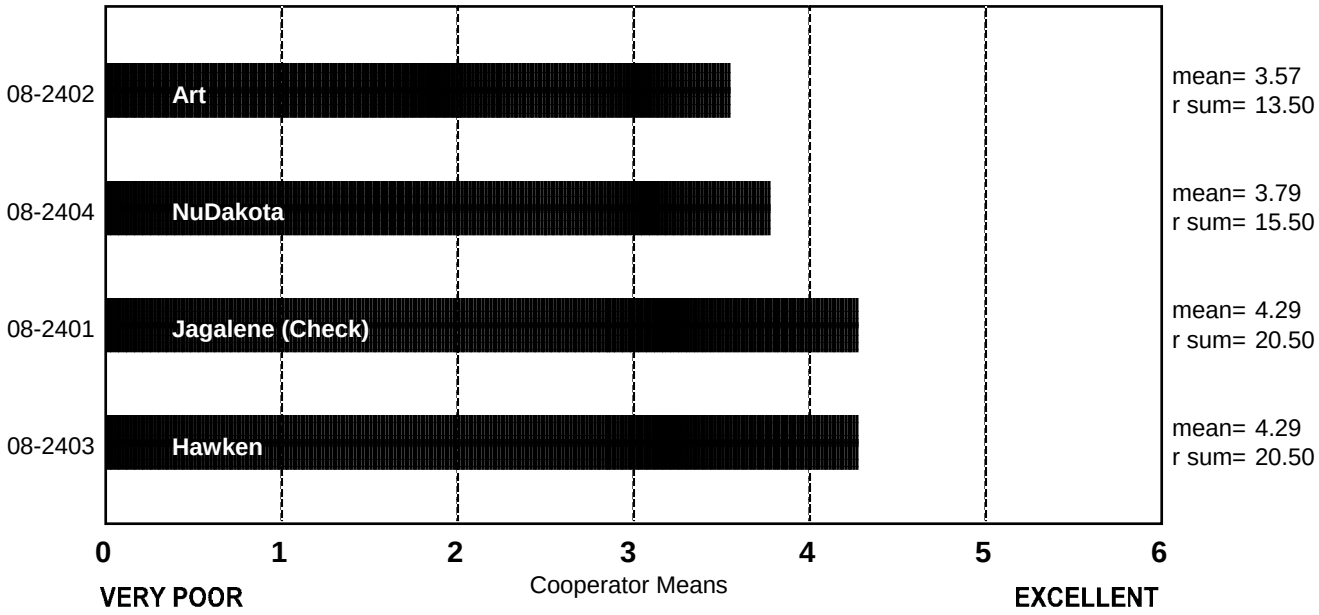
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2403	6007	148.8	3858	0.433	1.889	1.175	1.77	-20.7
2404	5589	155.6	3754	0.434	1.835	0.880	0.63	-26.5

SPONGE CHARACTERISTICS

(Small Scale) Agripro

ncoop= 7
chisq= 3.26
chisqc= -7.60
cvchisq= 7.82
crdiff=

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

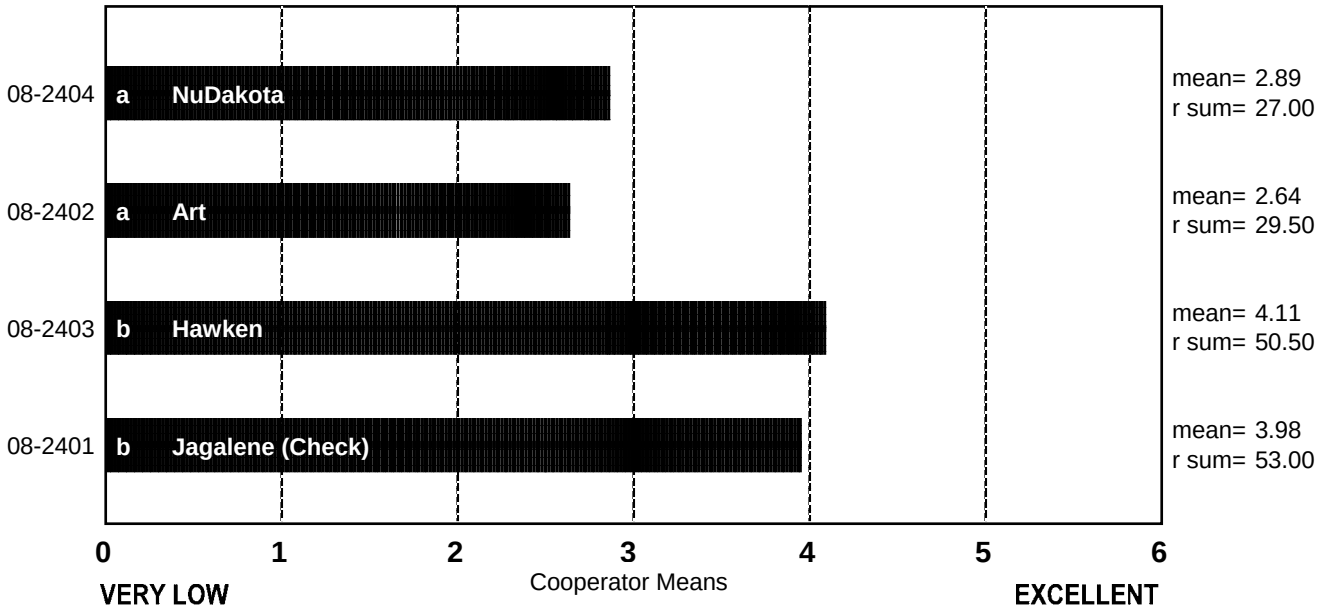


BAKE ABSORPTION

(Small Scale) Agripro

ncoop= 16
chisq= 20.94
chisqc= 26.60
cvchisq= 7.82
crdiff= 9.00

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) Agripro

	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
08-2401 Jagalene (Check)	**59.0**	**65.0**	**62.0**	**60.0**	**60.0**	**66.0**	**57.0**	**62.1**	**62.4**	**59.0**	**61.4**	**57.9**	**58.0**	**65.8**	**64.0**	**62.1**
08-2402 Art	**59.0**	**58.4**	**60.8**	**59.0**	**58.8**	**61.4**	**54.0**	**58.1**	**61.2**	**57.5**	**60.2**	**56.7**	**56.0**	**60.7**	**63.0**	**57.1**
08-2403 Hawken	**59.0**	**63.7**	**62.1**	**59.0**	**60.1**	**64.9**	**57.0**	**64.4**	**62.8**	**61.0**	**60.8**	**58.3**	**59.0**	**65.1**	**63.0**	**62.1**
08-2404 NuDakota	**57.0**	**61.4**	**58.8**	**59.0**	**56.8**	**64.6**	**54.0**	**58.6**	**60.2**	**58.0**	**59.2**	**55.7**	**56.0**	**64.1**	**61.0**	**61.1**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Agripro

	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
08-2401 Jagalene (Check)	**20.0**	**3.5**	**6.0**	**25.0**	**1.8**	**4.4**	**6.0**	**5.3**	**7.0**	**23.0**	**7.5**	**4.3**	**9.0**	**3.9**	**6.0**	**3.5**
08-2402 Art	**10.0**	**3.1**	**5.4**	**12.0**	**1.5**	**3.2**	**5.0**	**4.3**	**5.0**	**11.0**	**6.5**	**3.5**	**5.0**	**3.4**	**6.0**	**2.0**
08-2403 Hawken	**20.0**	**3.8**	**8.4**	**25.0**	**1.5**	**5.0**	**6.0**	**8.0**	**7.0**	**30.0**	**6.0**	**5.0**	**16.0**	**4.8**	**9.0**	**3.5**
08-2404 NuDakota	**10.0**	**2.6**	**5.0**	**23.0**	**1.0**	**3.0**	**5.0**	**3.1**	**4.0**	**11.0**	**5.0**	**3.0**	**4.0**	**2.9**	**3.0**	**2.5**

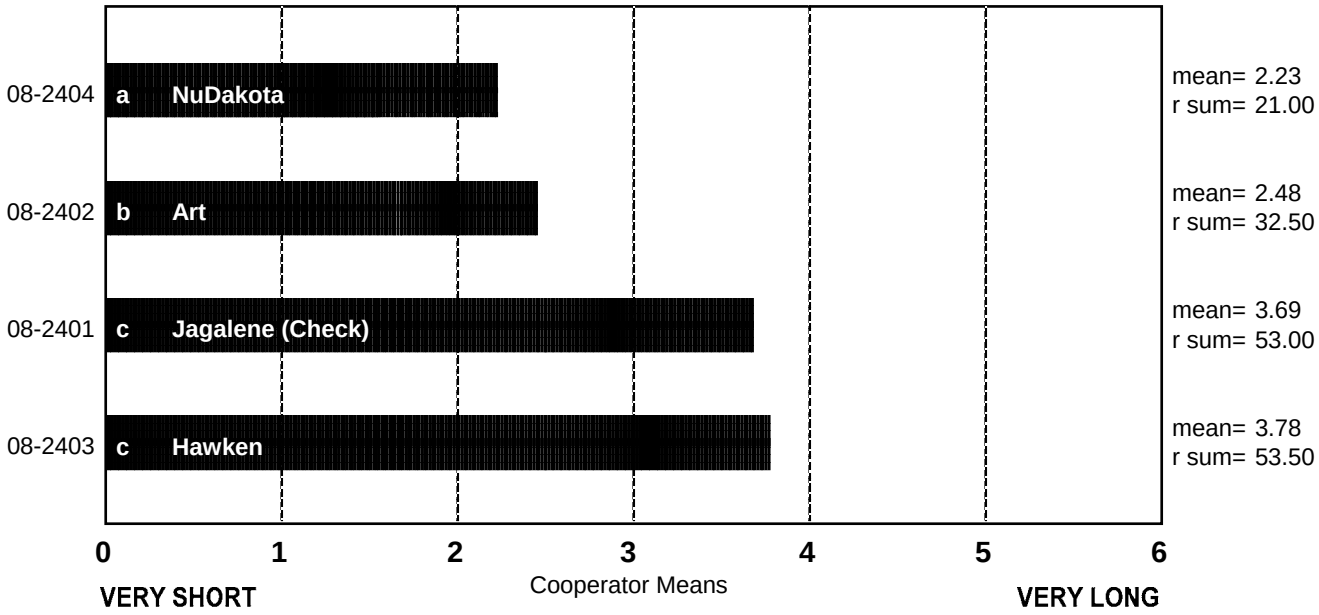
Raw Data

BAKE MIX TIME

(Small Scale) Agripro

ncoop= 16
chisq= 28.82
chisqc= 34.93
cvchisq= 7.82
crdiff= 7.20

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

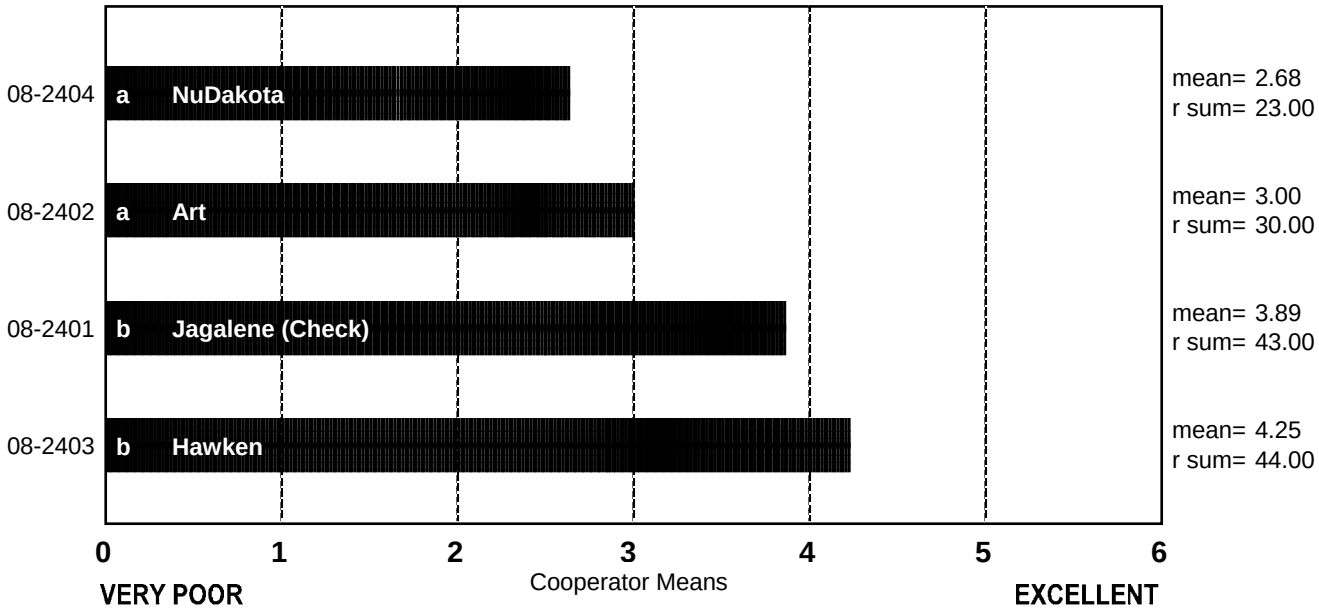


MIXING TOLERANCE

(Small Scale) Agripro

ncoop= 14
chisq= 13.46
chisqc= 16.38
cvchisq= 7.82
crdiff= 10.15

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

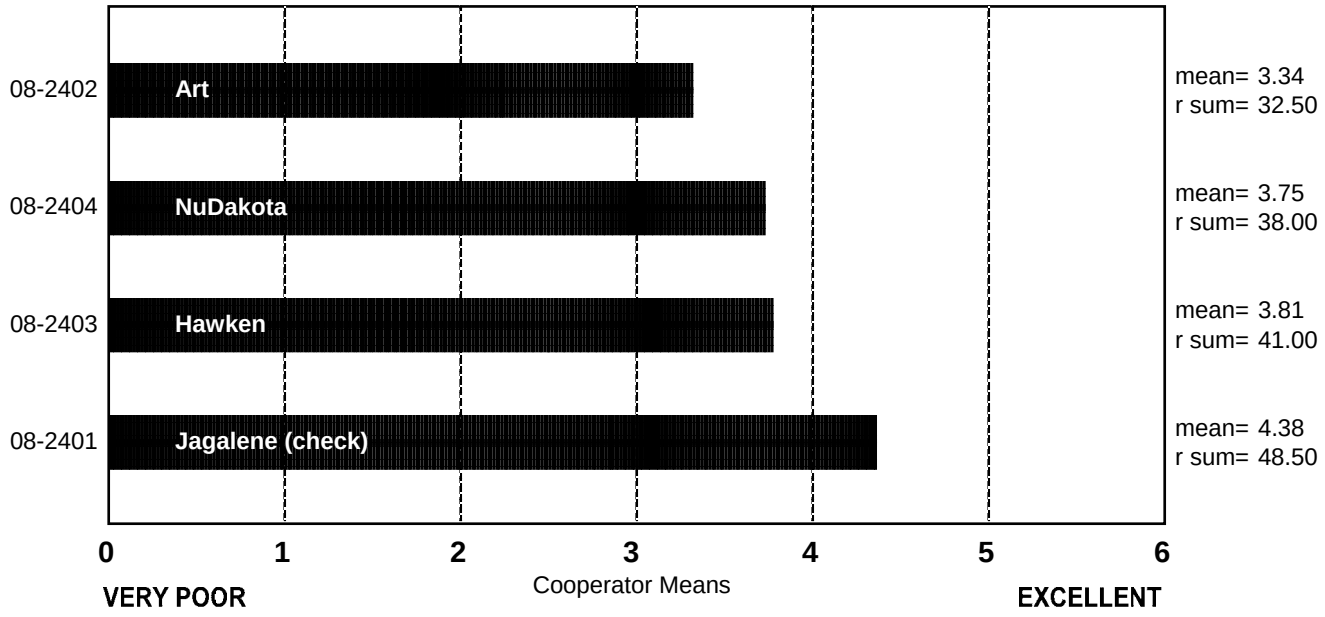


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Agripro

ncoop= 16
chisq= 5.01
chisqc= 7.42
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) Agripro

	Sticky	Wet	Tough	Good	Excellent
08-2401 Jagalene (check)	**1**	**0**	**2**	**11**	**2**
08-2402 Art	**3**	**3**	**1**	**8**	**1**
08-2403 Hawken	**0**	**1**	**5**	**9**	**1**
08-2404 NuDakota	**2**	**2**	**0**	**11**	**1**

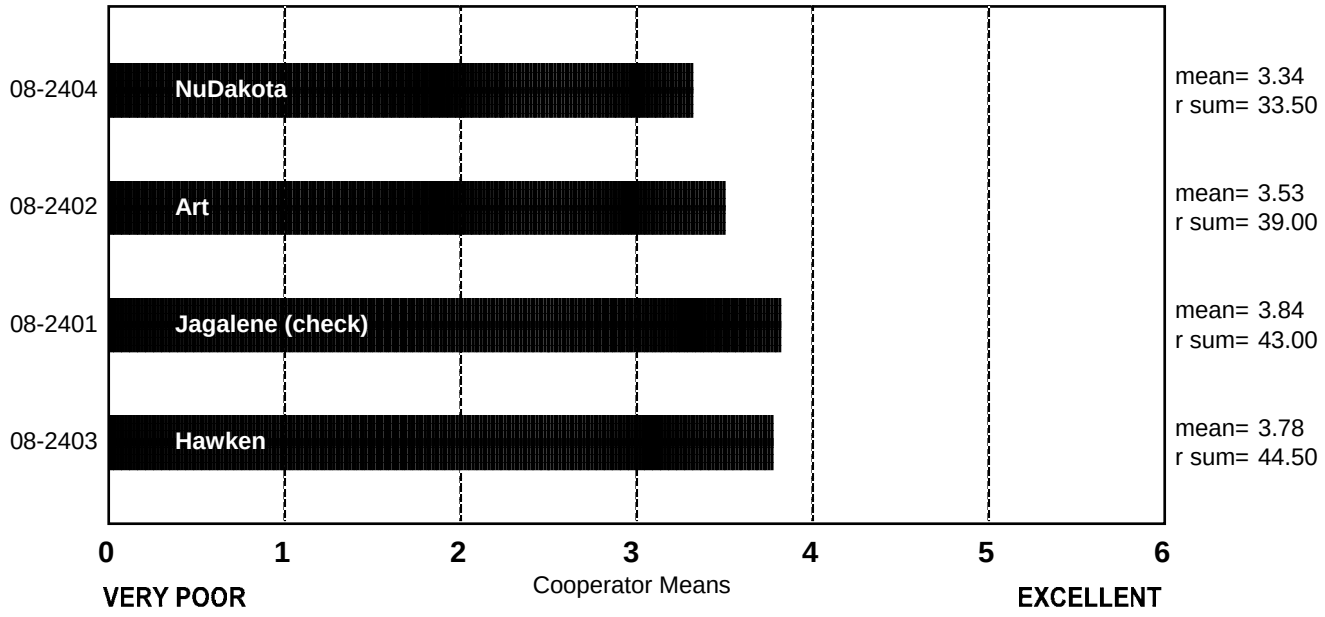
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Agripro

ncoop= 16
chisq= 2.72
chisqc= 3.95
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) Agripro

	Sticky	Wet	Tough	Good	Excellent
08-2401 Jagalene (check)	**0**	**2**	**4**	**9**	**1**
08-2402 Art	**0**	**3**	**2**	**10**	**1**
08-2403 Hawken	**0**	**1**	**4**	**10**	**1**
08-2404 NuDakota	**2**	**2**	**1**	**10**	**1**

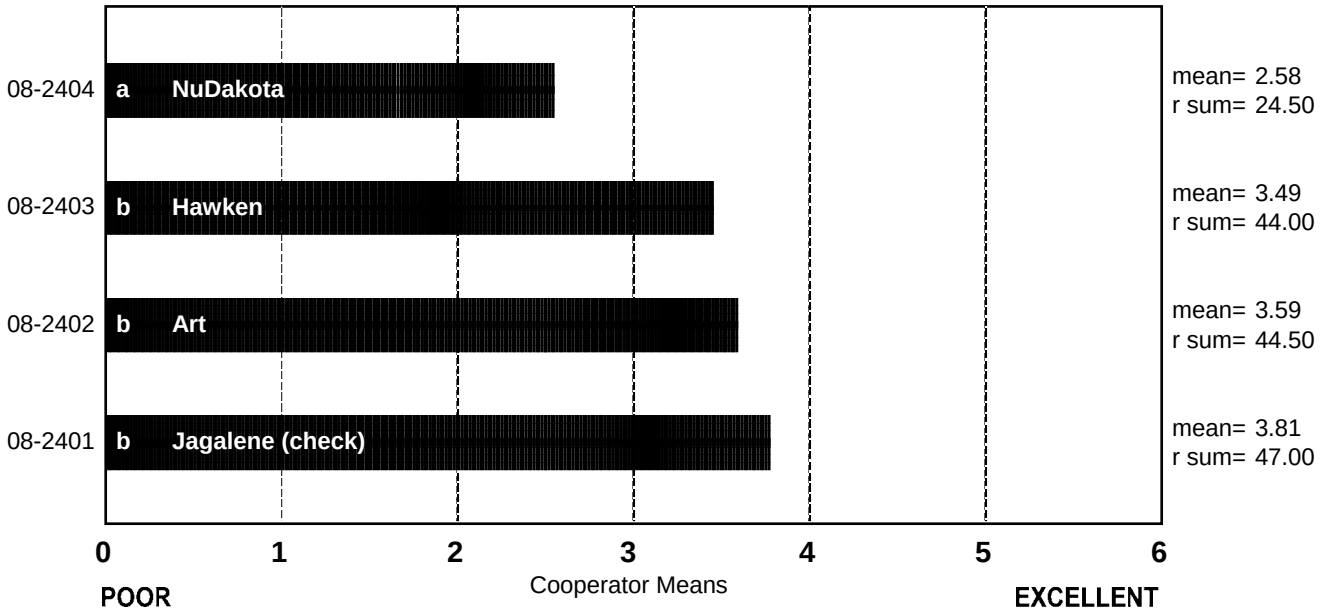
Frequency Table

CRUMB GRAIN

(Small Scale) Agripro

ncoop= 16
chisq= 12.21
chisqc= 15.02
cvchisq= 7.82
crdiff= 11.35

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



CRUMB GRAIN, DESCRIBED

(Small Scale) Agripro

	Open	Fine	Dense
08-2401 Jagalene (check)	**7**	**7**	**2**
08-2402 Art	**7**	**7**	**2**
08-2403 Hawken	**6**	**8**	**2**
08-2404 NuDakota	**7**	**3**	**6**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Agripro

	Round	Irregular	Elongated
08-2401 Jagalene (check)	**4**	**6**	**6**
08-2402 Art	**5**	**4**	**7**
08-2403 Hawken	**5**	**5**	**6**
08-2404 NuDakota	**9**	**7**	**0**

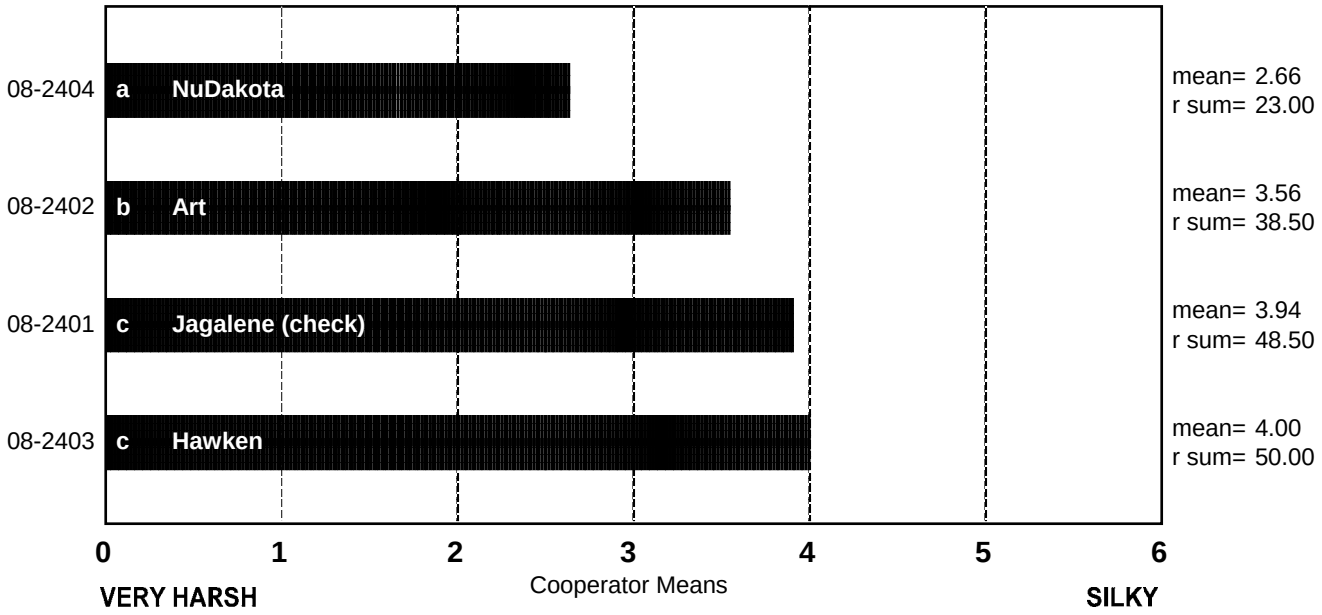
Frequency Table

CRUMB TEXTURE

(Small Scale) Agripro

ncoop= 16
chisq= 17.38
chisqc= 22.98
cvchisq= 7.82
crdiff= 9.54

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



CRUMB TEXTURE, DESCRIBED

(Small Scale) Agripro

	Harsh	Smooth	Silky
08-2401 Jagalene (check)	**2**	**10**	**4**
08-2402 Art	**7**	**7**	**2**
08-2403 Hawken	**4**	**9**	**3**
08-2404 NuDakota	**12**	**4**	**0**

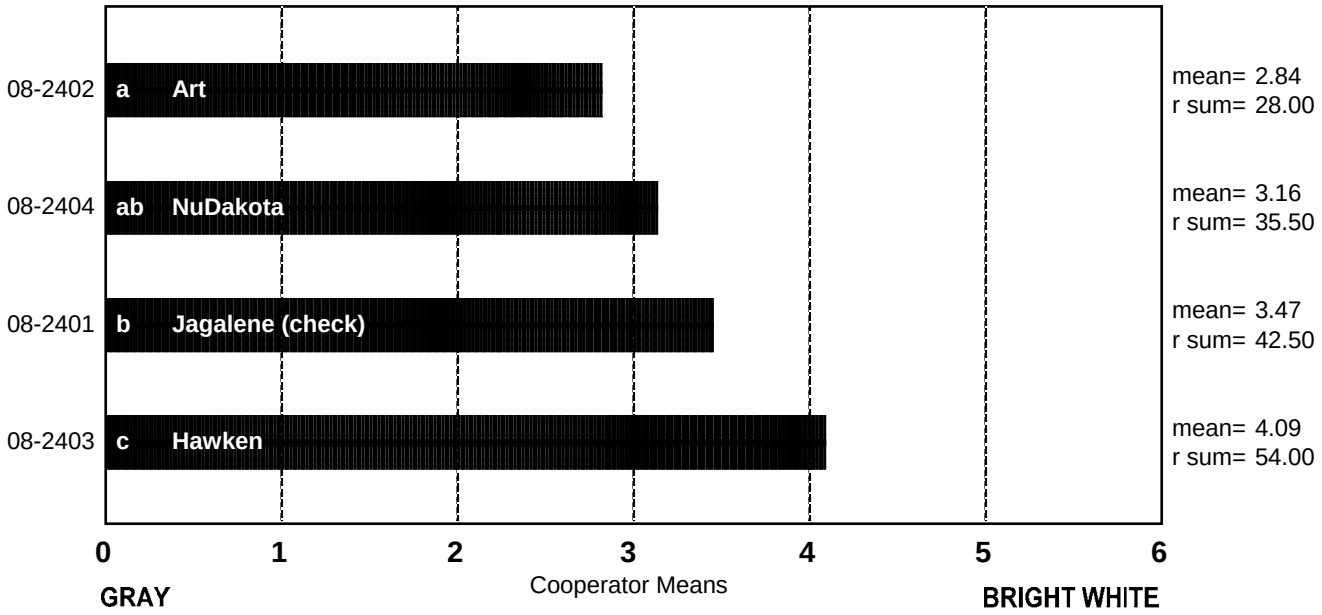
Frequency Table

CRUMB COLOR

(Small Scale) Agripro

ncoop= 16
chisq= 13.74
chisqc= 21.35
cvchisq= 7.82
crdiff= 9.08

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



CRUMB COLOR, DESCRIBED

(Small Scale) Agripro

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
08-2401 Jagalene (check)	**0**	**0**	**3**	**2**	**9**	**1**	**0**
08-2402 Art	**0**	**2**	**4**	**4**	**5**	**1**	**0**
08-2403 Hawken	**0**	**0**	**1**	**1**	**8**	**5**	**1**	**1**
08-2404 NuDakota	**0**	**1**	**5**	**2**	**5**	**3**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Agripro

	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
08-2401 Jagalene (check)	**423.0**		**144.9**	**472.8**	**134.2**	**155.3**	**510.0**	**148.6**	**455.7**	**456.0**	**460.0**	**126.6**	**463.2**	**140.1**	**134.0**	**139.8**
08-2402 Art	**420.0**		**143.0**	**472.4**	**133.9**	**154.1**	**510.0**	**147.4**	**454.2**	**456.0**	**459.0**	**124.9**	**467.1**	**135.9**	**134.0**	**144.7**
08-2403 Hawken	**421.0**		**144.9**	**470.8**	**136.3**	**148.9**	**510.0**	**149.8**	**455.0**	**465.0**	**457.0**	**127.2**	**465.7**	**140.3**	**134.0**	**136.9**
08-2404 NuDakota	**424.0**		**144.1**	**478.2**	**136.3**	**152.8**	**505.0**	**147.8**	**455.0**	**460.0**	**460.0**	**127.4**	**464.7**	**142.6**	**134.0**	**139.7**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Agripro

	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
08-2401 Jagalene (check)	**3150**	**925**	**848**	**3104**	**675**	**1010**	**3250**	**970**	**2325**	**2875**	**2675**	**915**	**2750**	**876**	**963**	**940**
08-2402 Art	**2875**	**825**	**808**	**2956**	**635**	**895**	**3050**	**850**	**2275**	**2650**	**2700**	**815**	**2563**	**766**	**930**	**700**
08-2403 Hawken	**3150**	**975**	**845**	**3074**	**635**	**960**	**2950**	**930**	**2250**	**2725**	**2925**	**910**	**2638**	**902**	**993**	**800**
08-2404 NuDakota	**2800**	**830**	**755**	**2868**	**550**	**870**	**2800**	**835**	**2190**	**2600**	**2600**	**815**	**2463**	**658**	**906**	**798**

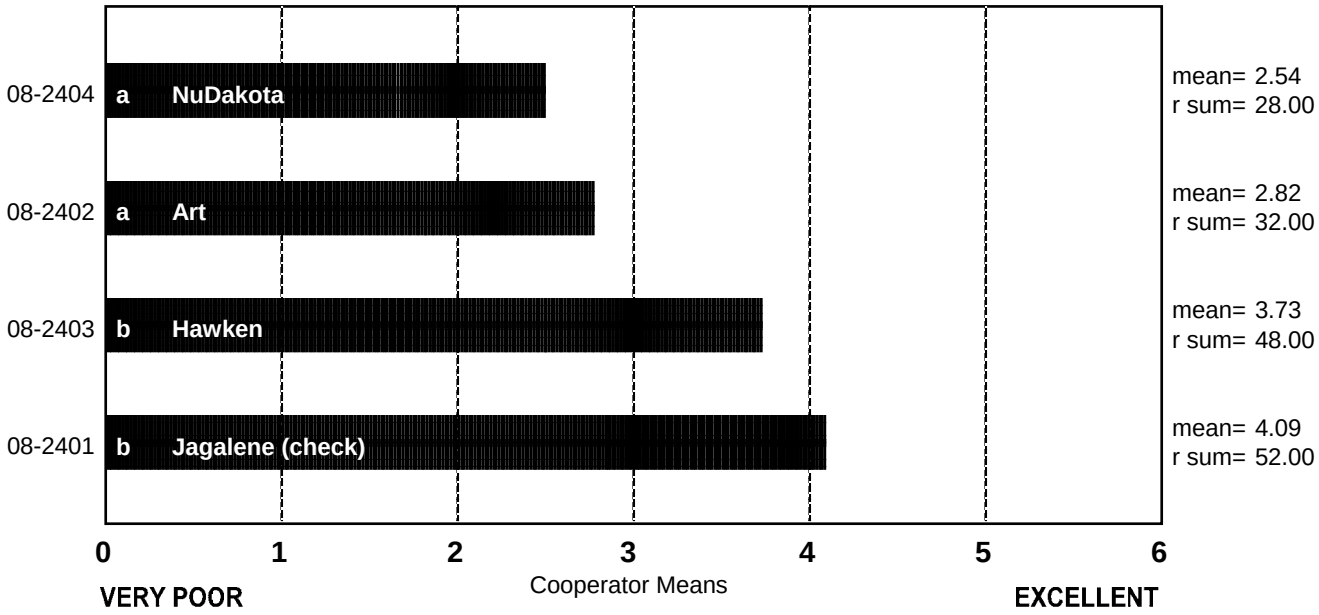
Raw Data

LOAF VOLUME

(Small Scale) Agripro

ncoop= 16
chisq= 15.60
chisqc= 18.77
cvchisq= 7.82
crdiff= 10.81

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

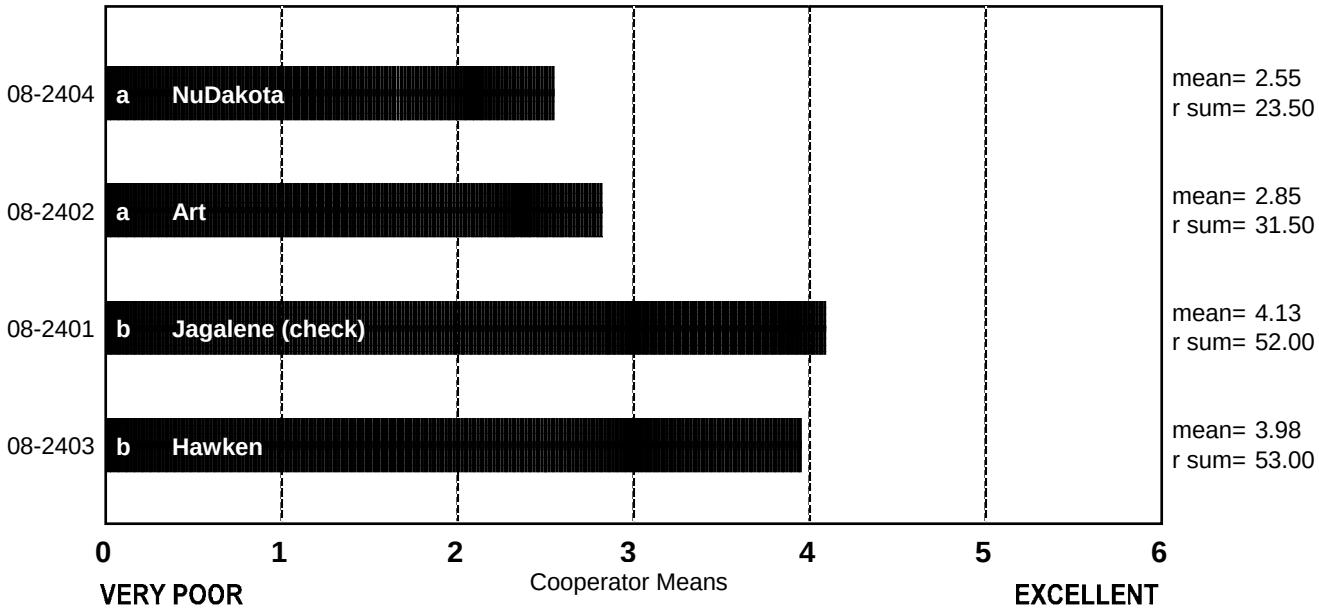


OVERALL BAKING QUALITY

(Small Scale) Agripro

ncoop= 16
chisq= 24.66
chisqc= 27.21
cvchisq= 7.82
crdiff= 9.52

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



COOPERATOR'S COMMENTS
(Small Scale) AgriPro

COOP. 08-2401 Jagalene (check)

A. Tough but molded okay. Dry, long mix, good volume.
B. No comment.
C. Slightly sticky dough, large loaf volume, fine elongated cells, slightly yellow crumb, smooth and resilient texture.
D. Slightly open, variable grain, excellent volume.
E. Low loaf volume.
F. Good mixing, good loaf volume and crumb grain, good performance for protein level.
G. High protein, tough at makeup, good volume.
H. Good flour protein, excellent dough handling, above satisfactory crumb grain, good loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Low absorption, open grain, yellow crumb, good volume.
N. No comment.
O. Shorter on mix tolerance, weaker on nine minute mix of dough. Bread open with irregular grain. Had extensible doughs for higher protein level.
P. No comment.

COOP. 08-2402 Art

A. Good out of mixer and makeup, slightly shorter mix.
B. No comment.
C. Slightly sticky dough, medium loaf volume, fine elongated cells, slightly yellow crumb, smooth and resilient texture.
D. Open, irregular grain. Slack doughs.
E. Low loaf volume.
F. Low to average dough performance, acceptable bread.
G. No comment.
H. Low bake absorption, good bake mix time, weak dough at mix, questionable crumb grain, poor tolerance.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, short mix time, sticky dough, good grain, yellow crumb.
N. No comment.
O. Soft and pliable doughs, poor mix tolerance overall, weak grain and smaller volumes.
P. No comment.

COOP. 08-2403 Hawken

A. Tough to mold, bright color, long mix.
B. No comment.
C. Soft wet dough, large loaf volume, fine elongated cells, creamy crumb, smooth and resilient texture.
D. Open, irregular grain. Harsh texture, excellent volume.
E. Low loaf volume.
F. Very good dough performance, good bread performance.
G. No comment.
H. Good bake absorption, long mix time, weak at pan, satisfactory crumb grain, dull crumb color, good loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Long mix time, open grain, average volume.
N. Slow dough pick-up during mixing which downgraded the mixing score.
O. Had good mix tolerances, doughs and volume. Doughs were very stiff on short mix.
P. No comment.

COOP. 08-2404 NuDakota

A. Nice grain, good out of mixer, average loaf volume, no oven spring.
B. Weak dough.
C. Sticky dough, small loaf volume, open round cells, yellow crumb, harsh texture.
D. Good mixing strength, slightly open grain, average volume.
E. Low loaf volume and absorption, short mix time.
F. Low dough strength, low to average bread with heavy grain, average loaf volume performance for protein level.
G. Short mix time, low stability, low volume.
H. Low bake absorption, poor mixing tolerance, weak at pan, Q-S crumb grain, low loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, short mix time, open grain, yellow crumb, low volume.
N. No comment.
O. Doughs were soft and pliable, had very poor mix tolerance and poor grain.
P. No comment.

Notes: **A, D, I, J, M, and O** conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

Colorado – Reported by 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 strip increases were fertilized prior to planting based on a soil test and a 60 bu/a yield goal.

Growing conditions included good fall stand establishment, adequate winter moisture and good spring moisture conditions, minor damage from two early May freezes, noticeable drought stress symptoms by late May relieved by excellent rains in early June, and mild temperature conditions throughout grain filling. Stripe rust and leaf rust both present at very low levels. Planting date 9/20/07, harvest date 7/14/08.

Grain yields of the adjacent state variety trial were quite good, averaging 55.2 bu/a (42.8-65.5 bu/a range) with an average test weight of 60.2 lb/bu (56.7-63.1 lb/bu range). Grain protein content (12% moisture basis) from the adjacent state variety trial averaged 14.4% with a range of 12.6-15.6%.

Hatcher (check) (08-2405)

Hatcher is a hard red winter wheat that was released in 2004. Hatcher was tested in previous WQC sample sets as a check and initially under its experimental number CO980607. Hatcher was chosen because it has shown good milling and baking quality characteristics and because it has become a dominant cultivar in Colorado acreage estimates (22.2% of the 2008 crop).

Thunder CL (CO03W239) (08-2406)

Thunder CL is a hard white winter wheat released to seed producers in fall 2008. Thunder CL was tested in the 2007 WQC set under the experimental designation CO03W239. Thunder CL is a medium-early maturing semidwarf that carries tolerance to *Beyond* and *Clearmax* herbicides (*Clearfield** wheat), moderate resistance to stripe rust, stem rust, and wheat streak mosaic virus, and moderate susceptibility to pre-harvest sprouting. Thunder CL has shown yields similar to Hatcher in Colorado trials and has also shown excellent milling and bread baking quality characteristics.

CO03W054 (08-2407)

CO03W054 is a hard white winter wheat from the cross KS96HW94//Trego/CO960293 made in 1999. CO03W054 was tested in the Southern Regional Performance Nursery (SRPN) in 2007 and 2008 and was evaluated in the 2007 WQC set. A reselection from CO03W054, designated as CO03W054-2, was entered in the 2009 SRPN and is also on Foundation seed increase for potential release in fall 2009. CO03W054 is a medium-maturing, tall semidwarf that carries "near-immunity" to wheat streak mosaic virus (WSMV, from the CO060293 parent), moderate resistance to stripe rust and stem rust, and moderate resistance to pre-harvest sprouting (similar to Trego). In three years of testing in the CSU Elite Trial, CO03W054 has yielded slightly less than Hatcher and greater than Danby and Avalanche hard white wheats. CO03W054-2 appears to be similar to CO03W054 except it has a higher proportion of plants carrying the WSMV resistance (about 80% vs. 50%) and slightly higher yield and test weight. CO03W054 and CO03W054-2 show very strong dough mixing properties.

CO03064 (08-2408)

CO03064 is a hard red winter wheat from the cross CO970547/Prowers 99 made in 1999. CO03064 was tested in the Southern Regional Performance Nursery (SRPN) in 2008 and a reselection, CO03064-2, is entered into the 2009 SRPN. CO03064-2 is currently on a Breeder seed increase for potential release in 2010. CO03064 is a medium-maturing, tall semidwarf with moderate resistance to stripe rust, moderate susceptibility to leaf rust, and straw strength best suited for dryland production. In three years of testing in the CSU Elite Trial, CO03064 has shown yields about 1 bu/a less than Hatcher with 1 lb/bu lower test weight. CO03064-2 appears to be similar to CO03064 except it has slightly better straw strength, yield, and test weight. CO03064 and CO03064-2 show very strong dough mixing properties.

Colorado: 2008 (Small-Scale) Samples [a]

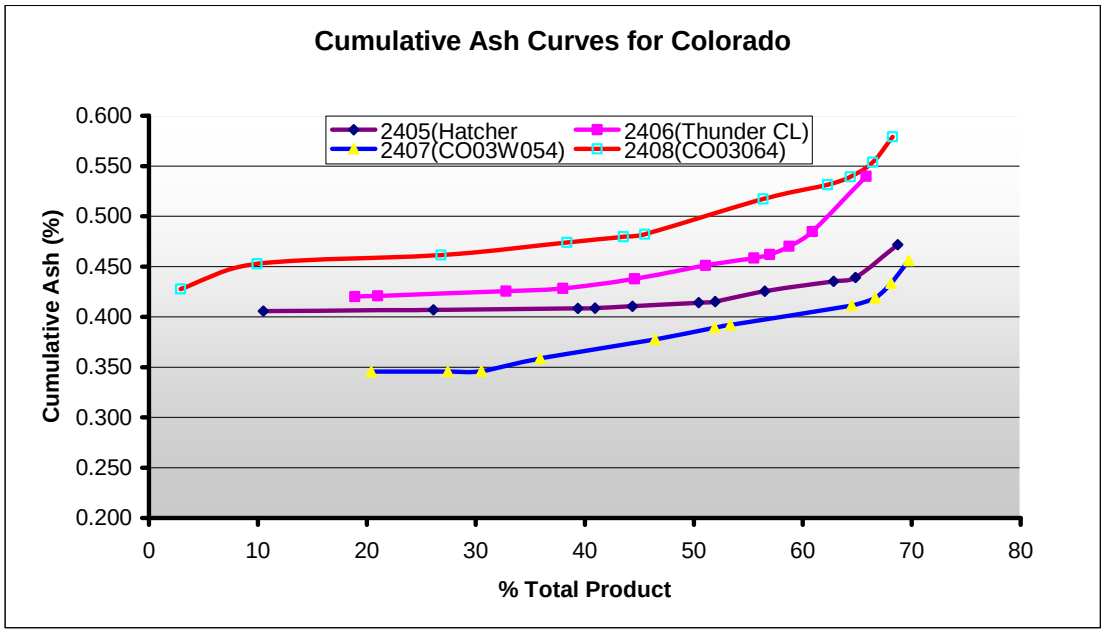
Test entry number	08-2405	08-2406	08-2407	07-2408
Sample identification	**Hatcher (check)**	**Thunder CL**	**CO03W054**	**CO03064**
Wheat Data				
FGIS classification	1 HRW	1 HDWH	1 HDWH	3 HRW
Test weight (lb/bu)	61.1	60.8	60.8	57.6
Hectoliter weight (kg/hl)	80.4	80.0	80.0	75.8
1000 kernel weight (gm)	27.2	27.1	29.1	24.0
NIR hardness	60	80	69	59
Wheat kernel size (Rotap)				
Over 7 wire (%)	34.3	50.7	48.6	25.0
Over 9 wire (%)	65.0	49.2	50.8	74.6
Through 9 wire (%)	0.6	0.2	0.6	0.4
Single kernel (skcs)				
Hardness (avg /s.d)	74.1/14.0	78.1/14.4	85.3/14.2	84.3/15.7
Weight (mg) (avg/s.d)	26.7/5.7	25.6/6.5	28.1/7.6	22.4/6.2
Diameter (mm)(avg/s.d)	2.53/0.23	2.55/0.30	2.66/0.29	2.44/0.24
SKCS distribution	02-01-10-87	01-01-08-90	00-01-04-95	00-01-05-94
Classification	Hard	Hard	Hard	Hard
Wheat moisture (%)	9.3	9.0	8.9	9.2
Wheat protein (12% mb)	13.6	14.2	14.1	13.7
Wheat ash (12% mb)	1.64	1.49	1.57	1.77
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	68.7	65.9	69.7	68.2
Quadrumat Sr. Mill	69.5	69.9	69.6	66.4
NIR Flour moisture (%)	10.7	11.4	12.1	11.6
NIR Flour protein (14% mb)	12.1	12.8	12.7	12.2
Flour ash (14% mb)	0.51	0.60	0.49	0.55
Glutomatic				
Wet gluten (%)	35.8	28.7	35.7	29.3
Dry gluten (%)	13.3	10.9	13.1	11.1
Gluten index	95.1	99.3	98.3	99.3
Rapid Visco-Analyser				
Peak Time (min)	6.3	6.5	6.5	6.4
Peak Viscosity (RVU)	197.1	218.9	233.6	204.5
Breakdown (RVU)	52.3	57.2	73.3	44.3
Final Viscosity at 13 min (RVU)	271.2	281.5	272.1	287.8
Minolta color meter				
L*	93.22	92.29	92.29	92.31
a*	-1.21	-1.77	-1.55	-1.19
b*	7.97	10.07	9.71	8.81
Falling number (sec)	532	576	548	575
Flour particle size (avg)				
Fisher sub sieve sizer	21.5	20.0	23.3	19.8

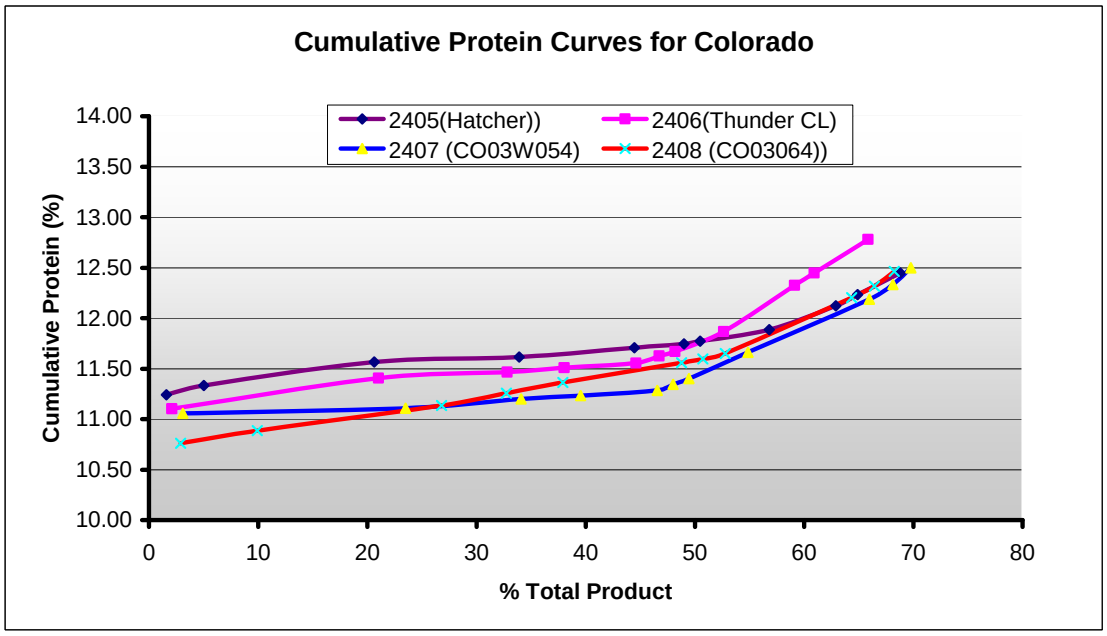
[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Colorado: Physical Dough Tests and Gluten Analysis For 2008 (Small-Scale) Samples

Test Entry Number	08-2405	08-2406	08-2407	08-2408
Sample Identification	Hatcher (check)	Thunder CL	CO03W054	CO03064
MIXOGRAPH				
Flour Abs (% as-is)	65.7	67.3	66.3	66.0
Flour Abs (14% mb)	62.0	64.3	64.1	63.3
Mix Time (min)	4.38	9.00	4.50	9.38
Mix tolerance (0-6)	3	6	3	5
FARINOGRAPH				
Flour Abs (% as-is)	60.9	65.0	61.5	60.8
Flour Abs (14% mb)	57.2	62.3	59.3	58.1
Development time (min)	9.3	30.3	11.0	8.0
Mix stability (min)	28.1	39.7	25.0	24.3
Mix Tolerance Index (FU)	2	1	5	17
Breakdown time (min)	30.0	43.5	23.3	16.3
ALVEOGRAPH				
P(mm. $_{H2O}$): Tenacity	93	128	74	97
L(mm): Extensibility	97	59	135	98
G($mm_{0.5}$): Swelling index	21.5	17.1	25.9	22.0
W(10^{-4} J): strength (curve area)	326	336	378	389
P/L: curve configuration ratio	1.00	2.17	0.55	0.99
Ie(P_{200}/P): elasticity index	64.7	72.0	70.1	69.7
EXTENSIGRAPH				
Resist (BU at 30/60/90 min)	390/658/513	708/996/498	321/534/670	367/582/659
Extensibility (mm at 30/60/90 min)	174/146/140	126/84/83	229/187/160	213/174/172
Energy (cm^2 at 30/60/90 min)	147/179/183	147/110/97	197/223/209	204/224/232
Resist $_{max}$ (BU at 30/60/90 min)	679/983/999	963/996/993	681/959/998	760/998/998
Ratio (at 30/60/90 min)	2.2/4.5/5.4	5.7/11.9/11.9	1.4/2.9/4.2	1.7/3.4/3.8
PROTEIN ANALYSIS				
HMW-GS Composition	1/2*, 5, 10, 7, 8	2*, 5 10, 7, 8	2*, 5, 10, 7, 8	2*, 5, 10, 7, 9
Glu/Gli	0.47	0.42	0.48	0.48
HMW/LMW	0.32	0.37	0.25	0.19
%IPP	50.81	58.38	52.41	59.18
SEDIMENTATION TEST				
Volume (ml)	63.6	64.5	62.6	68.6

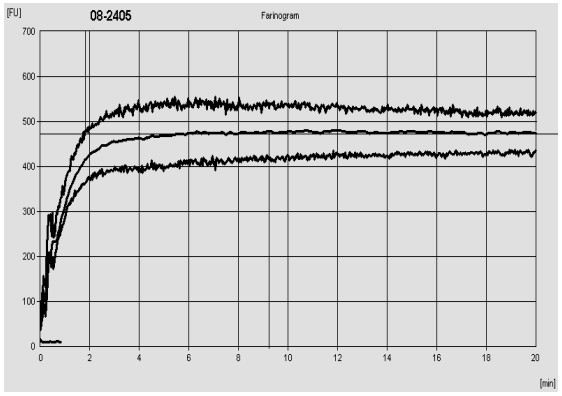
Colorado: Cumulative Ash and Protein Curves





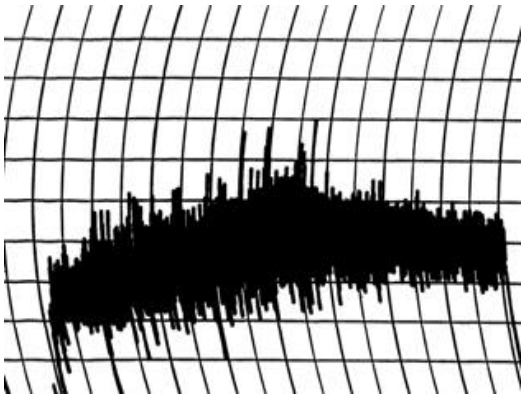
Physical Dough Tests
2008 (Small Scale) Samples – Colorado

Farinograms



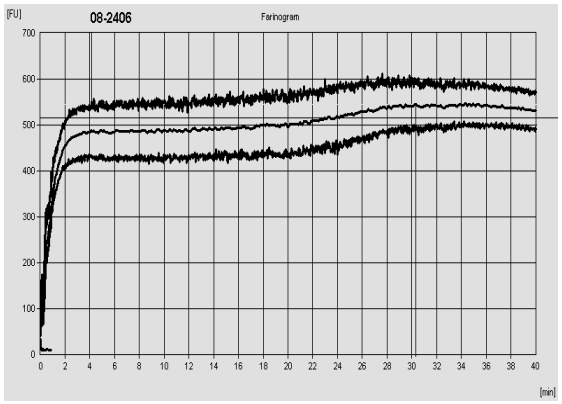
Water Abs. = 57.2%, Peak time = 9.3 min,
Mix Stab. = 28.1 min, MTI = 2 FU

Mixograms

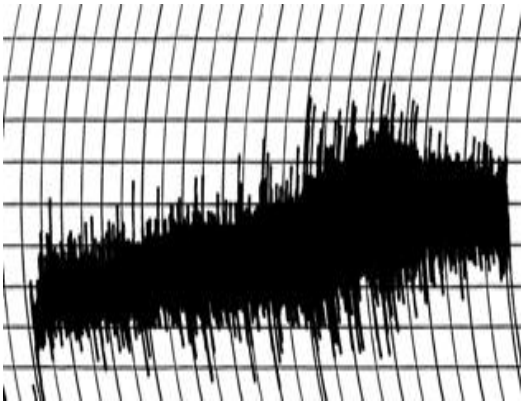


Abs. = 62.0%, Mix time = 4.4 min,
Mix tolerance = 3

08-2405, Hatcher (check)



Water Abs. = 62.3%, Peak time = 30.3 min,
Mix Stab. = 39.7 min, MTI = 1 FU

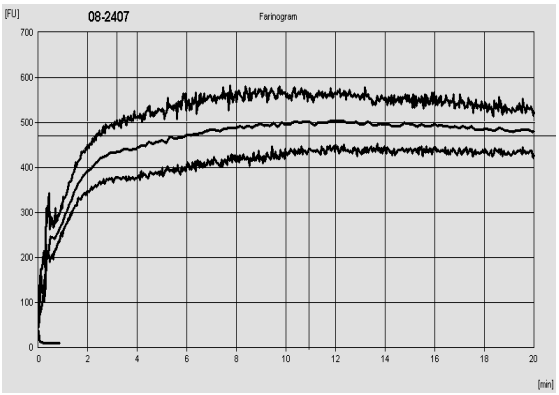


Abs. = 64.3%, Mix time = 9.0 min,
Mix tolerance = 6

08-2406, Thunder CL

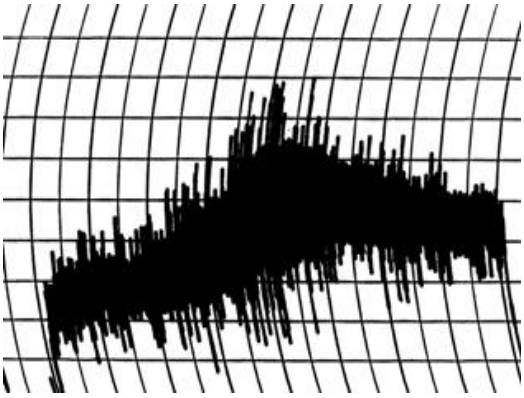
Physical Dough Tests
2008 (Small Scale) Samples – Colorado (continued)

Farinograms



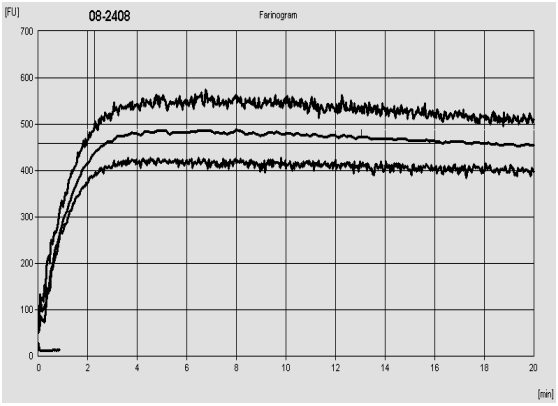
Water Abs. = 59.3%, Peak time = 11.0 min,
Mix Stab. = 25.0 min, MTI = 5 FU

Mixograms

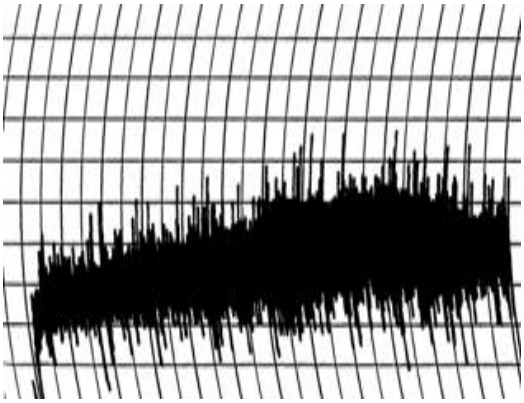


Abs. = 64.1%, Mix time = 4.5 min,
Mix tolerance = 3

08-2407, CO03W054



Water Abs. = 58.1%, Peak time = 8.0 min,
Mix Stab. = 24.3 min, MTI = 17 FU

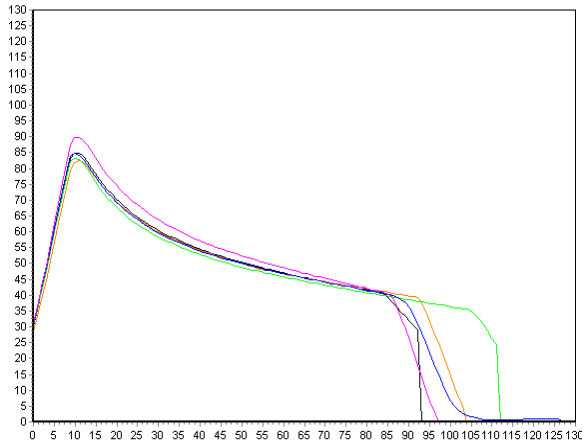


Abs. = 63.3%, Mix time = 9.4 min,
Mix tolerance = 5

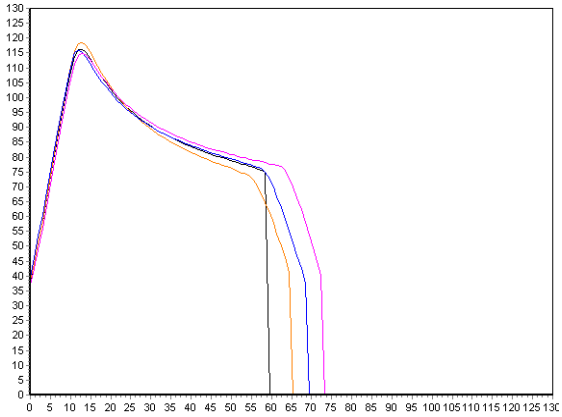
08-2408, CO03064

Physical Dough Tests - Alveograph

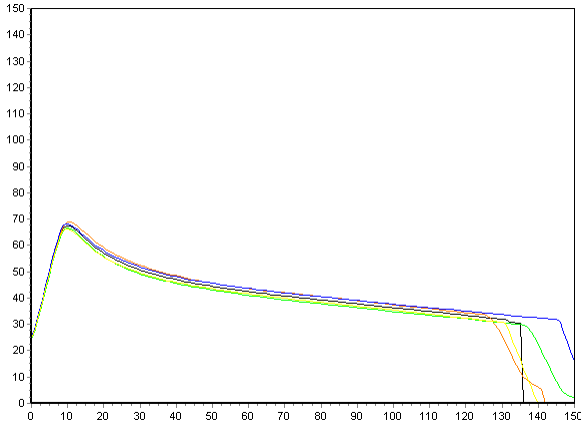
2008 (Small Scale) Samples – Colorado



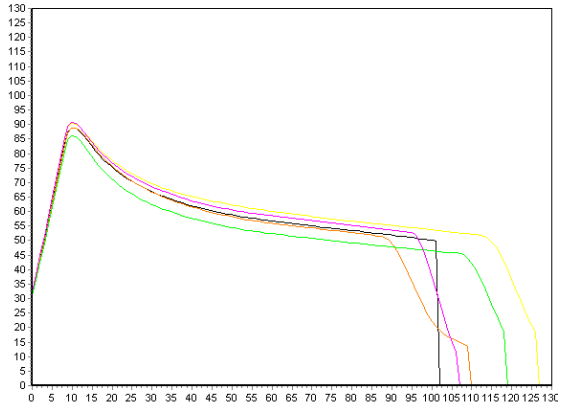
08-2405 (Hatcher)
P(mm $_{H20}$)=93, L(mm)=93, W(10^{-4} J)=326



08-2406 (Thunder CL)
P(mm $_{H20}$)=128, L(mm)=59, W(10^{-4} J)=336



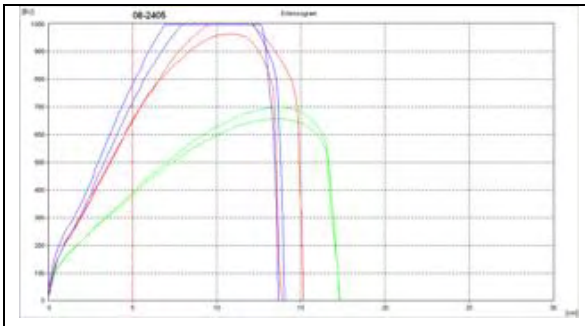
08-2407 (CO03W054)
P(mm $_{H20}$)=74, L(mm)=135, W(10^{-4} J)=378



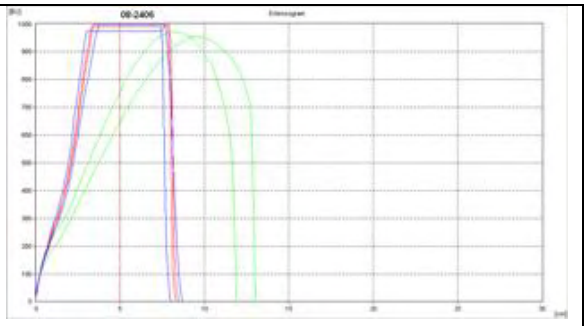
08-2408 (CO03064)
P(mm $_{H20}$)=97, L(mm)=98, W(10^{-4} J)=389

Physical Dough Tests - Extensigraph

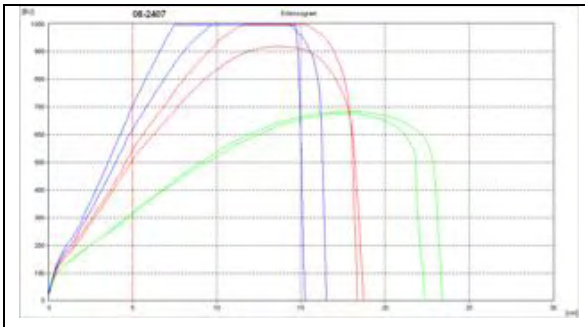
2008 (Small Scale) Samples – Colorado



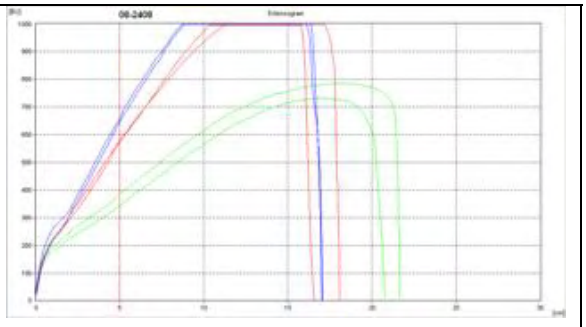
08-2405 (Hatcher)
R (BU) = 390, E (mm) = 174, W (cm^2) = 147
Rmax (BU) = 679, Ratio = 2.2 at 30 min



08-2406 (Thunder CL)
R (BU) = 708, E (mm) = 126, W (cm^2) = 147
Rmax (BU) = 963, Ratio = 5.7 at 30 min



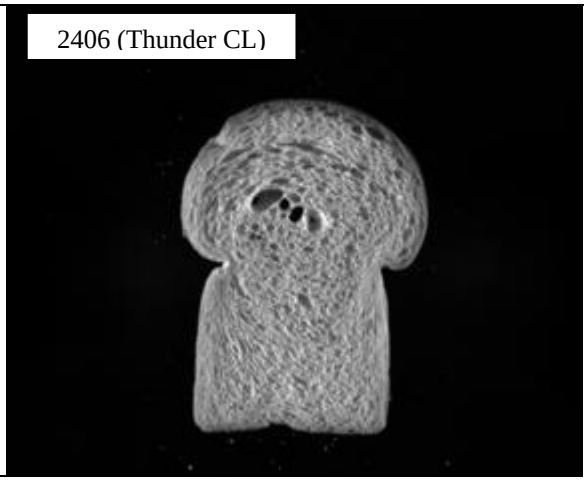
08-2407 (CO03W054)
R (BU) = 321, E (mm) = 229, W (cm^2) = 197
Rmax (BU) = 681, Ratio = 1.4 at 30 min



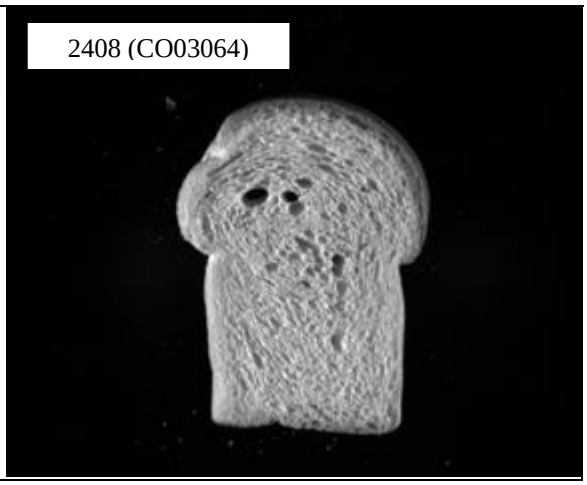
08-2408 (CO03064)
R (BU) = 367, E (mm) =213, W (cm^2) = 204
Rmax (BU) = 760, Ratio = 1.7 at 30 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm2) = Energy; Rmax (BU) = Maximum resistance. Green = test at 30 min, Red = test at 60 min, and Blue =a test at 90 min.

Colorado: C-Cell Bread Images and Analysis for 2008 (Small-Scale) Samples



Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2405	5708	150.9	3950	0.430	1.829	1.103	1.75	-28.4
2406	6146	133.2	3785	0.440	1.928	2.604	1.79	-20.2



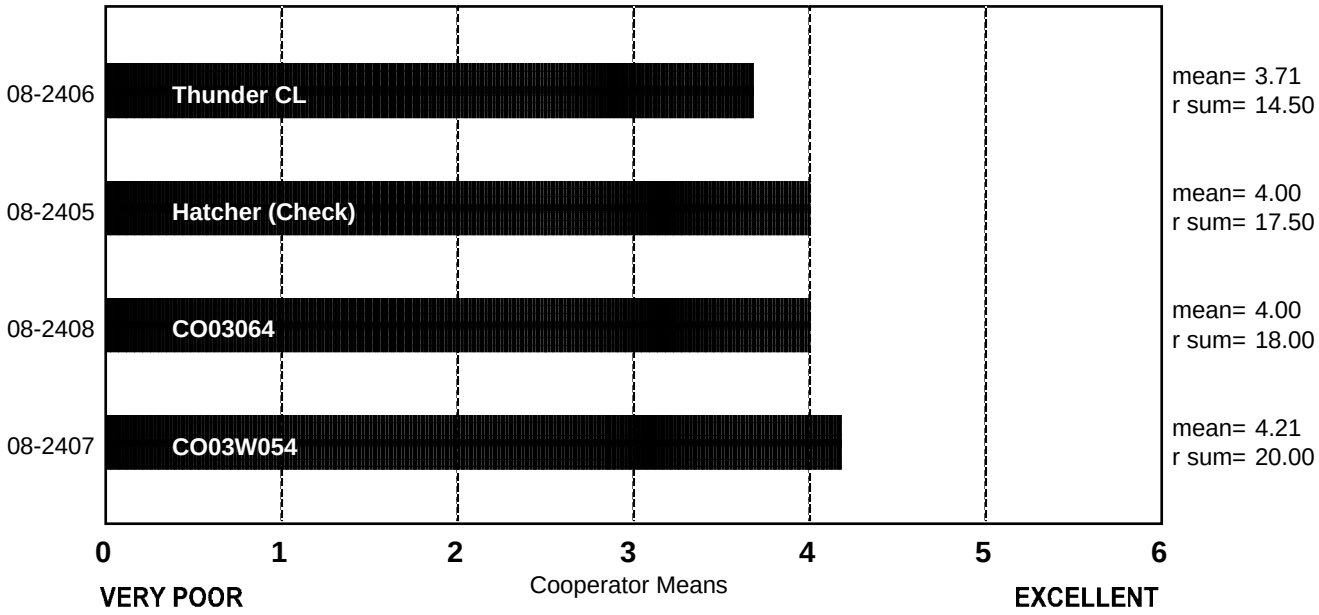
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2407	6232	148.8	3975	0.434	1.909	0.768	1.75	-21.5
2408	6532	148.3	4027	0.446	1.909	4.835	1.77	-21.0

SPONGE CHARACTERISTICS

(Small Scale) Colorado

ncoop= 7
chisq= 1.33
chisqc= -2.27
cvchisq= 7.82
crdiff=

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

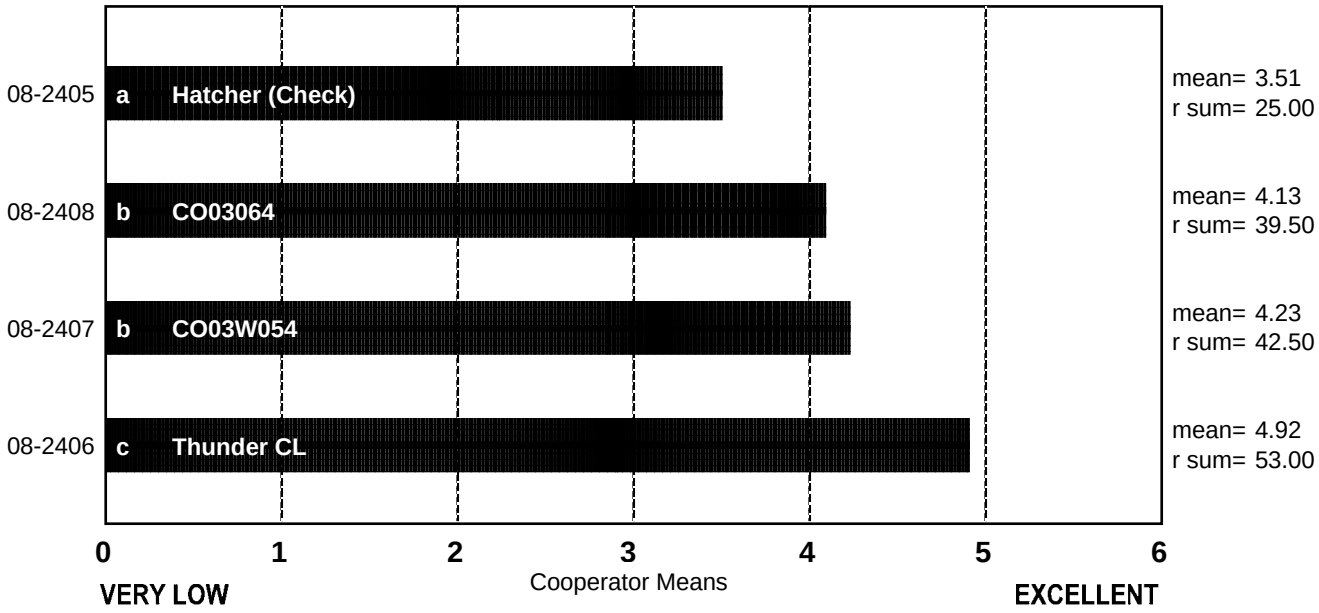


BAKE ABSORPTION

(Small Scale) Colorado

ncoop= 16
chisq= 15.02
chisqc= 19.70
cvchisq= 7.82
crdiff= 10.19

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
08-2405 Hatcher (Check)	**59.0**	**62.3**	**60.9**	**59.0**	**58.9**	**63.9**	**59.0**	**60.0**	**60.2**	**62.5**	**59.2**	**55.7**	**59.0**	**64.5**	**63.0**	**61.1**
08-2406 Thunder CL	**59.0**	**65.1**	**65.0**	**63.0**	**63.0**	**69.1**	**57.0**	**68.7**	**65.3**	**64.5**	**64.3**	**60.8**	**63.0**	**67.1**	**64.0**	**63.1**
08-2407 CO03W054	**59.0**	**64.8**	**61.5**	**60.0**	**59.5**	**67.9**	**55.0**	**62.0**	**62.3**	**62.0**	**61.3**	**57.8**	**59.0**	**66.5**	**64.0**	**63.1**
08-2408 CO03064	**59.0**	**64.3**	**60.8**	**59.0**	**58.8**	**66.4**	**57.0**	**64.5**	**61.1**	**62.5**	**60.1**	**56.6**	**60.0**	**65.9**	**63.0**	**62.1**

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
08-2405 Hatcher (Check)	**20.0**	**3.7**	**6.0**	**25.0**	**2.0**	**4.4**	**6.0**	**5.3**	**10.0**	**19.0**	**6.5**	**4.8**	**8.0**	**4.2**	**9.0**	**3.5**
08-2406 Thunder CL	**20.0**	**7.8**	**12.4**	**25.0**	**3.0**	**9.7**	**9.0**	**14.1**	**20.0**	**30.0**	**7.0**	**8.8**	**24.0**	**10.8**	**9.0**	**8.5**
08-2407 CO03W054	**20.0**	**4.6**	**7.2**	**25.0**	**2.3**	**6.4**	**8.0**	**6.1**	**9.0**	**30.0**	**6.8**	**4.5**	**11.0**	**6.3**	**9.0**	**4.3**
08-2408 CO03064	**20.0**	**6.8**	**10.4**	**25.0**	**2.3**	**9.6**	**8.0**	**11.8**	**19.0**	**30.0**	**6.8**	**8.0**	**24.0**	**9.7**	**6.0**	**7.5**

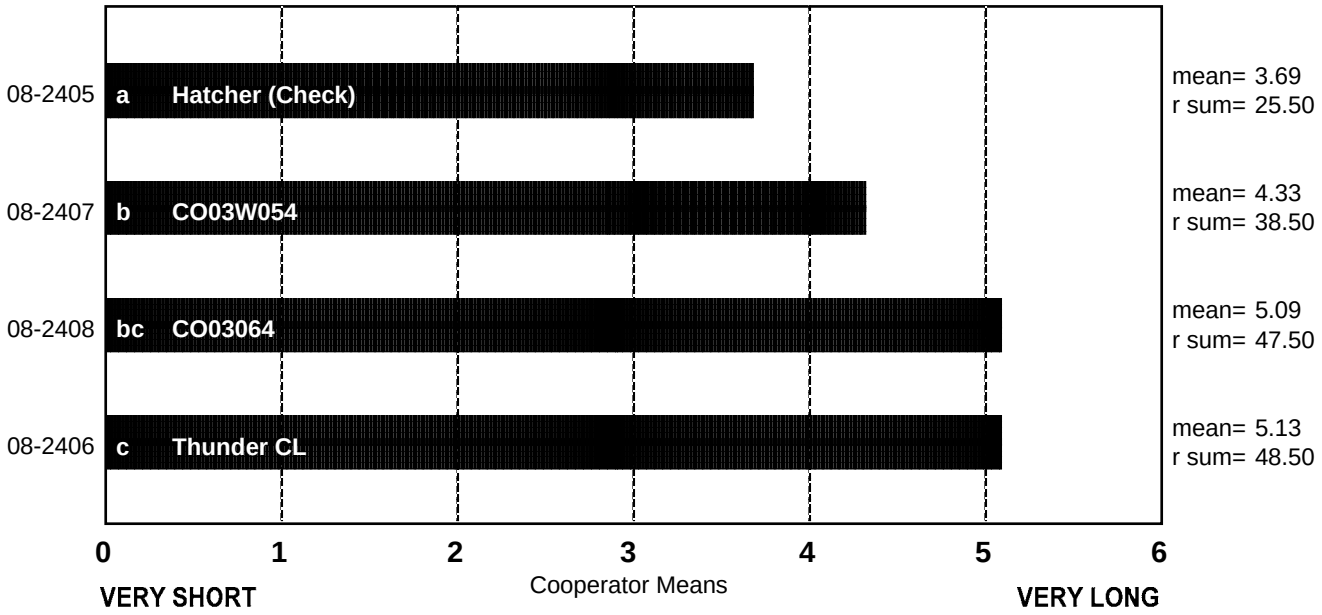
Raw Data

BAKE MIX TIME

(Small Scale) Colorado

ncoop= 16
chisq= 12.79
chisqc= 19.12
cvchisq= 7.82
crdiff= 9.64

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

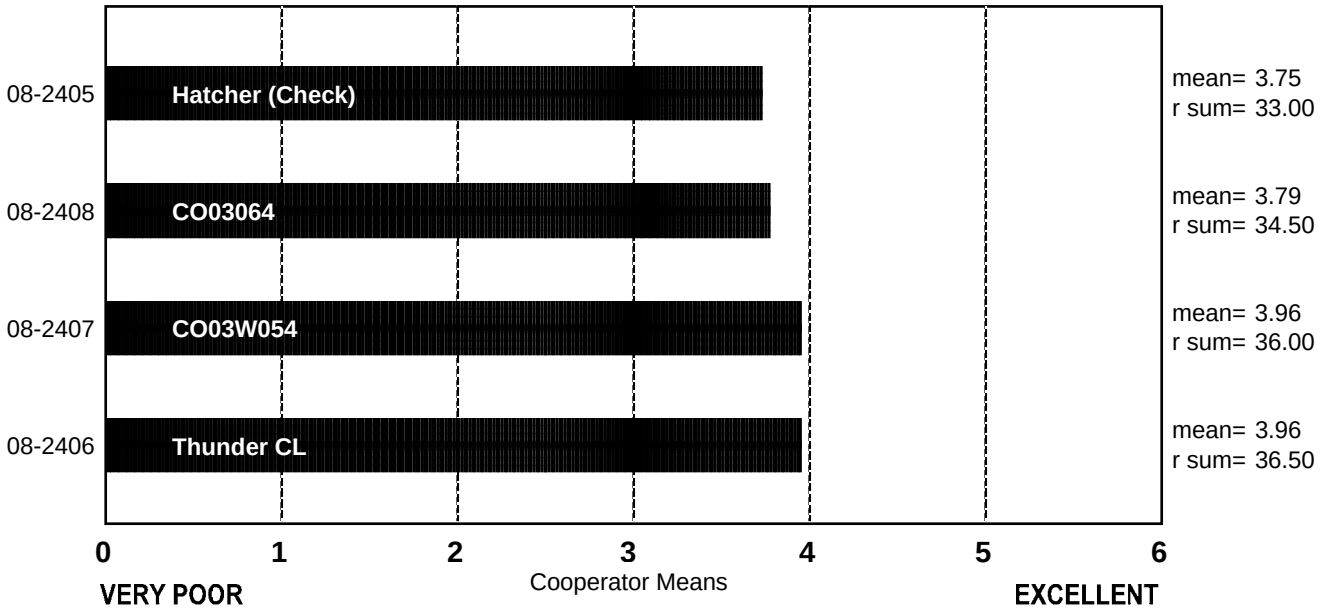


MIXING TOLERANCE

(Small Scale) Colorado

ncoop= 14
chisq= 0.32
chisqc= 0.44
cvchisq= 7.82
crdiff=

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

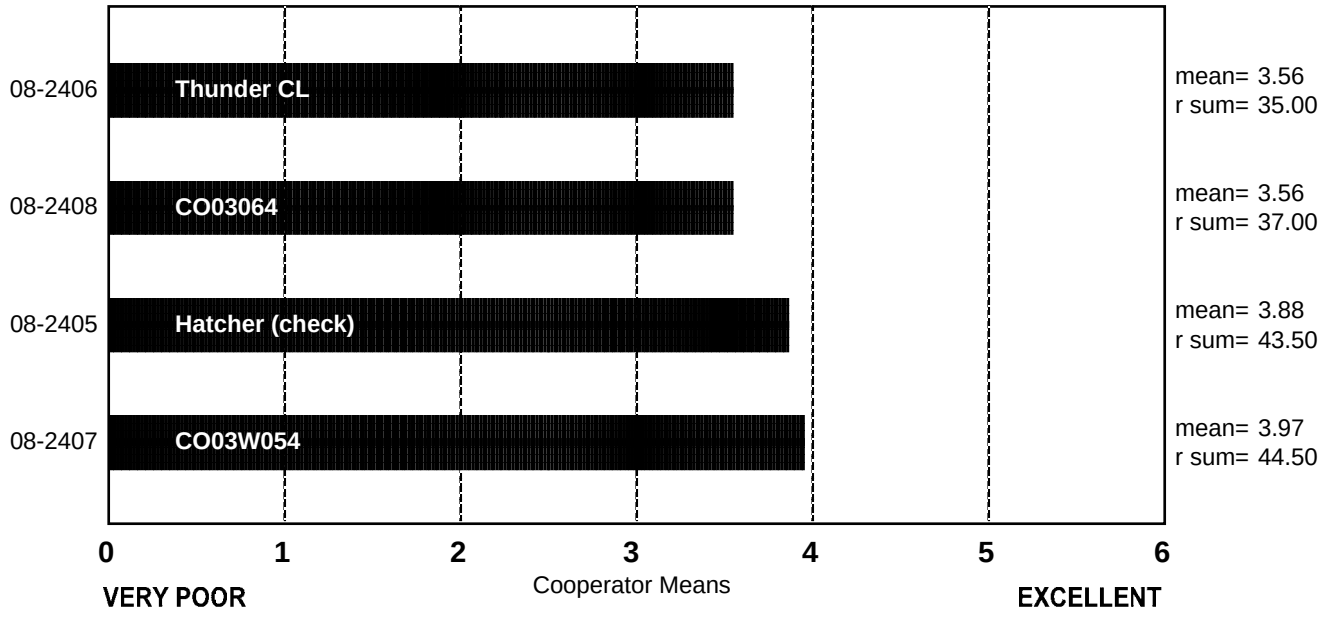


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Colorado

ncoop= 16
chisq= 2.49
chisqc= 3.56
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
08-2405 Hatcher (check)	**0**	**1**	**4**	**10**	**1**
08-2406 Thunder CL	**1**	**0**	**10**	**3**	**2**
08-2407 CO03W054	**1**	**1**	**4**	**9**	**1**
08-2408 CO03064	**0**	**1**	**7**	**6**	**2**

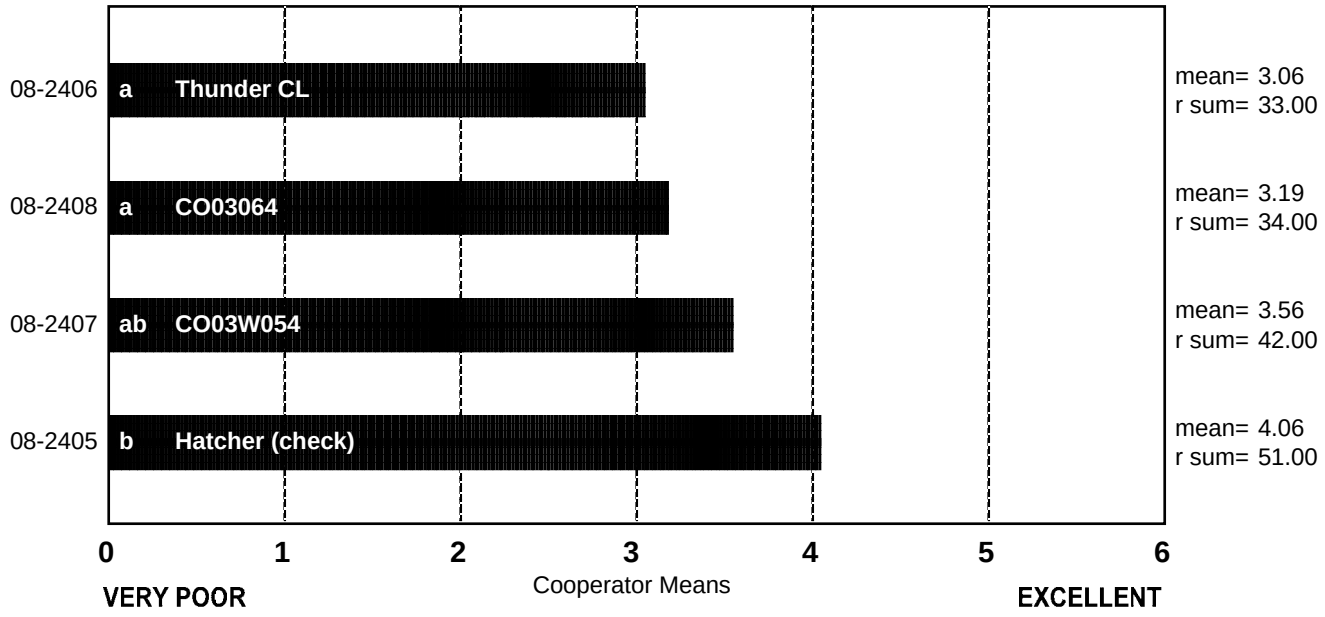
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Colorado

ncoop= 16
chisq= 7.88
chisqc= 10.68
cvchisq= 7.82
crdiff= 11.50

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



DOUGH CHAR. 'AT MAKE UP', DESCRIBED

(Small Scale) Colorado

	Sticky	Wet	Tough	Good	Excellent
08-2405 Hatcher (check)	**0**	**1**	**5**	**10**	**0**
08-2406 Thunder CL	**1**	**0**	**11**	**2**	**2**
08-2407 CO03W054	**0**	**3**	**5**	**5**	**3**
08-2408 CO03064	**0**	**1**	**9**	**4**	**2**

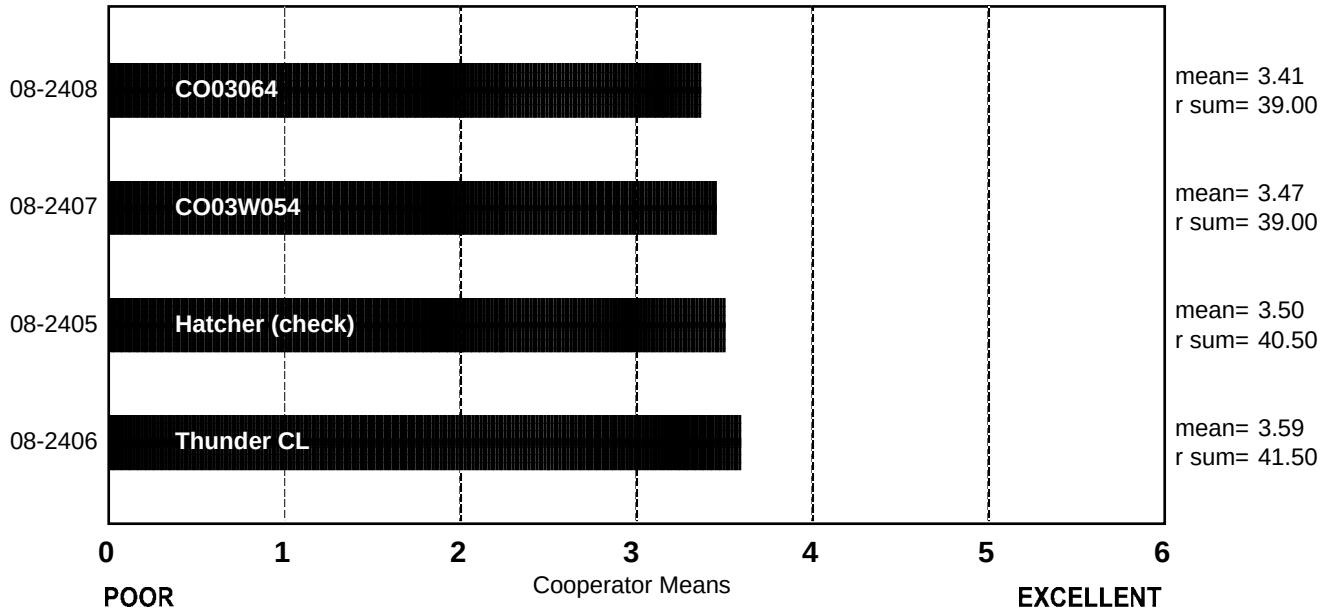
Frequency Table

CRUMB GRAIN

(Small Scale) Colorado

ncoop= 16
chisq= 0.17
chisqc= 0.24
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
08-2405 Hatcher (check)	**8**	**7**	**1**
08-2406 Thunder CL	**9**	**5**	**2**
08-2407 CO03W054	**8**	**6**	**2**
08-2408 CO03064	**9**	**6**	**1**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Colorado

	Round	Irregular	Elongated
08-2405 Hatcher (check)	**3**	**4**	**9**
08-2406 Thunder CL	**0**	**7**	**9**
08-2407 CO03W054	**5**	**7**	**4**
08-2408 CO03064	**1**	**8**	**7**

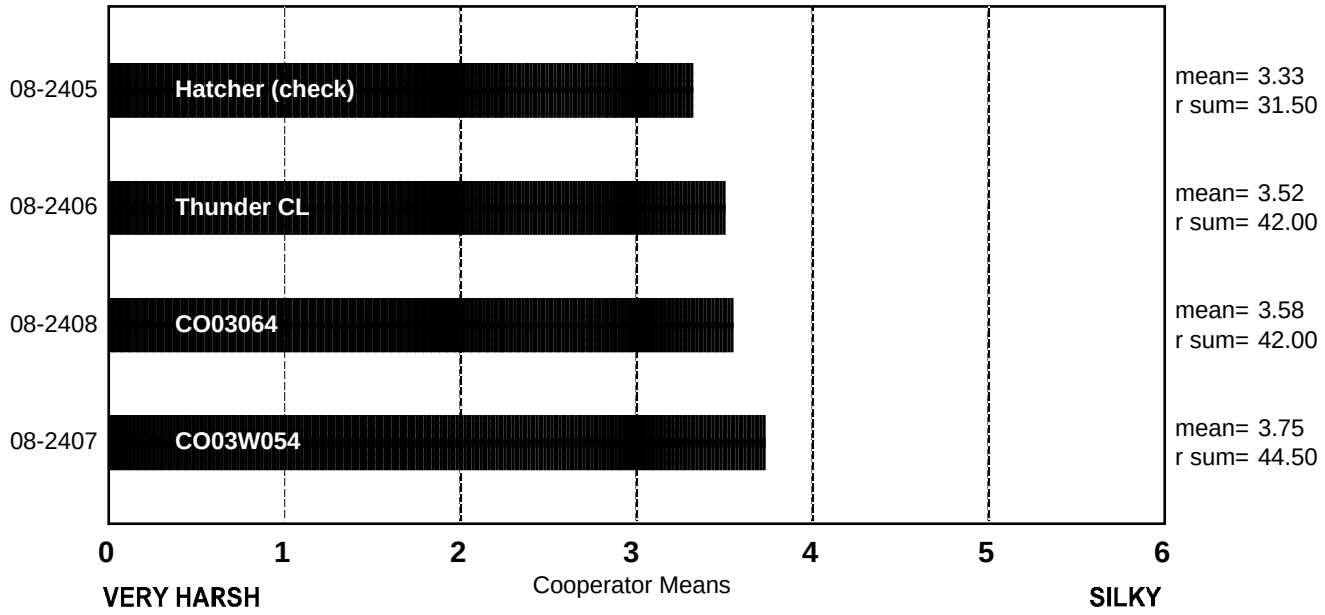
Frequency Table

CRUMB TEXTURE

(Small Scale) Colorado

ncoop= 16
chisq= 3.77
chisqc= 6.63
cvchisq= 7.82
crdiff=

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



CRUMB TEXTURE, DESCRIBED

(Small Scale) Colorado

	Harsh	Smooth	Silky
08-2405 Hatcher (check)	**7**	**7**	**2**
08-2406 Thunder CL	**3**	**9**	**4**
08-2407 CO03W054	**3**	**9**	**4**
08-2408 CO03064	**4**	**9**	**3**

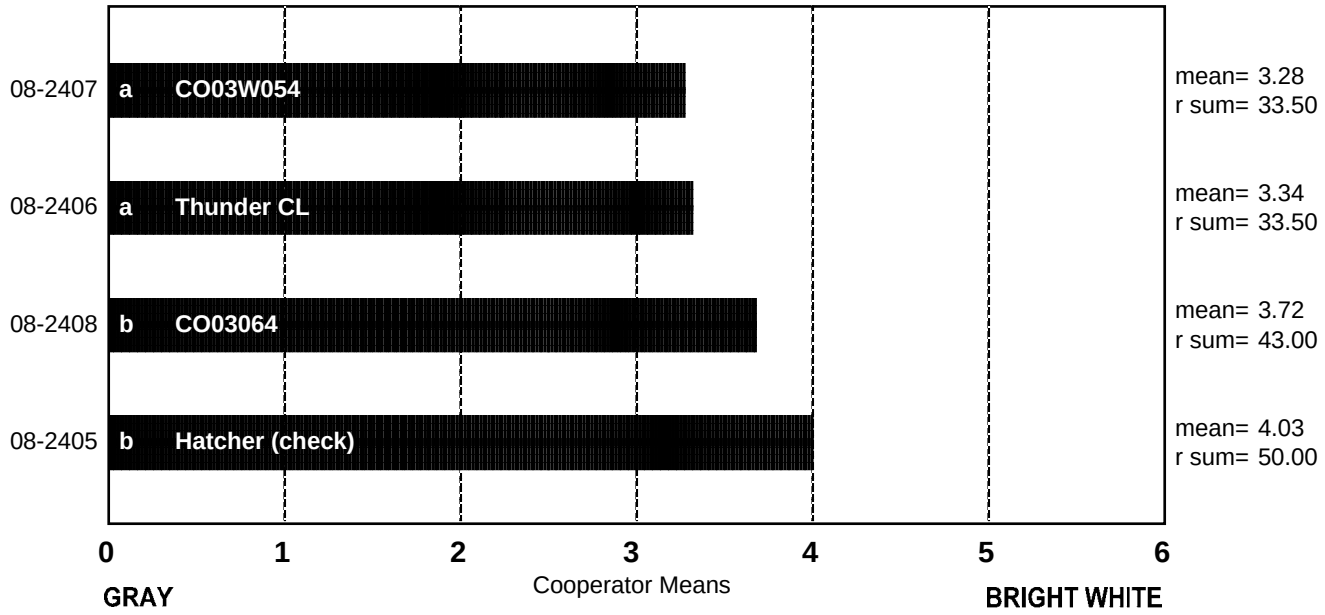
Frequency Table

CRUMB COLOR

(Small Scale) Colorado

ncoop= 16
chisq= 7.26
chisqc= 14.70
cvchisq= 7.82
crdiff= 8.89

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



CRUMB COLOR, DESCRIBED

(Small Scale) Colorado

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
08-2405 Hatcher (check)	**0**	**0**	**0**	**3**	**8**	**5**	**0**
08-2406 Thunder CL	**0**	**1**	**2**	**5**	**6**	**2**	**0**
08-2407 CO03W054	**0**	**1**	**2**	**7**	**5**	**1**	**0**
08-2408 CO03064	**0**	**0**	**0**	**4**	**10**	**2**	**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
08-2405 Hatcher (check)	**423.0**		**142.7**	**470.0**	**132.1**	**153.3**	**510.0**	**147.8**	**458.0**	**464.0**	**461.0**	**125.3**	**466.5**	**138.6**	**134.0**	**141.7**
08-2406 Thunder CL	**423.0**		**142.2**	**472.6**	**133.4**	**151.3**	**510.0**	**150.7**	**454.7**	**457.0**	**461.0**	**125.9**	**466.6**	**138.4**	**134.0**	**139.7**
08-2407 CO03W054	**425.0**		**145.2**	**469.9**	**131.7**	**152.4**	**510.0**	**148.3**	**455.7**	**462.0**	**462.0**	**127.2**	**464.5**	**141.4**	**134.0**	**140.7**
08-2408 CO03064	**421.0**		**144.5**	**467.9**	**133.3**	**154.2**	**510.0**	**147.6**	**457.1**	**463.0**	**458.0**	**125.7**	**467.8**	**139.4**	**134.0**	**135.8**

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
08-2405 Hatcher (check)	**3000**	**990**	**813**	**3104**	**695**	**975**	**3150**	**900**	**2225**	**2700**	**3000**	**840**	**2513**	**814**	**968**	**840**
08-2406 Thunder CL	**3100**	**1115**	**883**	**3162**	**780**	**1040**	**2800**	**1030**	**2433**	**2625**	**2725**	**1015**	**2588**	**916**	**983**	**1005**
08-2407 CO03W054	**3100**	**1130**	**835**	**3162**	**800**	**1035**	**3000**	**1000**	**2400**	**2600**	**2750**	**1015**	**2613**	**866**	**1017**	**948**
08-2408 CO03064	**3000**	**1150**	**803**	**3162**	**685**	**1075**	**2900**	**975**	**2250**	**2800**	**2875**	**950**	**2675**	**838**	**1023**	**983**

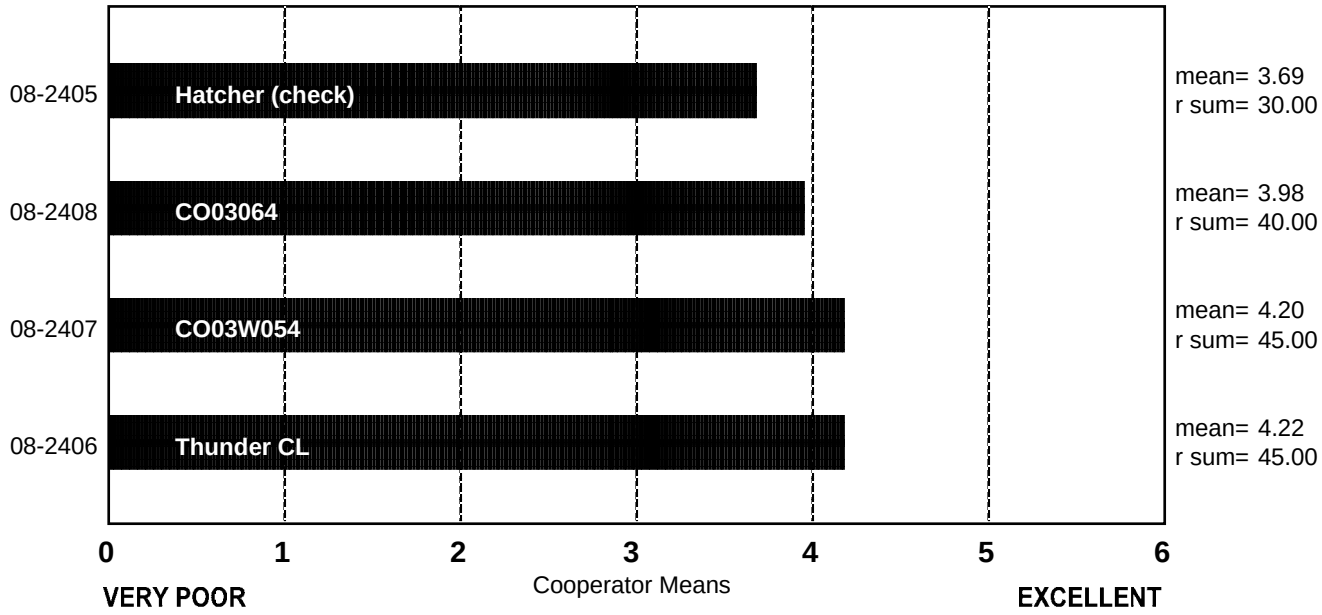
Raw Data

LOAF VOLUME

(Small Scale) Colorado

ncoop= 16
chisq= 5.63
chisqc= 7.38
cvchisq= 7.82
crdiff=

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

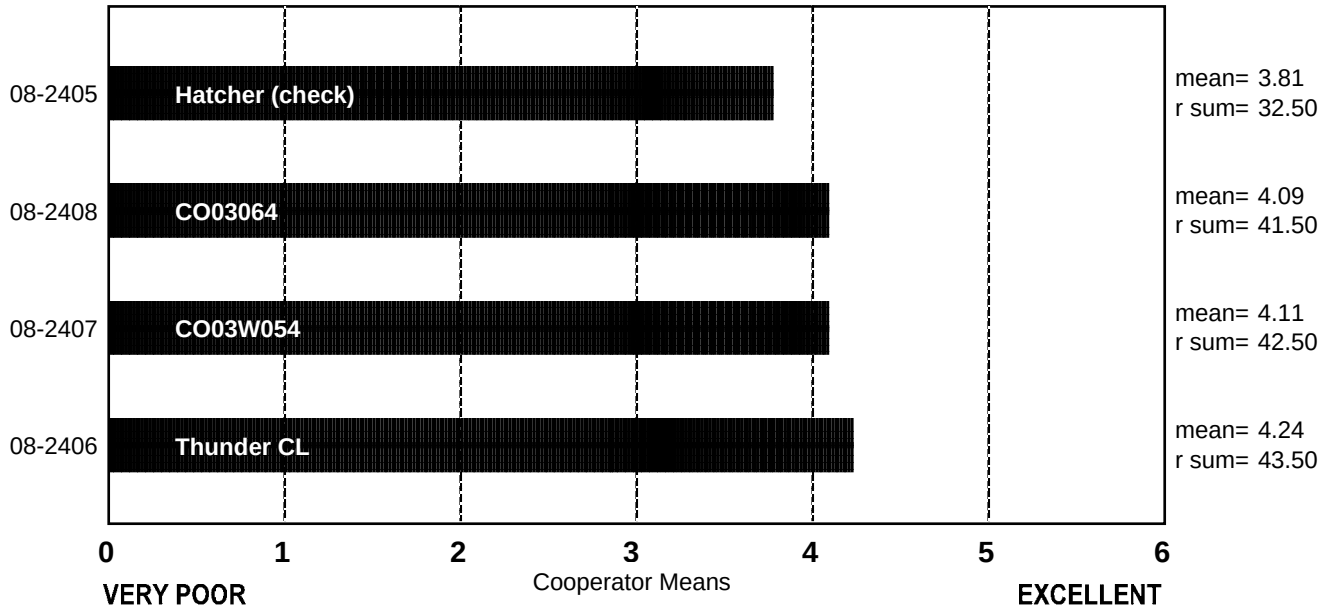


OVERALL BAKING QUALITY

(Small Scale) Colorado

ncoop= 16
chisq= 2.89
chisqc= 3.21
cvchisq= 7.82
crdiff=

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



COOPERATOR'S COMMENTS
(Small Scale) Colorado

COOP. **08-2405 Hatcher (check)**

A. Tough to mold, very shotty, could have increased water absorption worst.
B. No comments.
C. Wet dough, medium loaf volume, fine elongated cells, cream crumb, smooth & resilient texture.
D. Strong doughs, slightly open grain, excellent volume.
E. Low loaf volume.
F. Average dough strength but maybe a little weak, average to good bread performance, good loaf volume performance for protein.
G. Strong mix, long stability.
H. Low bake absorption, good bake mix time, good at pan, questionable to satisfactory crumb grain.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Good grain.
N. Slow dough pick-up during mixing which downgraded the mixing score.
O. Doughs were very stiff and underdeveloped on short mix, very strong doughs with good mix tolerance, slightly open grain.
P. No comment.

COOP. **08-2406 Thunder CL**

A. Could have used more water, very dry to mold, very open, one of worst harsh.
B. Questionable mix time.
C. Strong dough, very large loaf volume, open elongated cells, cream crumb, smooth & resilient texture.
D. Very good absorption, very strong mixing doughs, open, streaky grain, excellent volume.
E. No comments.
F. Very strong dough – a little bucky, very long mixing, good overall bread performance and good loaf volume performance for grain.
G. Very good absorption. Extremely strong, good protein, low volume.
H. Excellent bake absorption, long bake MT, tough out of mixer & pan, above satisfactory crumb grain, excellent loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. High absorption, very long mix time, tough dough, open grain.
N. Very slow dough pick-up during mixing which downgraded mixing score.
O. Dough had very good mix tolerance, stiff and gassy, under developed on short, great tolerance, grain and volume.
P. No comment.
Q.

COOP. 08-2407 CO03W054

A. Okay, very open interior, one of worst interior.
B. No comment.
C. Strong dough, large loaf volume, fine elongated cells, slight yellow crumb, smooth & resilient texture.
D. Extremely strong flour. Irregular, slightly streaky grain. Excellent volume.
E. No comment.
F. Very strong dough, excellent feel, very long mixing, good overall bread performance and good loaf volume performance for grain.
G. Good protein, strong mix, long stability.
H. Average bake absorption, excellent dough handling at pan, above satisfactory crumb grain with excellent loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Tough dough, open grain, yellow crumb, average volume.
N. Slow dough pick-up during mixing which downgraded the mixing score.
O. Short mix slightly under developed, good dough handling, doughs not too stiff or extensible, nice grain and volumes.
P. No comment.

COOP. 08-2408 CO03064

A. Could have used more water, very dry, very open, one of worst interior.
B. No comment.
C. Strong dough, medium loaf volume, fine elongated cells, cream crumb, smooth & resilient texture.
D. Very strong flour, slightly open, streaky grain, excellent volume.
E. Low loaf volume.
F. Very strong dough—a little bucky. Very long mixing, good overall bread performance and excellent loaf volume performance for grain, good blending wheat.
G. Long stability.
H. Good bake absorption, long bake MT, excellent dough handling at pan, above satisfactory crumb grain with good loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Good absorption, very long mix time, tough dough, slightly open grain, average volume.
N. Very slow dough pick-up during mixing which downgraded the mixing score.
O. Performed well for medium protein sample, good mix tolerance, doughs relaxed well on long mix, nice volumes on medium and long mixes.
P. No comment.

Notes: **A, D, I, J, M, and O** collaborators conducted sponge and dough bake tests

Description of Test Plots and Breeder Entries

Kansas-Hays – reported by Joe Martin

The samples submitted were grown at a bottomland site at Hays in 2008. The nursery was not fertilized. The yield of the entries at this location ranged from 70 to 80 bushels per acre. There was little stress on the nursery and diseases were limited to leaf rust on the Danby check that showed up fairly late in the filling process.

Danby (check) (08-2409)

Danby was the most popular white wheat grown in western Kansas in 2008. It has very good sprouting tolerance and has resistance to stripe rust which are the reasons it has replaced Trego in western Kansas. Danby's overall milling baking quality has been very similar to that of Trego.

Tiger (KS05HW136-3) (08-2410)

This line is a hard white selection from the cross KS98HW518//KS98H245/Trego. It has been our top yielding hard white line across our western Kansas locations of the KIN the last two years. It has an excellent disease resistance package, it is resistant to leaf and stripe rust, it is resistant to soil-borne mosaic virus and it has a good level of resistance to Septoria leaf blotch. KS05HW136-3 will be our first Hessian fly resistant white wheat. In our KSU bake tests we have seen improved mixing strength, improved loaf volume, and improved levels of water absorption relative to that of Danby. KS05HW136-3 is also low in PPO similar to Lakin. Thus we normally do not see a large drop in the L value in the 24 hr noodle test. We are increasing this line for possible release next year. It will be a restricted release; it will only go to those individuals or organizations that can produce this wheat for an identity preserved market and take advantage of its noodle making characteristics. If released, the variety will be named 'Tiger' to recognize the many contributions made to wheat improvement by my technical staff during my career at Hays. I believe all but one of my technicians were all trained at Fort Hays State University. FSHU has been a very valuable resource for us at Hays.

Kansas-Hays: 2008 (Small-Scale) Samples [a]

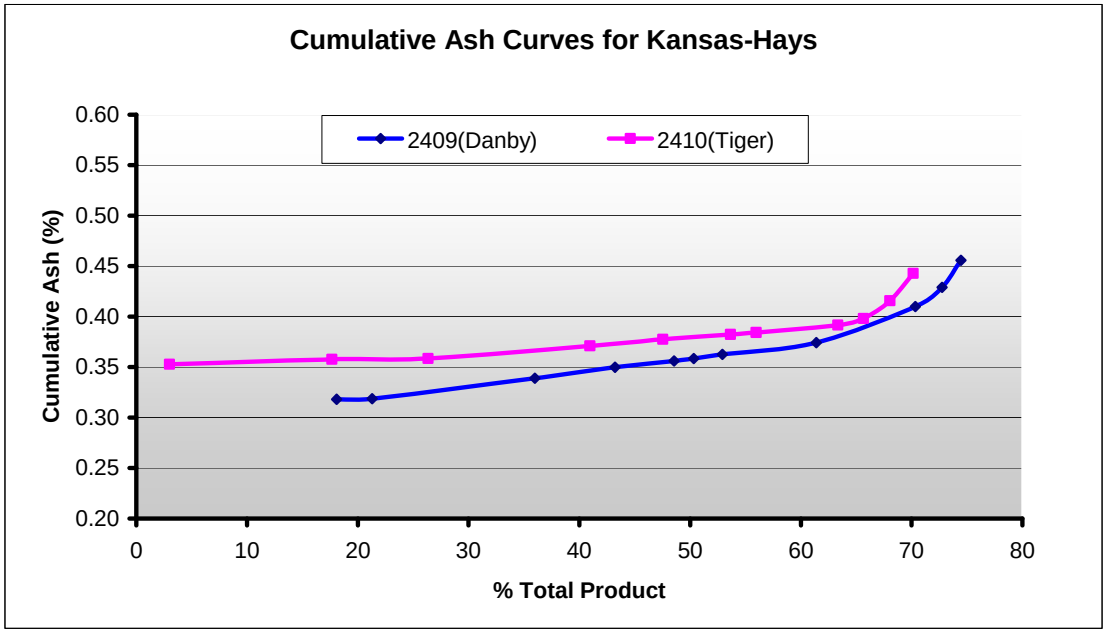
Test entry number	08-2409	08-2410
Sample identification	**Danby (check)**	**Tiger**
Wheat Data		
FGIS classification	1 HDWH	2HDWH
Test weight (lb/bu)	63.3	59.6
Hectoliter weight (kg/hl)	83.2	78.4
1000 kernel weight (gm)	30.8	28.3
NIR hardness	76	60
Wheat kernel size (Rotap)		
Over 7 wire (%)	67.9	47.7
Over 9 wire (%)	31.7	52.1
Through 9 wire (%)	0.4	0.2
Single kernel (skcs)		
Hardness (avg /s.d)	70.7/15.2	56.1/16.1
Weight (mg) (avg/s.d)	29.5/7.0	28.0/7.4
Diameter (mm)(avg/s.d)	2.68/0.29	2.62/0.27
SKCS distribution	01-03-17-79	08-16-33-43
Classification	Hard	Hard
Wheat moisture (%)	10.3	10.1
Wheat protein (12% mb)	12.95	13.66
Wheat ash (12% mb)	1.50	1.53
Milling and Flour Quality Data		
Flour yield (%, str. grade)		
Miag Multomat Mill	74.4	70.2
Quadrumat Sr. Mill	75.3	72.8
NIR Flour moisture (%)	12.1	12.3
NIR Flour protein (14% mb)	11.2	11.8
Flour ash (14% mb)	0.46	0.47
Glutomatic		
Wet gluten (%)	33.9	32.4
Dry gluten (%)	11.5	11.7
Gluten index	85.5	98.3
Rapid Visco-Analyser		
Peak time (min)	6.3	6.2
Peak viscosity (RVU)	253.2	210.3
Breakdown (RVU)	108.4	103.8
Final viscosity at 13 min (RVU)	244.4	193.9
Minolta color meter		
L*	92.74	92.85
a*	-1.36	-1.28
b*	8.66	7.82
Falling number (sec)	469	455
Flour particle size (avg)		
Fisher sub sieve sizer	22.8	20.0

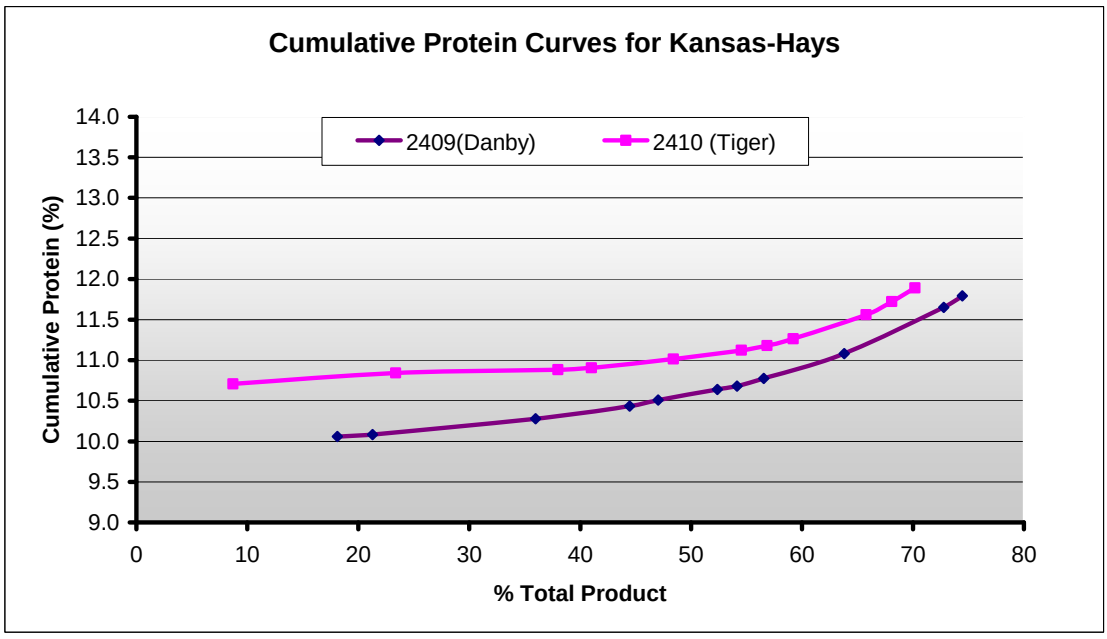
[a]s.d.= standard deviation; skcs = Single Kernel Characterization System 4100.

Kansas-Hays: Physical Dough Tests and Gluten Analysis For 2008 (Small-Scale) Samples

Test Entry Number	08-2409	08-2410
Sample Identification	Danby (check)	Tiger
MIXOGRAPH		
Flour Abs (% as-is)	63.8	63.5
Flour Abs (14% mb)	61.6	61.6
Mix Time (min)	2.63	4.50
Mix tolerance (0-6)	2	4
FARINOGRAPH		
Flour Abs (% as-is)	61.2	57.4
Flour Abs (14% mb)	59.0	55.5
Development time (min)	6.5	8.8
Mix stability (min)	9.8	22.4
Mix Tolerance Index (FU)	37	17
Breakdown time (min)	10.1	21.3
ALVEOGRAPH		
P(mm. $_{H2O}$): Tenacity	59	66
L(mm): Extensibility	125	112
G($mm_{0.}5$): Swelling index	24.9	23.6
W(10^{-4} J): strength (curve area)	225	292
P/L: curve configuration ratio	0.47	0.59
Ie(P_{200}/P): elasticity index	56.5	69.6
EXTENSIGRAPH		
Resist (BU at 30/60/90 min)	193/261/277	381/604/723
Extensibility (mm at 30/60/90 min)	198/195/182	216/171/149
Energy (cm^2 at 30/60/90 min)	81/108/102	198/215/199
Resist $_{max}$ (BU at 30/60/90 min)	296/406/417	726/992/997
Ratio (at 30/60/90 min)	1.0/1.3/1.5	1.8/3.5/4.9
PROTEIN ANALYSIS		
HMW-GS Composition	1, 5, 10, 7, 9	2*, 5, 10, 7, 9
Glu/Gli	0.51	0.50
HMW/LMW	0.28	0.31
%IPP	46.11	53.01
SEDIMENTATION TEST		
Volume (ml)	48.4	64.7

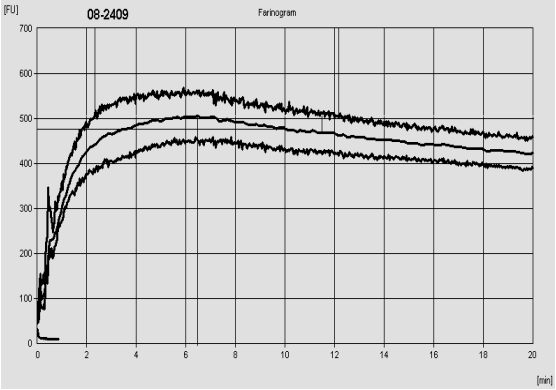
Kansas-Hays: Cumulative Ash and Protein Curves





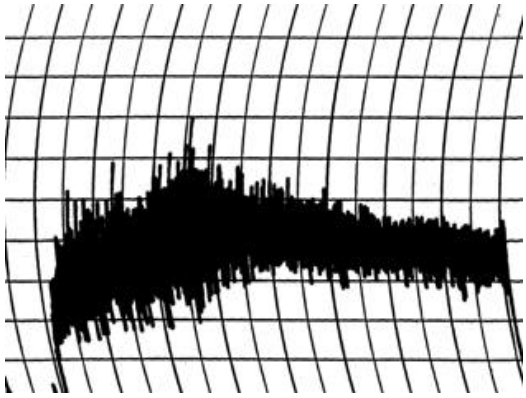
Physical Dough Tests
2008 (Small Scale) Samples – Kansas-Hays

Farinograms



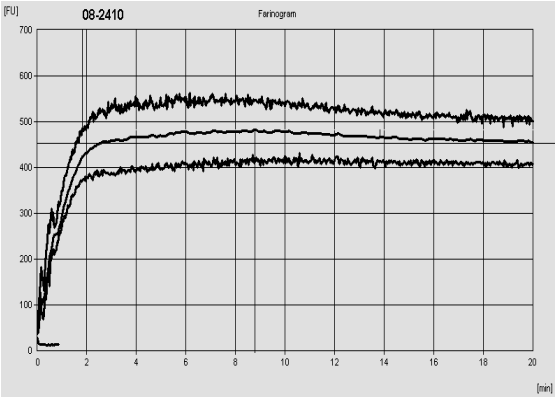
Water Abs. = 59.0%, Peak time = 6.5 min,
Mix Stab. = 9.8 min, MTI = 37

Mixograms

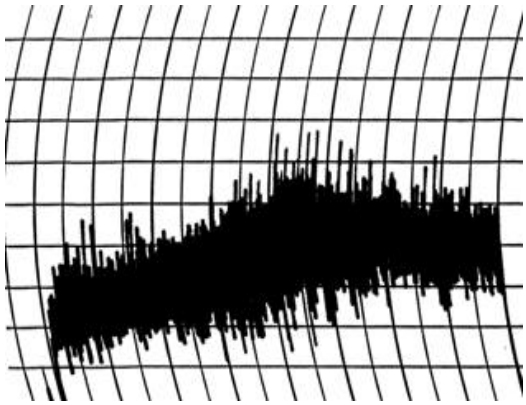


Abs. = 61.6%, Mix time = 2.6 min,
Mix tolerance = 2

08-2409, Danby (check)



Water Abs. = 55.5%, Peak time = 8.8 min,
Mix Stab. = 22.4 min, MTI = 17 FU

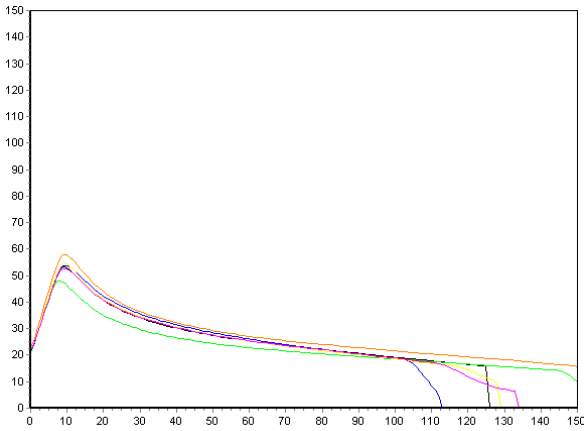


Abs. = 61.6%, Mix time = 4.5 min,
Mix tolerance = 4

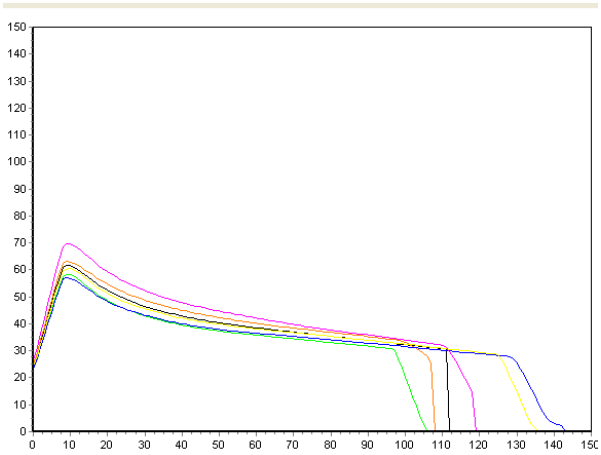
08-2410, Tiger

Physical Dough Tests - Alveograph

2008 (Small Scale) Samples – Kansas-Hays



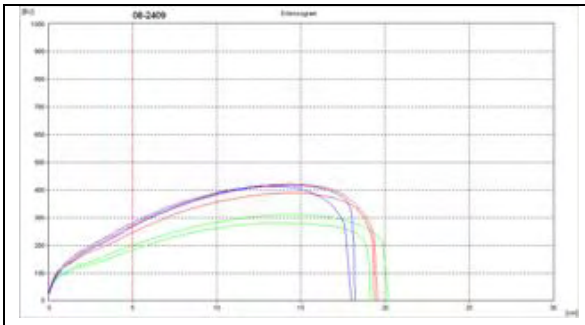
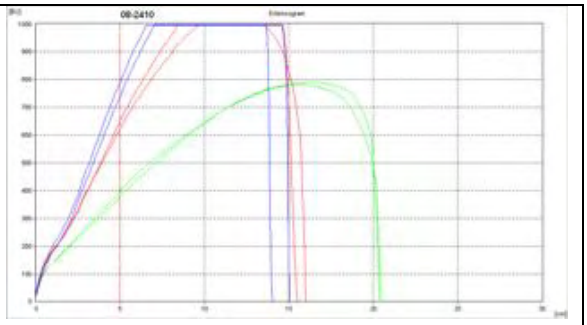
08-2409 (Danby)
P(mm $_{H20}$)=59, L(mm)=125, W(10^{-4} J)=225



08-2410 (Tiger)
P(mm $_{H20}$)=66, L(mm)=112, W(10^{-4} J)=292

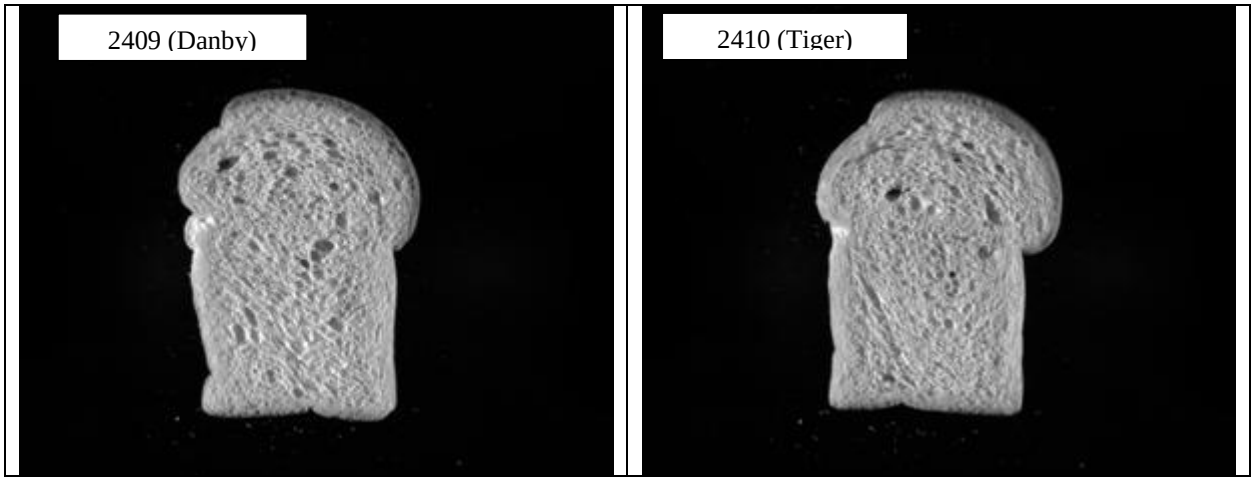
Physical Dough Tests - Extensigraph

2008 (Small Scale) Samples – Kansas-Hays

	
08-2409 (Danby) R (BU) = 193, E (mm) =198, W (cm^2) = 81 Rmax (BU) = 296, Ratio = 1.0 at 30 min	**08-2410 (Tiger)** R (BU) = 381, E (mm) =216, W (cm^2) = 198 Rmax (BU) = 726, Ratio = 1.8 at 30 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = test at 30 min, Red = test at 60 min, and Blue =a test at 90 min.

Kansas-Hays: C-Cell Bread Images and Analysis for 2008 (Small-Scale) Samples



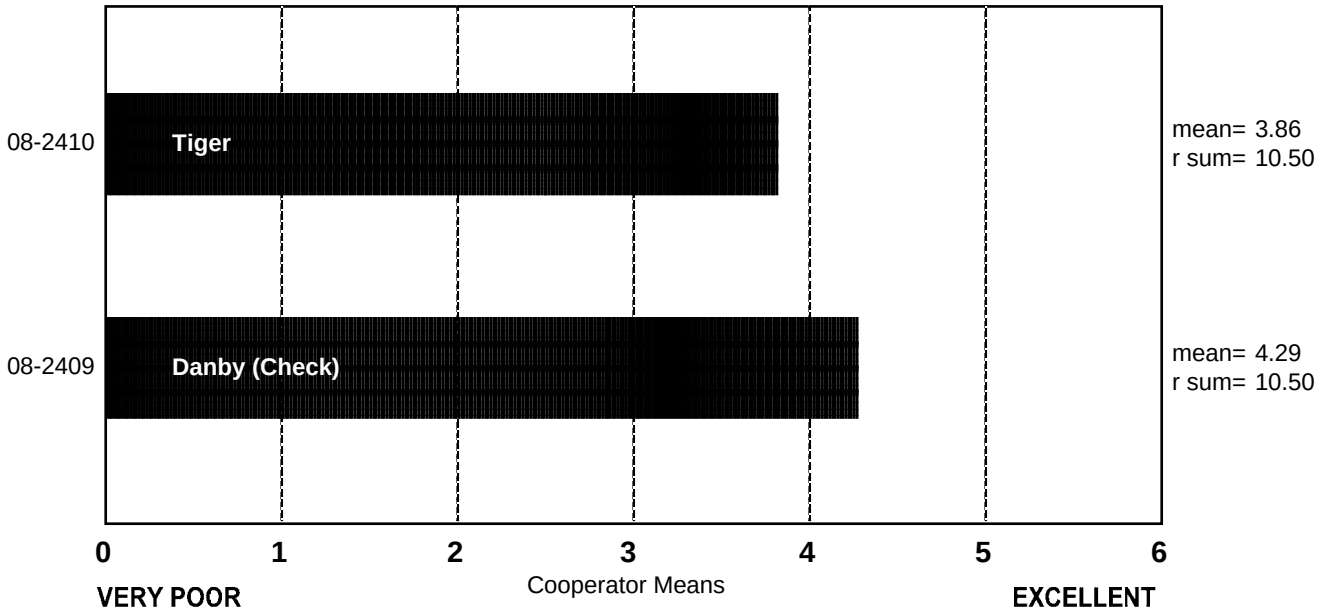
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2409	6058	155.9	3851	0.447	1.876	1.036	1.65	-25.2
2410	6189	153.6	4001	0.437	1.979	4.054	1.68	-18.5

SPONGE CHARACTERISTICS

(Small Scale) Kansas-Hays

ncoop= 7
chisq= -0.00
chisqc= 0.00
cvchisq= 3.84
crdiff=

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

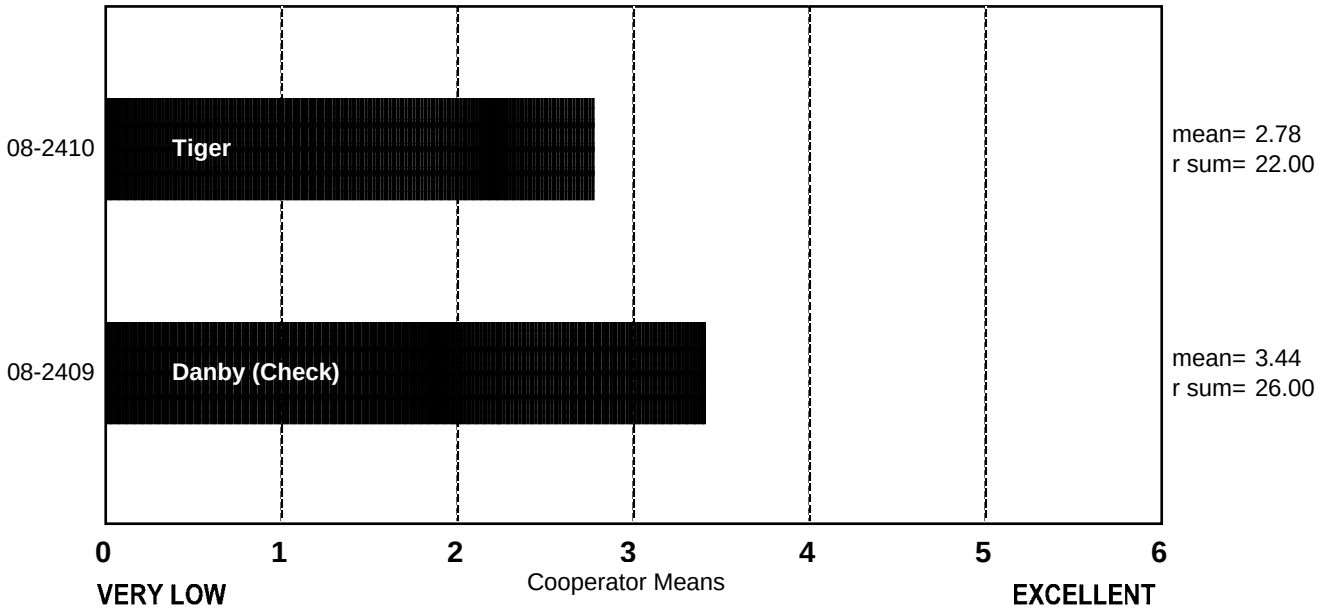


BAKE ABSORPTION

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 1.00
chisqc= 1.33
cvchisq= 3.84
crdiff=

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



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Kansas-Hays

	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
08-2409 Danby (Check)	**57.0**	**61.3**	**61.2**	**59.0**	**59.2**	**62.9**	**52.0**	**57.5**	**62.0**	**58.5**	**61.0**	**57.5**	**58.0**	**64.0**	**61.0**	**61.1**
08-2410 Tiger	**58.0**	**62.1**	**57.4**	**58.0**	**55.4**	**65.2**	**57.0**	**60.3**	**58.5**	**57.5**	**57.5**	**54.0**	**56.0**	**64.3**	**62.0**	**61.1**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Kansas-Hays

	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
08-2409 Danby (Check)	**8.0**	**2.5**	**4.7**	**12.0**	**1.0**	**3.2**	**5.0**	**3.8**	**3.0**	**12.0**	**4.5**	**2.8**	**5.0**	**2.8**	**6.0**	**2.5**
08-2410 Tiger	**20.0**	**4.3**	**7.0**	**25.0**	**2.0**	**5.8**	**6.0**	**6.8**	**6.0**	**30.0**	**6.0**	**4.8**	**12.0**	**5.7**	**9.0**	**4.3**

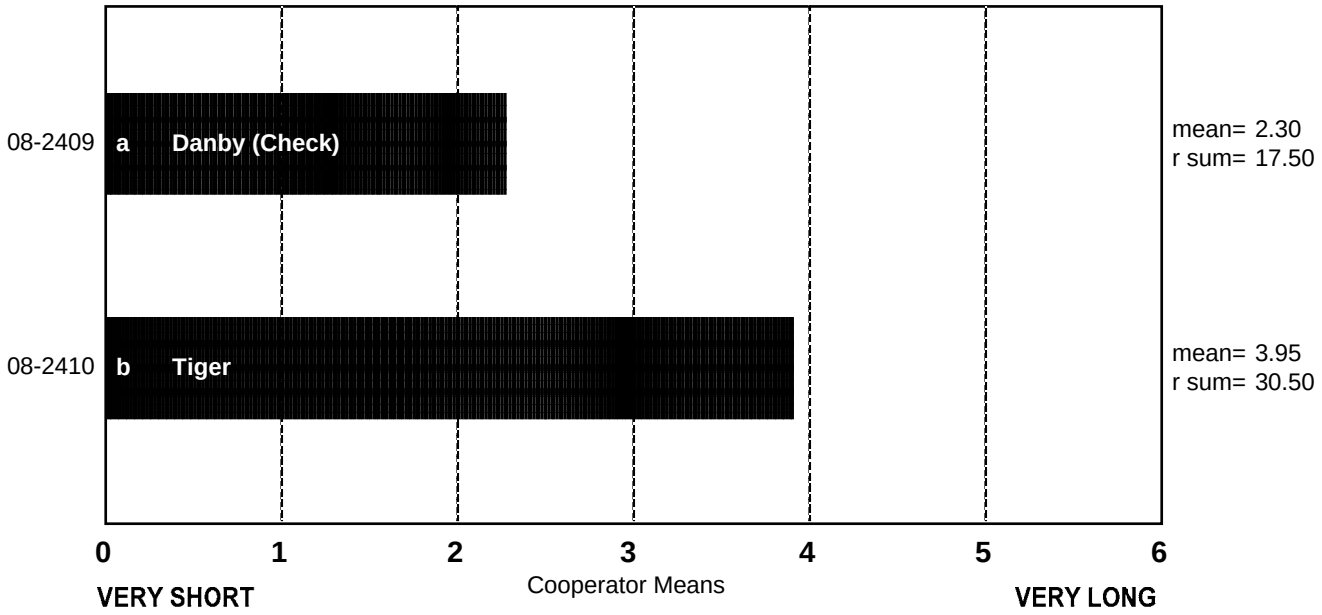
Raw Data

BAKE MIX TIME

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 10.56
chisqc= 11.27
cvchisq= 3.84
crdiff= 4.64

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

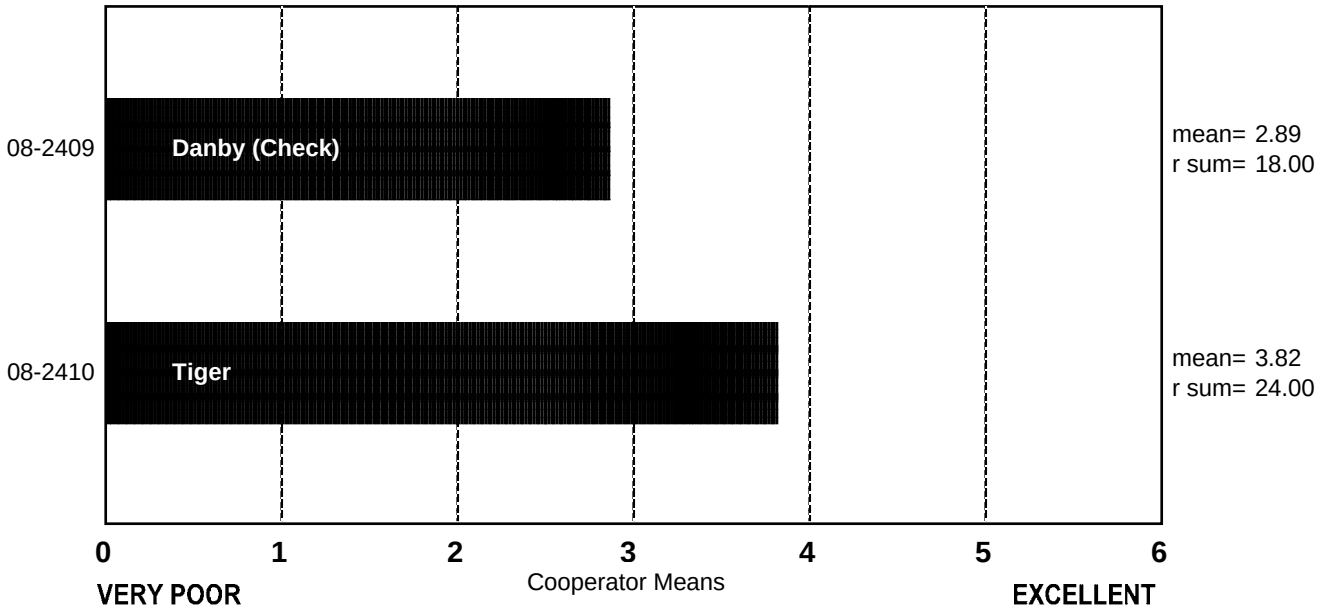


MIXING TOLERANCE

(Small Scale) Kansas-Hays

ncoop= 14
chisq= 2.57
chisqc= 2.57
cvchisq= 3.84
crdiff=

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

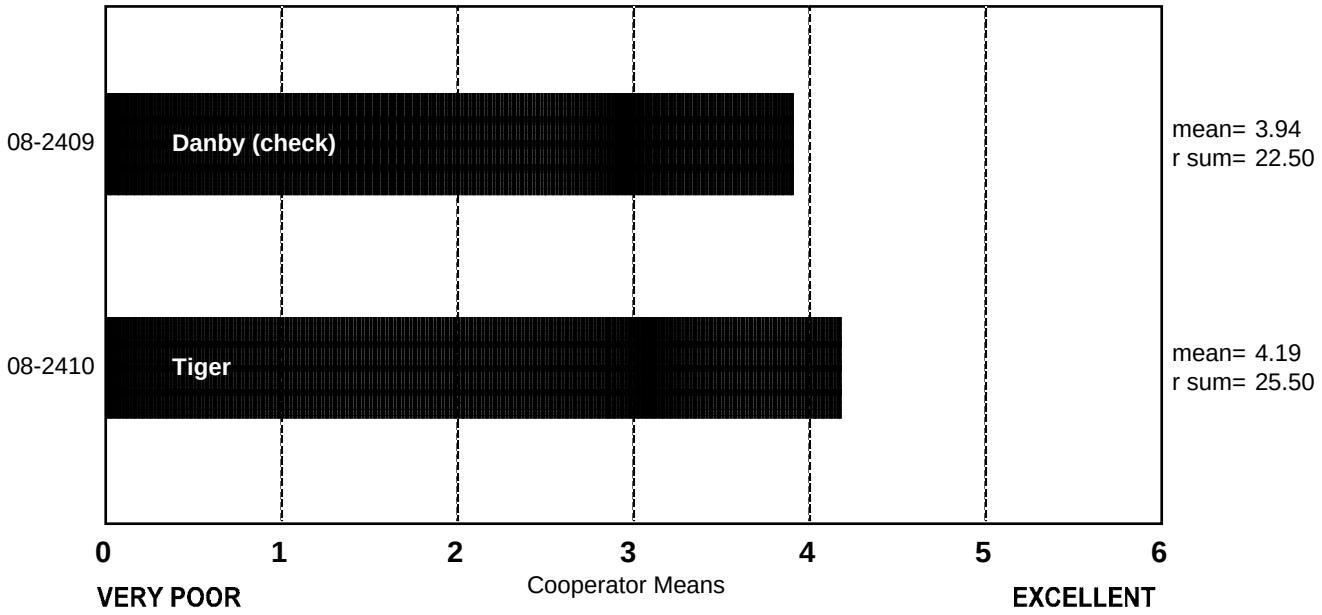


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 0.56
chisqc= 0.90
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) Kansas-Hays

	Sticky	Wet	Tough	Good	Excellent
08-2409 Danby (check)	**3**	**2**	**0**	**10**	**1**
08-2410 Tiger	**1**	**0**	**4**	**7**	**4**

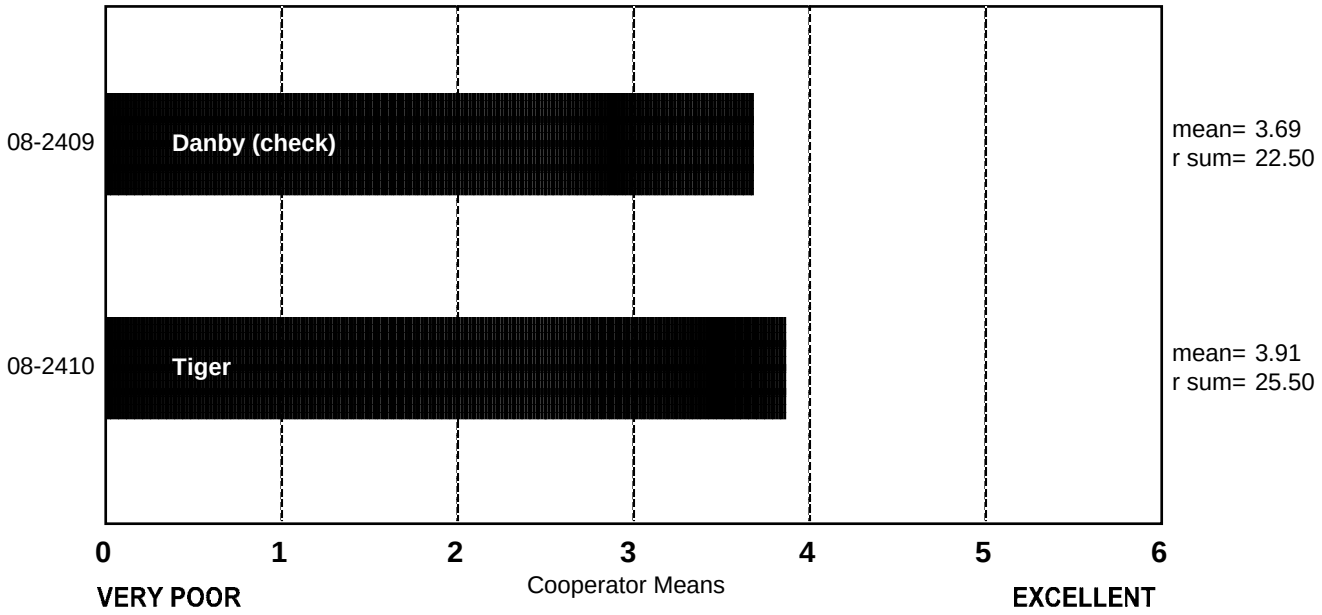
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 0.56
chisqc= 1.00
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) Kansas-Hays

	Sticky	Wet	Tough	Good	Excellent
08-2409 Danby (check)	**1**	**1**	**1**	**12**	**1**
08-2410 Tiger	**0**	**0**	**3**	**12**	**1**

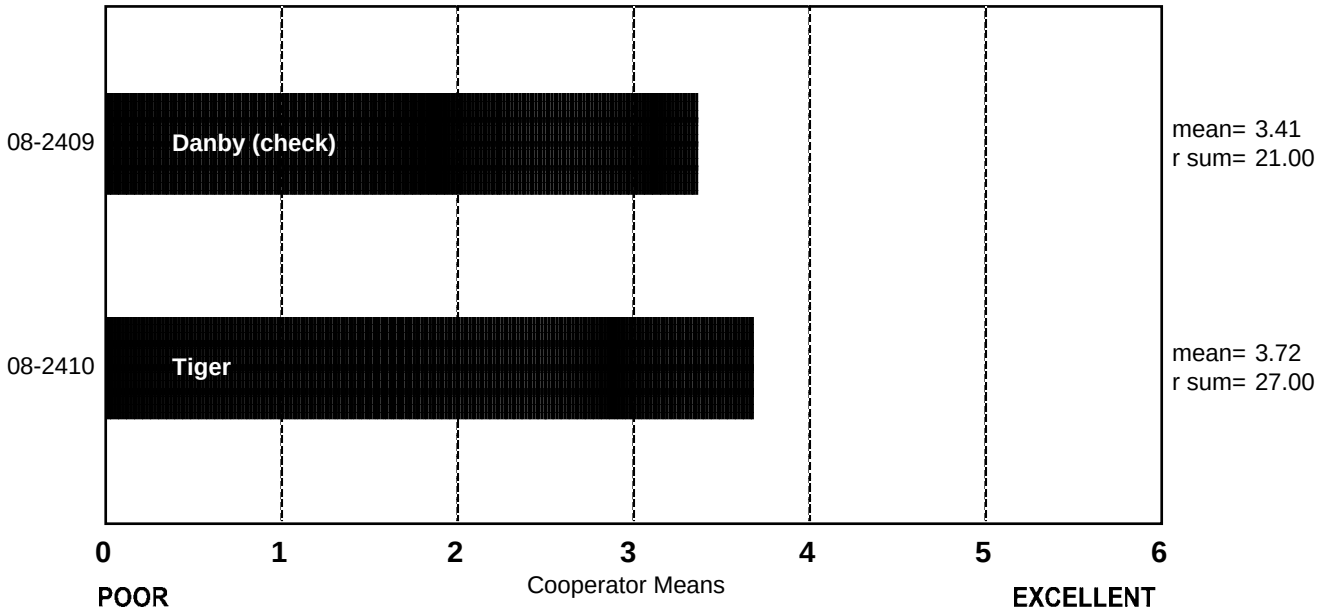
Frequency Table

CRUMB GRAIN

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 2.25
chisqc= 2.57
cvchisq= 3.84
crdiff=

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



CRUMB GRAIN, DESCRIBED

(Small Scale) Kansas-Hays

	Open	Fine	Dense
08-2409 Danby (check)	**7**	**9**	**0**
08-2410 Tiger	**8**	**8**	**0**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Kansas-Hays

	Round	Irregular	Elongated
08-2409 Danby (check)	**2**	**8**	**6**
08-2410 Tiger	**2**	**5**	**9**

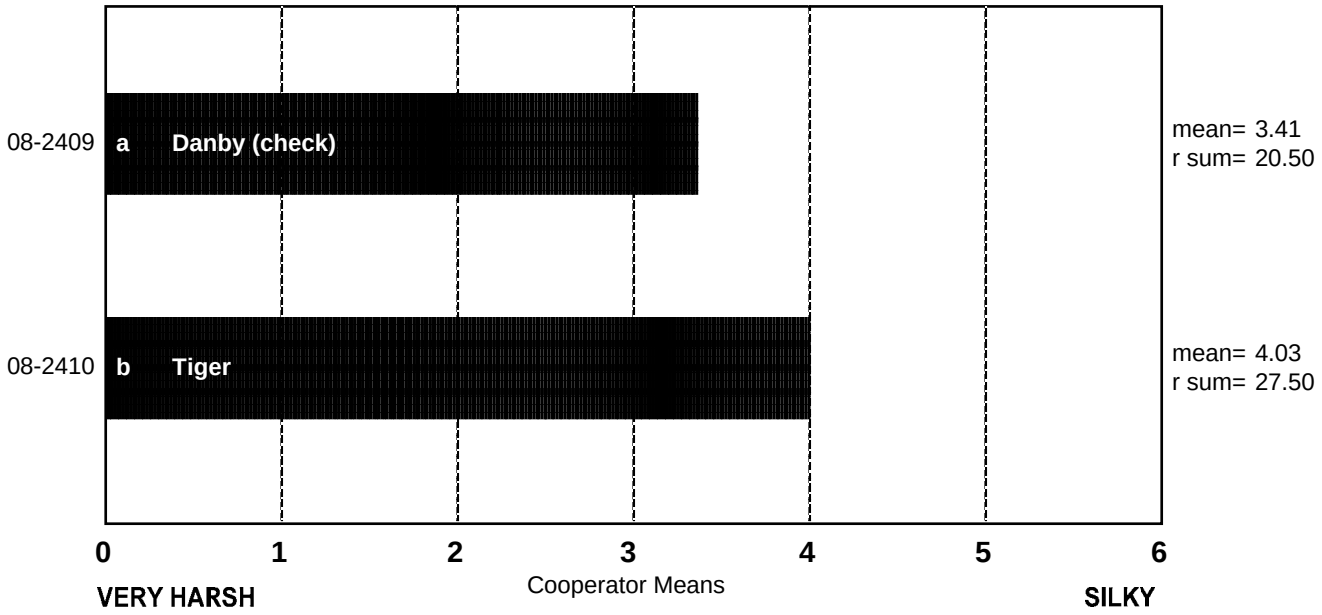
Frequency Table

CRUMB TEXTURE

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 3.06
chisqc= 5.44
cvchisq= 3.84
crdiff= 5.36

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



CRUMB TEXTURE, DESCRIBED

(Small Scale) Kansas-Hays

	Harsh	Smooth	Silky
08-2409 Danby (check)	**6**	**7**	**3**
08-2410 Tiger	**2**	**6**	**7**

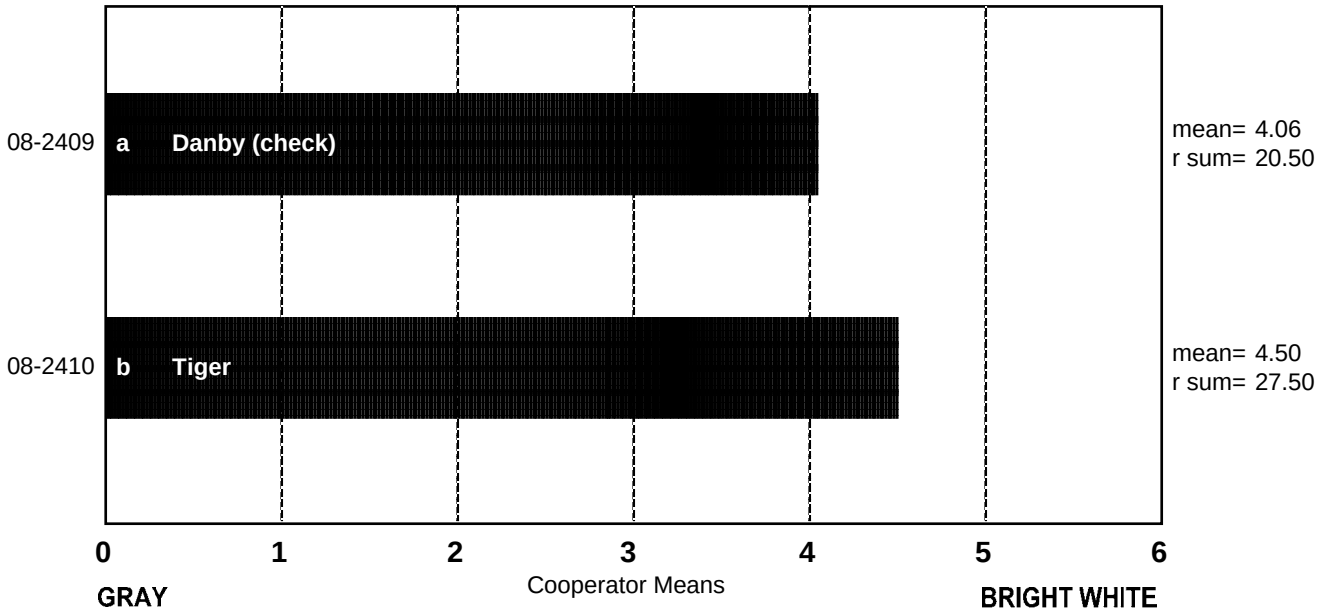
Frequency Table

CRUMB COLOR

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 3.06
chisqc= 5.44
cvchisq= 3.84
crdiff= 5.36

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



CRUMB COLOR, DESCRIBED

(Small Scale) Kansas-Hays

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
08-2409 Danby (check)	**0**	**0**	**2**	**0**	**8**	**6**	**0**
08-2410 Tiger	**0**	**0**	**1**	**1**	**5**	**7**	**2**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Kansas-Hays

	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
08-2409 Danby (check)	**418.0**		**144.7**	**469.1**	**137.5**	**151.4**	**510.0**	**145.1**	**452.5**	**454.0**	**457.0**	**127.5**	**466.2**	**140.5**	**134.0**	**139.7**
08-2410 Tiger	**417.0**		**144.8**	**468.2**	**128.8**	**151.2**	**510.0**	**145.5**	**453.6**	**466.0**	**458.0**	**125.1**	**465.2**	**140.8**	**134.0**	**141.3**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Kansas-Hays

	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
08-2409 Danby (check)	**3050**	**955**	**775**	**3045**	**570**	**980**	**3350**	**895**	**2275**	**2675**	**3000**	**900**	**2675**	**831**	**1016**	**870**
08-2410 Tiger	**3150**	**1110**	**860**	**3104**	**760**	**1065**	**3150**	**960**	**2540**	**2725**	**3175**	**990**	**2775**	**914**	**1026**	**1033**

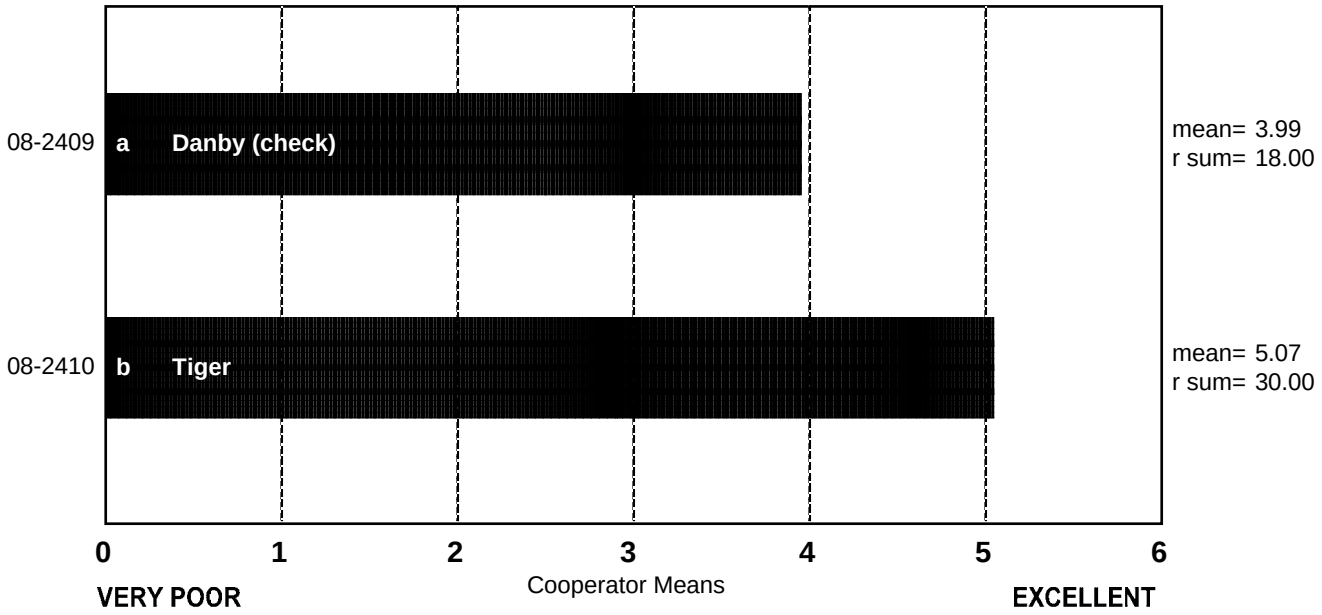
Raw Data

LOAF VOLUME

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 9.00
chisqc= 10.29
cvchisq= 3.84
crdiff= 4.92

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

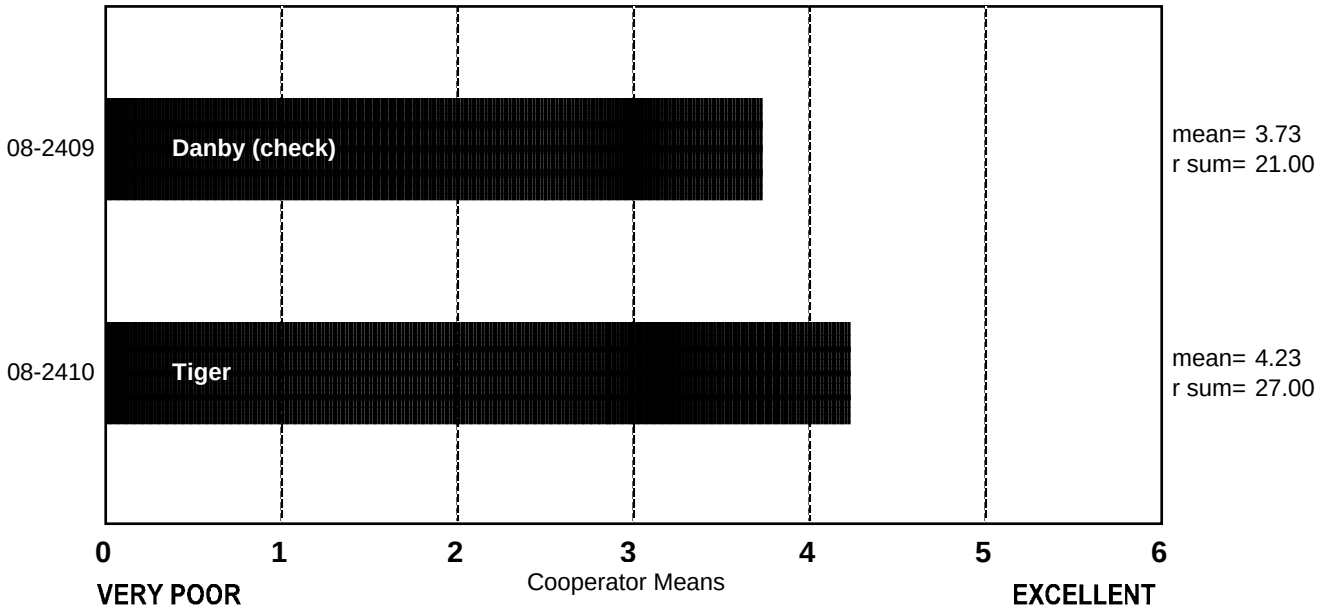


OVERALL BAKING QUALITY

(Small Scale) Kansas-Hays

ncoop= 16
chisq= 2.25
chisqc= 2.57
cvchisq= 3.84
crdiff=

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



COOPERATOR'S COMMENTS
(Small Scale) Kansas-Hays

COOP. **08-2409 Danby (check)**

A. Good nice interior, short mix, and excellent volume.
B. No comments.
C. Sticky dough, small loaf volume, fine round cells, slightly yellow crumb, resilient & slight harsh texture.
D. Above average interior scores, good volume.
E. Low loaf volume and short mix time.
F. Dough slightly on weaker side, short mixing, good overall bread performance and excellent loaf volume performance for grain.
G. Low stability, very low bake absorption, very good volume.
H. Low bake absorption, short bake mix time, poor tolerance, weak at pan, satisfactory crumb grain.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Low absorption, short mix time, sticky dough, good grain, average volume.
N. No comment.
O. Performed very well for lower protein sample, dough handling was softer and extensible, slightly tacky, open grain, good recovery in baking of long mixes, nice white crumb.
P. No comment.

COOP. **08-2410 Tiger**

A. Good, nice interior, bright color.
B. No comment.
C. Strong dough, large loaf volume, open elongated cells, slightly yellow crumb, silky smooth & resilient texture.
D. Low absorption, above average interior scores, excellent volumes.
E. Low absorption.
F. Very strong dough, long mixing, excellent overall bread performance, very nice grain and excellent loaf volume performance for grain, good blending wheat, BEST OF SHOW.
G. Low absorption, strong flour.
H. Low bake absorption, excellent dough handling, above satisfactory crumb grain with excellent loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, slightly long mix time, very fine grain, white crumb, good volume.
N. Slow dough pick-up during mixing which downgraded the mixing score.
O. Excellent performance for lower protein, soft dough handling on the bench, great grain and white crumb.
P. No comment.

Notes: **A, D, I, J, M, and O** collaborators conducted sponge and dough bake tests.

Description of Test Plots and Breeder Entries

Kansas-Manhattan – reported by Allan Fritz

Growing Location

KS970093-8-9-#1 and Karl 92 (the check) were grown in side-by-side blocks at the Ashland Research Farm near Manhattan, KS in a conventional till system. A total of 80# of N was applied.

Karl 92 (Check) (08-2411)

Karl 92 was used as the check.

KS970093-8-9-#1 (082412)

The pedigree is HBK1064-3/Betty 'S'//VBF0589-1/IL89-6483. It is currently resistant to leaf rust, stripe rust, soil-borne mosaic virus and Hessian fly. It has demonstrated a moderate level of resistance to FHB over three years of testing and also has good resistance to barley yellow dwarf virus. It is moderately susceptible to tan spot. KS970093-8-9-#1 is a medium early line with height similar to Jagger. It is also tolerant of shattering. It has had a strong yield record in central and eastern Kansas, particularly in the northern half of the state. It has not performed well under drought conditions. The quality profile of this line has not been outstanding, but it meets almost all of the hard winter wheat quality targets.

Kansas-Manhattan: 2008 (Small-Scale) Samples [a]

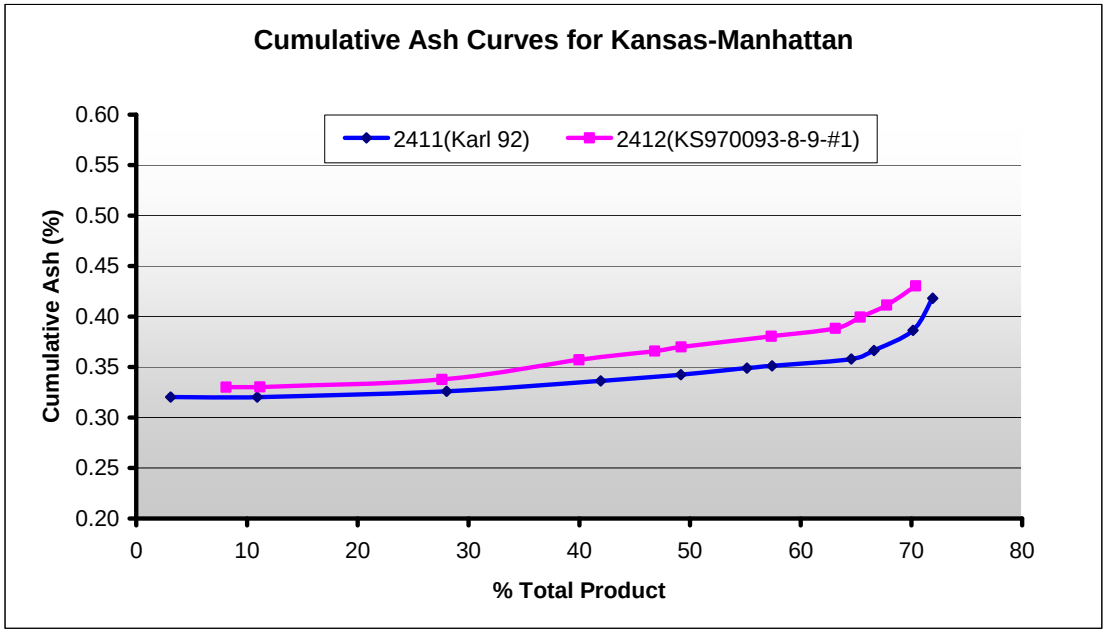
Test entry number	08-2411	08-2412
Sample identification	**Karl 92 (check)**	**KS970093-8-9-#1**
Wheat Data		
FGIS classification	1 HRW	2HRW
Test weight (lb/bu)	60.0	59.3
Hectoliter weight (kg/hl)	78.9	78.0
1000 kernel weight (gm)	32.8	30.1
NIR hardness	58	69
Wheat kernel size (Rotap)		
Over 7 wire (%)	74.5	65.8
Over 9 wire (%)	25.5	34.2
Through 9 wire (%)	0.0	0.1
Single kernel (skcs)		
Hardness (avg /s.d)	52.3/11.9	63.5/16.3
Weight (mg) (avg/s.d)	31.5/6.2	28.8/7.7
Diameter (mm)(avg/s.d)	2.73/0.25	2.69/0.28
SKCS distribution	05-27-43-25	03-10-26-61
Classification	Hard	Hard
Wheat moisture (%)	10.4	10.9
Wheat protein (12% mb)	14.1	16.2
Wheat ash (12% mb)	1.73	1.92
Milling and Flour Quality Data		
Flour yield (%, str. grade)		
Miag Multomat Mill	72.0	70.4
Quadrumat Sr. Mill	71.6	68.7
NIR Flour moisture (%)	12.1	12.0
NIR Flour protein (14% mb)	12.5	14.2
Flour ash (14% mb)	0.46	0.51
Glutomatic		
Wet gluten (%)	29.8	44.0
Dry gluten (%)	12.9	14.8
Gluten index	98.2	66.1
Rapid Visco-Analyser		
Peak time (min)	6.5	6.5
Peak viscosity (RVU)	230.3	243.8
Breakdown (RVU)	79.9	79.0
Final viscosity at 13 min (RVU)	253.7	268.2
Minolta color meter		
L*	92.84	91.99
a*	-0.87	-1.15
b*	6.76	8.53
Falling number (sec)	434	514
Flour particle size (avg)		
Fisher sub sieve sizer	18.8	21.8

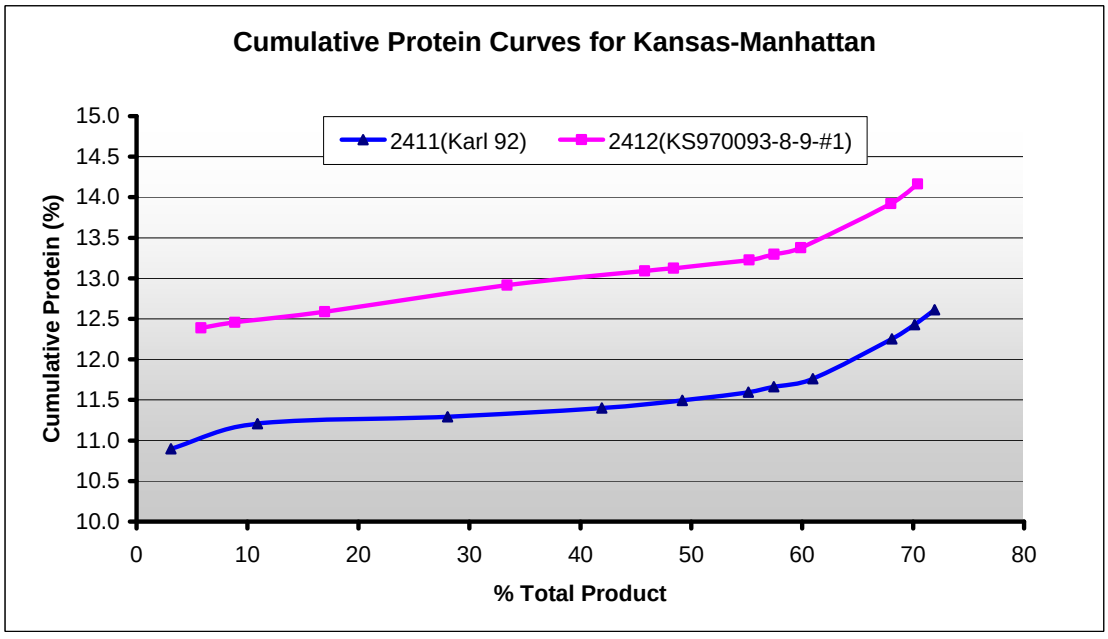
[a]s.d.= standard deviation; skcs = Single Kernel Characterization System 4100.

Kansas-Manhattan: Physical Dough Tests and Gluten Analysis For 2008 (Small-Scale) Samples

Test Entry Number	08-2411	08-2412
Sample Identification	Karl 92 (check)	KS970093-8-9-#1
MIXOGRAPH		
Flour Abs (% as-is)	65.9	66.9
Flour Abs (14% mb)	63.7	64.6
Mix Time (min)	5.38	2.25
Mix tolerance (0-6)	5	0
FARINOGRAPH		
Flour Abs (% as-is)	61.0	64.2
Flour Abs (14% mb)	58.8	61.8
Development time (min)	8.7	6.4
Mix stability (min)	25.9	9.5
Mix Tolerance Index (FU)	20	36
Breakdown time (min)	17.3	9.1
ALVEOGRAPH		
P(mm. $_{H2O}$): Tenacity	67	68
L(mm): Extensibility	104	91
G($mm_{0.5}$): Swelling index	22.7	21.2
W(10^{-4} J): strength (curve area)	284	194
P/L: curve configuration ratio	0.64	0.75
Ie(P_{200}/P): elasticity index	70.8	52.5
EXTENSIGRAPH		
Resist (BU at 30/60/90 min)	295/455/548	192/255/264
Extensibility (mm at 30/60/90 min)	229/186/169	196/190/186
Energy (cm^2 at 30/60/90 min)	176/187/189	76/96/98
Resist $_{max}$ (BU at 30/60/90 min)	596/796/879	279/365/379
Ratio (at 30/60/90 min)	1.3/2.4/3.3	1.0/1.3/1.4
PROTEIN ANALYSIS		
HMW-GS Composition	1, 5, 10, 7, 8	2*, 5, 10, 7, 9
Glu/Gli	0.49	0.45
HMW/LMW	0.33	0.21
%IPP	53.66	44.10
SEDIMENTATION TEST		
Volume (ml)	64.6	46.4

Kansas-Manhattan: Cumulative Ash and Protein Curves

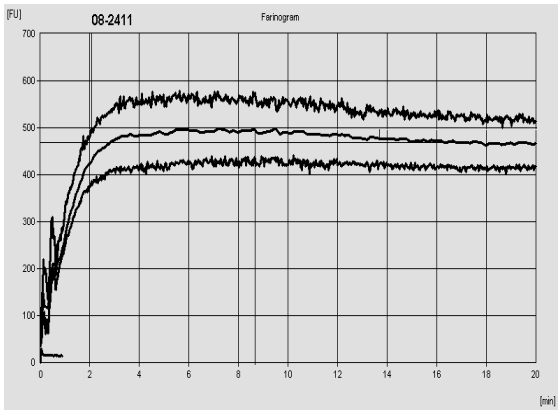




Physical Dough Tests

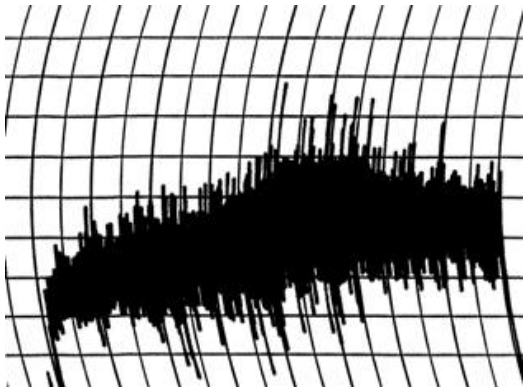
2008 (Small Scale) Samples – Kansas-Manhattan

Farinograms



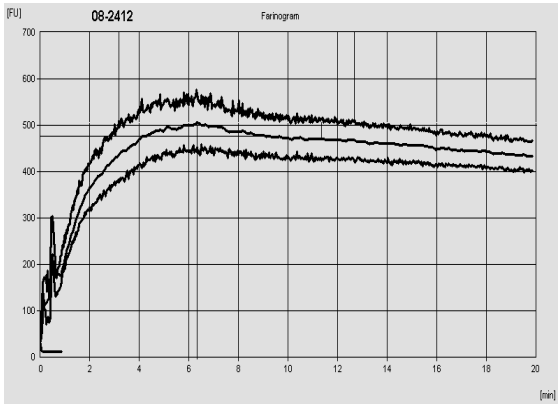
Water Abs. = 58.8%, Peak time = 8.7 min,
Mix Stab. = 25.9 min, MTI = 20 FU

Mixograms

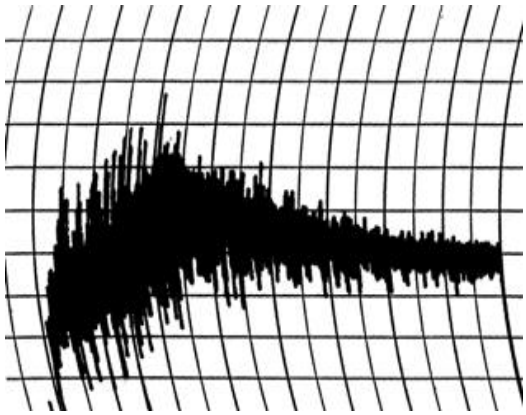


Abs. = 63.7%, Mix time = 5.4 min,
Mix tolerance = 5

08-2411, Karl 92 (check)



Water Abs. = 61.8%, Peak time = 6.4 min,
Mix Stab. = 6.4 min, MTI = 36 FU

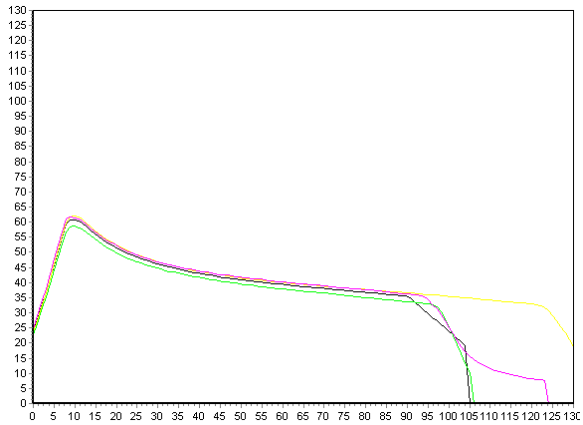


Abs. = 64.6%, Mix time = 2.3 min,
Mix tolerance = 0

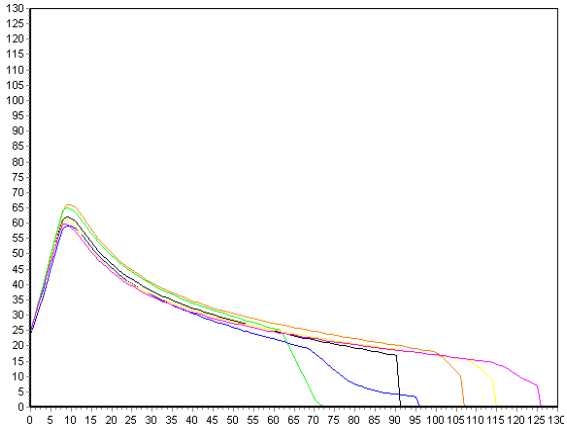
08-2412, KS970093-8-9-#1

Physical Dough Tests - Alveograph

2008 (Small Scale) Samples – Kansas-Manhattan



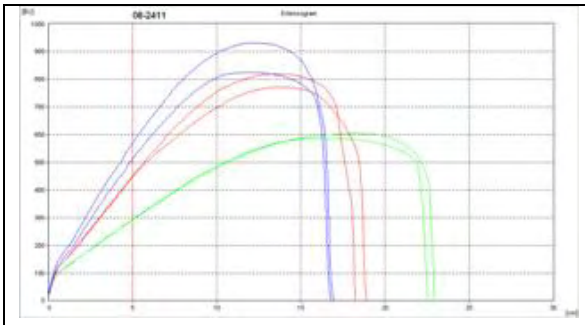
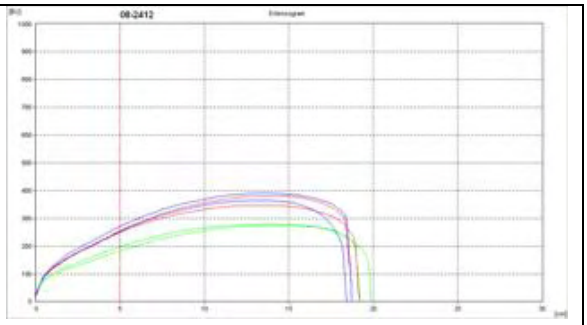
08-2411 (Karl 92)
P(mm $_{H20}$)=67, L(mm)=104, W(10^{-4} J)=284



08-2412 (KS970093-8-9-#1)
P(mm $_{H20}$)=68, L(mm)=91, W(10^{-4} J)=194

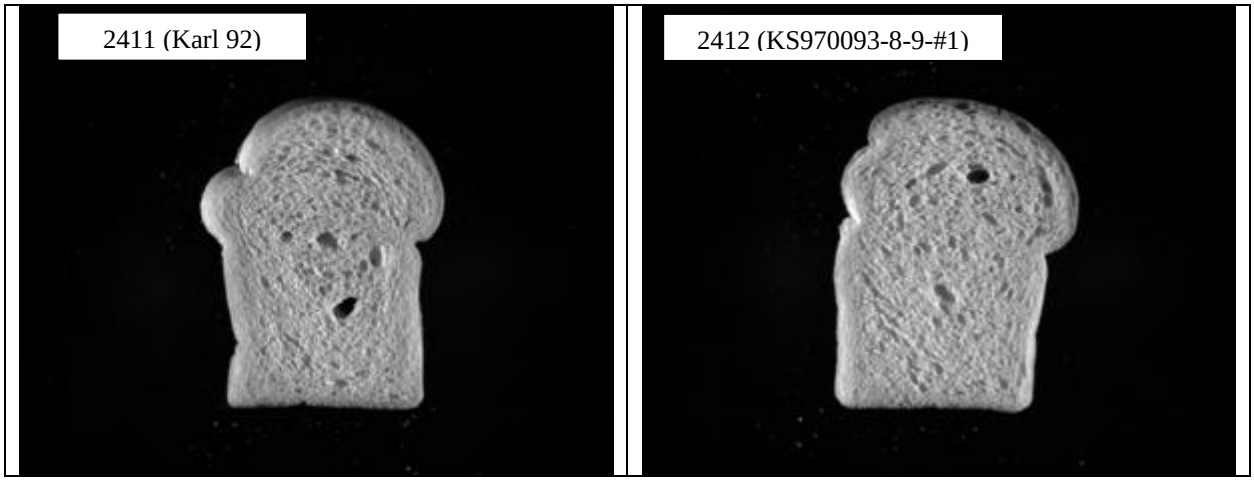
Physical Dough Tests - Extensigraph

2008 (Small Scale) Samples – Kansas-Manhattan

	
08-2411 (Karl 92) R (BU) = 292, E (mm) =229, W (cm^2) = 176 Rmax (BU) = 596, Ratio = 1.3 at 30 min	**08-2412 (KS970093-8-9-#1)** R (BU) = 192, E (mm) =196, W (cm^2) = 76 Rmax (BU) = 279, Ratio = 1.0 at 30 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = test at 30 min, Red = test at 60 min, and Blue =a test at 90 min.

Kansas-Manhattan: C-Cell Bread Images and Analysis for 2008 (Small-Scale) Samples



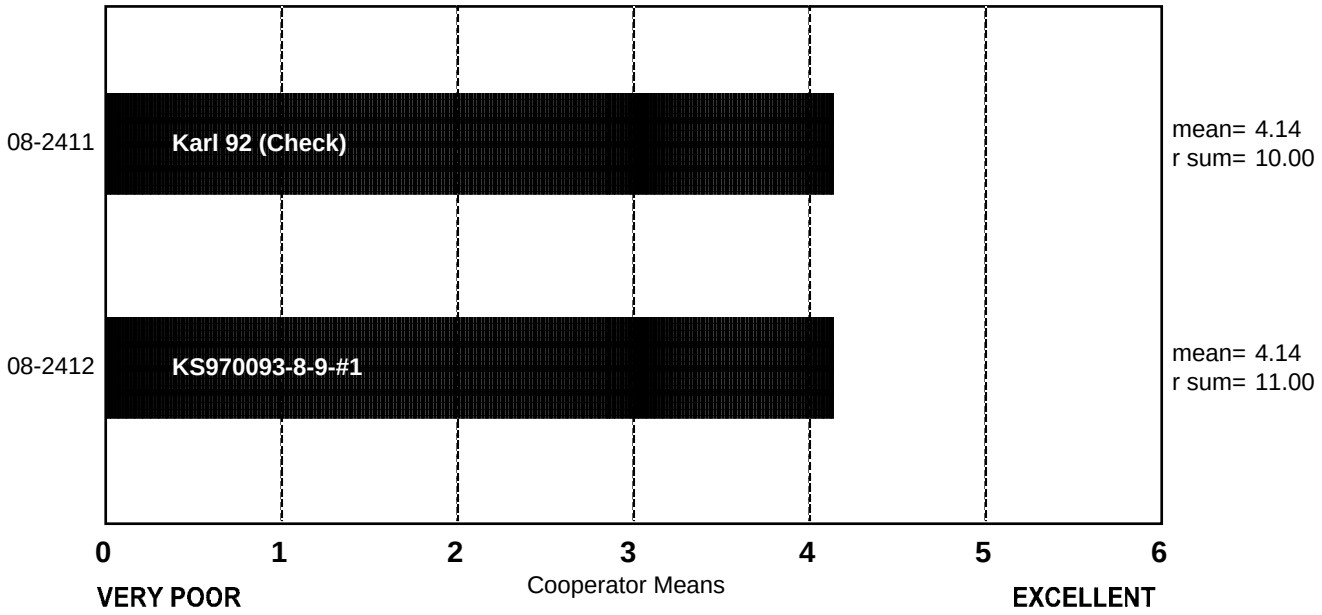
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2411	5548	146.5	3795	0.429	1.829	2.099	1.71	-20.2
2412	5843	152.2	3814	0.439	1.869	1.127	1.63	-21.8

SPONGE CHARACTERISTICS

(Small Scale) Kansas-Manhattan

ncoop= 7
chisq= 0.14
chisqc= -0.25
cvchisq= 3.84
crdiff=

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

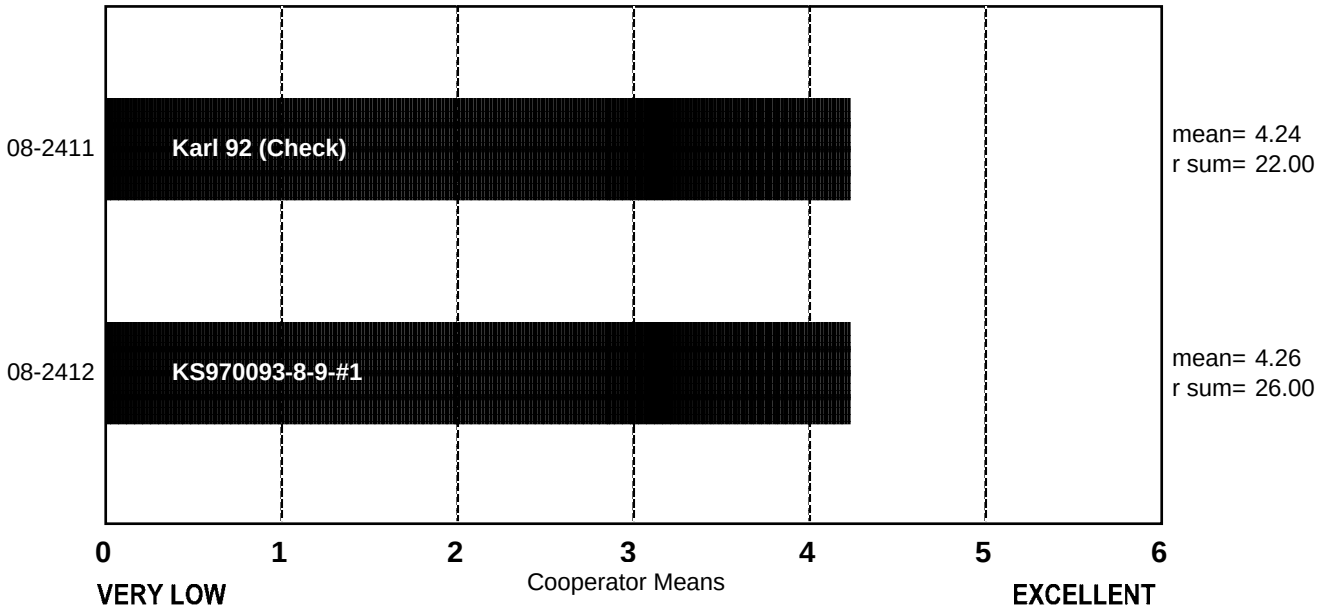


BAKE ABSORPTION

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 1.00
chisqc= 1.33
cvchisq= 3.84
crdiff=

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



BAKE ABSORPTION, ACTUAL (14% MB)

(Small Scale) Kansas-Manhattan

	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
08-2411 Karl 92 (Check)	**59.0**	**63.8**	**61.0**	**59.0**	**59.0**	**66.9**	**56.0**	**63.8**	**61.8**	**62.0**	**60.8**	**57.3**	**58.0**	**65.9**	**63.0**	**63.1**
08-2412 KS970093-8-9-#1	**60.0**	**65.6**	**64.2**	**61.0**	**62.2**	**69.8**	**57.0**	**59.4**	**64.8**	**60.5**	**63.8**	**60.3**	**61.0**	**67.1**	**64.0**	**64.1**

Raw Data

BAKE MIX TIME, ACTUAL

(Small Scale) Kansas-Manhattan

	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
08-2411 Karl 92 (Check)	**20.0**	**4.1**	**6.6**	**25.0**	**1.8**	**5.8**	**6.0**	**7.4**	**13.0**	**30.0**	**6.8**	**4.5**	**24.0**	**5.6**	**6.0**	**4.0**
08-2412 KS970093-8-9-#1	**11.0**	**2.3**	**3.9**	**18.0**	**1.0**	**2.3**	**6.0**	**2.5**	**6.0**	**10.0**	**6.0**	**2.3**	**5.0**	**3.2**	**3.0**	**2.0**

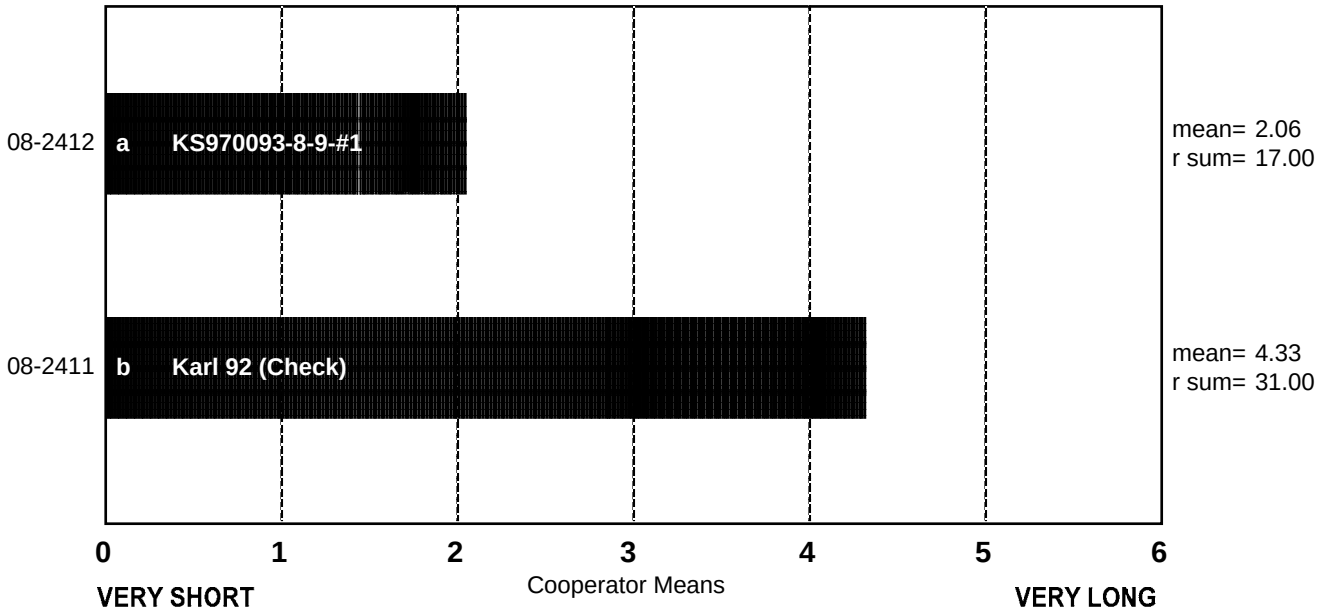
Raw Data

BAKE MIX TIME

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 12.25
chisqc= 14.00
cvchisq= 3.84
crdiff= 2.91

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

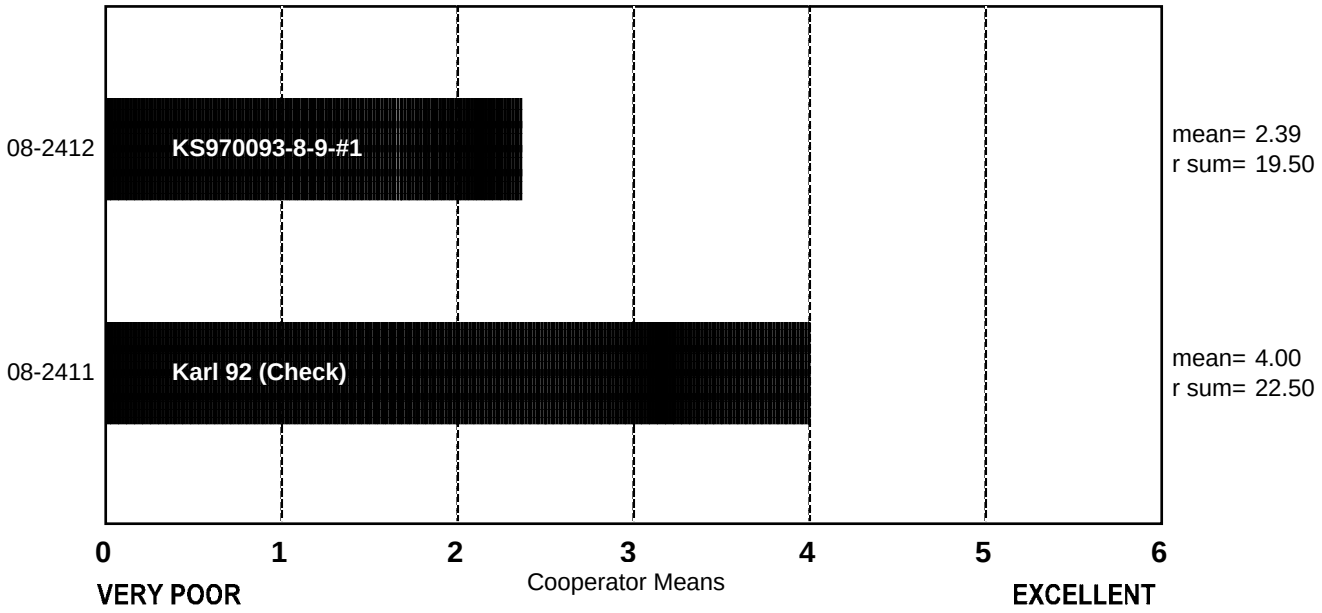


MIXING TOLERANCE

(Small Scale) Kansas-Manhattan

ncoop= 14
chisq= 0.64
chisqc= 0.75
cvchisq= 3.84
crdiff=

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

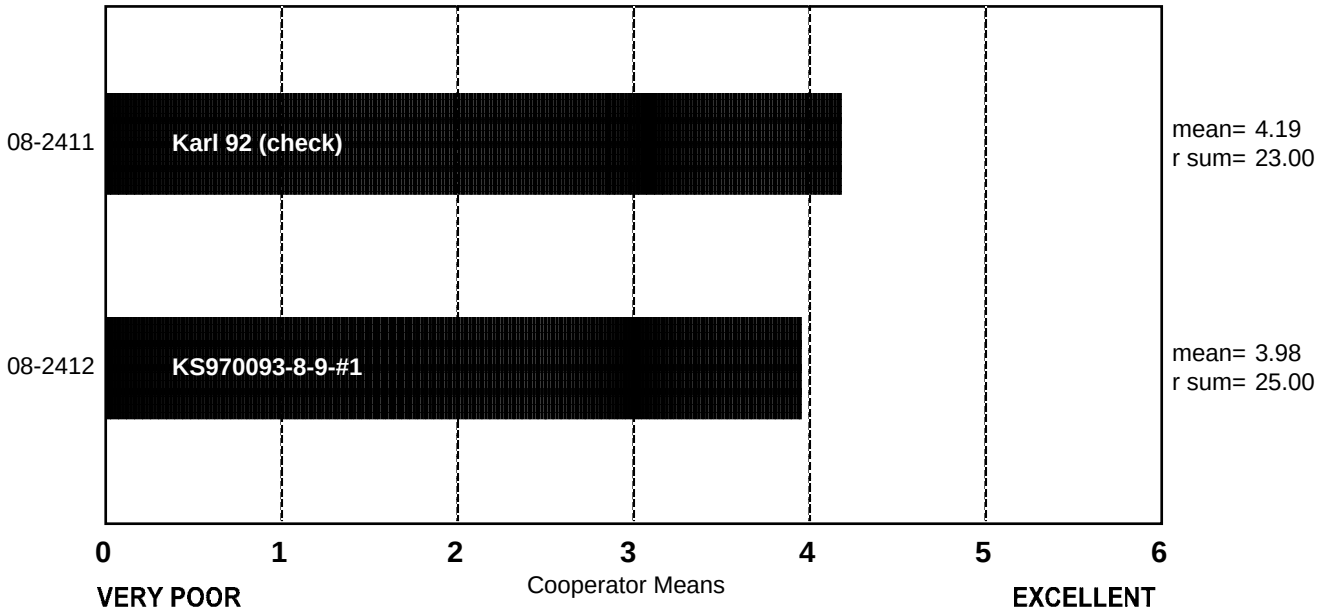


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 0.25
chisqc= 0.29
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) Kansas-Manhattan

	Sticky	Wet	Tough	Good	Excellent
08-2411 Karl 92 (check)	**0**	**0**	**4**	**10**	**2**
08-2412 KS970093-8-9-#1	**5**	**0**	**2**	**8**	**1**

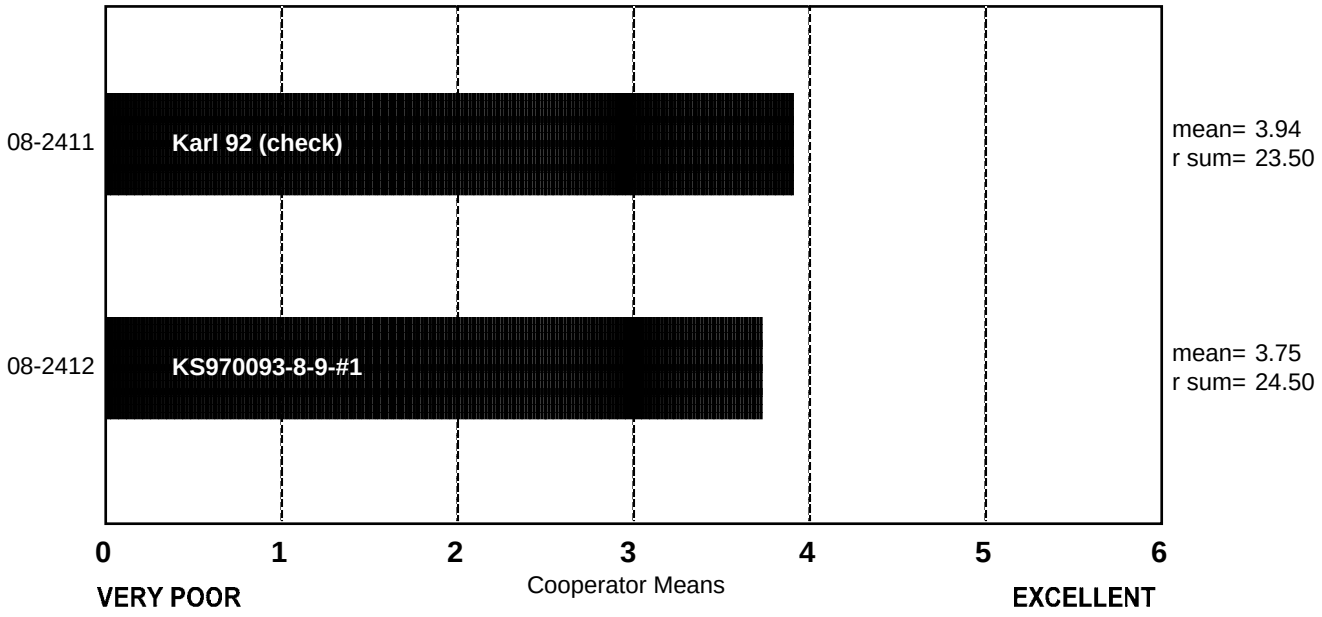
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 0.06
chisqc= 0.08
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) Kansas-Manhattan

	Sticky	Wet	Tough	Good	Excellent
08-2411 Karl 92 (check)	**0**	**0**	**4**	**11**	**1**
08-2412 KS970093-8-9-#1	**3**	**3**	**0**	**8**	**2**

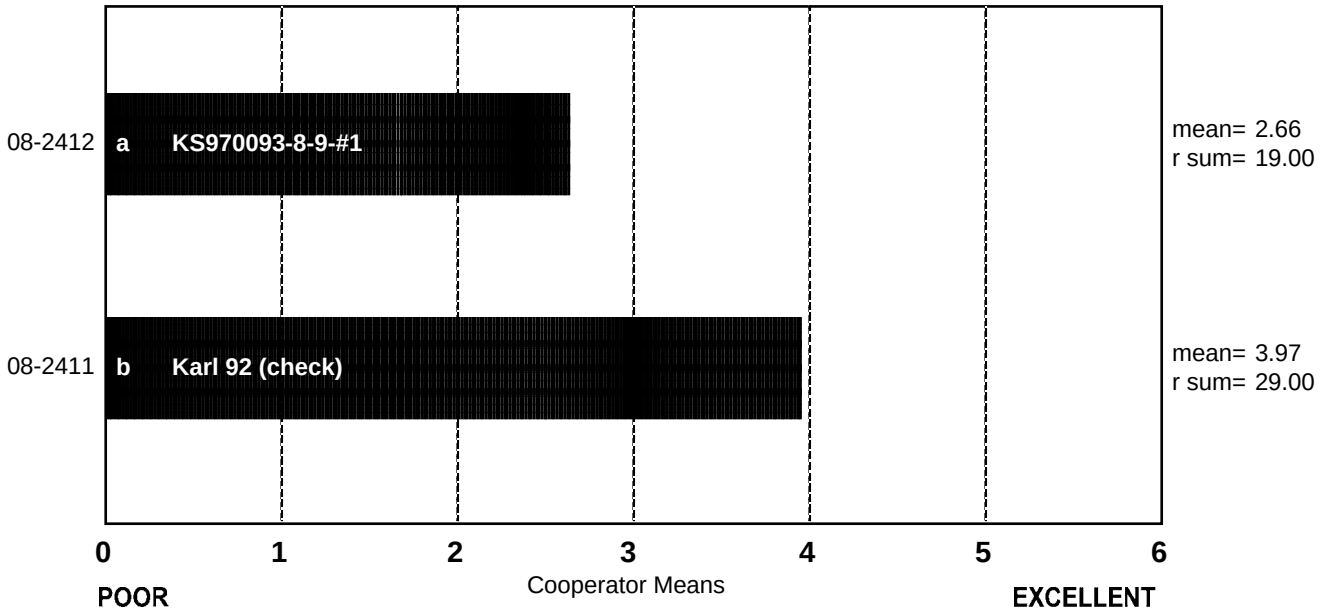
Frequency Table

CRUMB GRAIN

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 6.25
chisqc= 7.14
cvchisq= 3.84
crdiff= 6.13

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



CRUMB GRAIN, DESCRIBED

(Small Scale) Kansas-Manhattan

	Open	Fine	Dense
08-2411 Karl 92 (check)	**8**	**6**	**2**
08-2412 KS970093-8-9-#1	**8**	**7**	**1**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Kansas-Manhattan

	Round	Irregular	Elongated
08-2411 Karl 92 (check)	**4**	**3**	**9**
08-2412 KS970093-8-9-#1	**9**	**4**	**3**

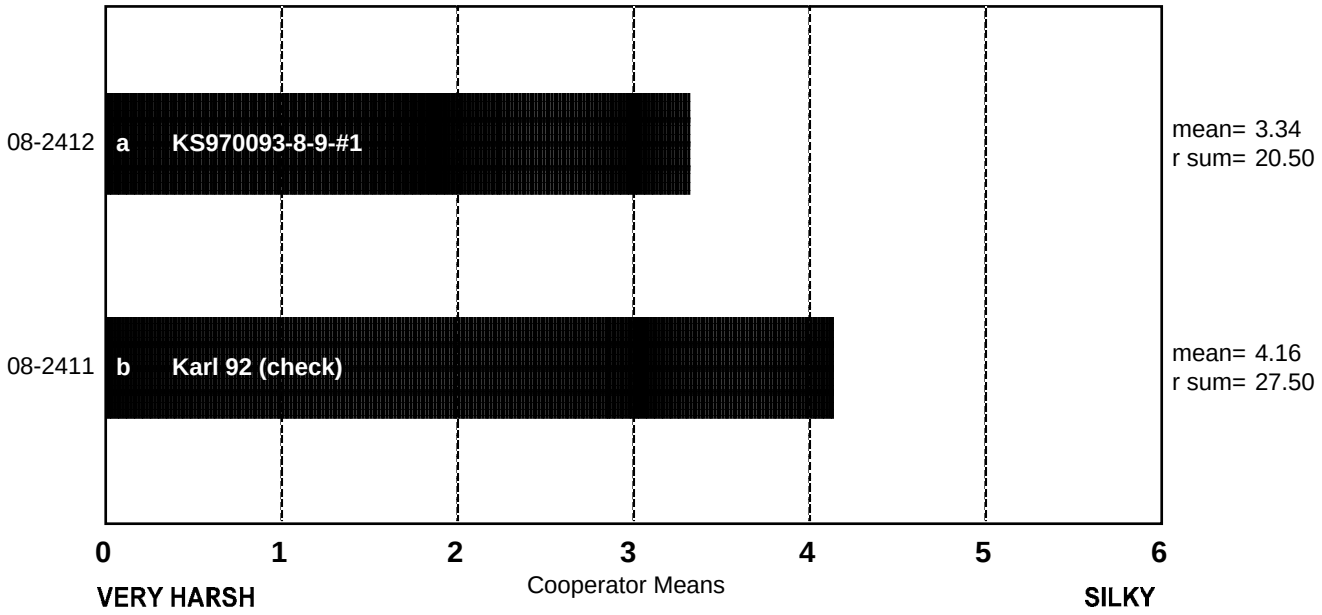
Frequency Table

CRUMB TEXTURE

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 3.06
chisqc= 4.08
cvchisq= 3.84
crdiff= 6.20

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



CRUMB TEXTURE, DESCRIBED

(Small Scale) Kansas-Manhattan

	Harsh	Smooth	Silky
08-2411 Karl 92 (check)	**1**	**10**	**5**
08-2412 KS970093-8-9-#1	**8**	**5**	**3**

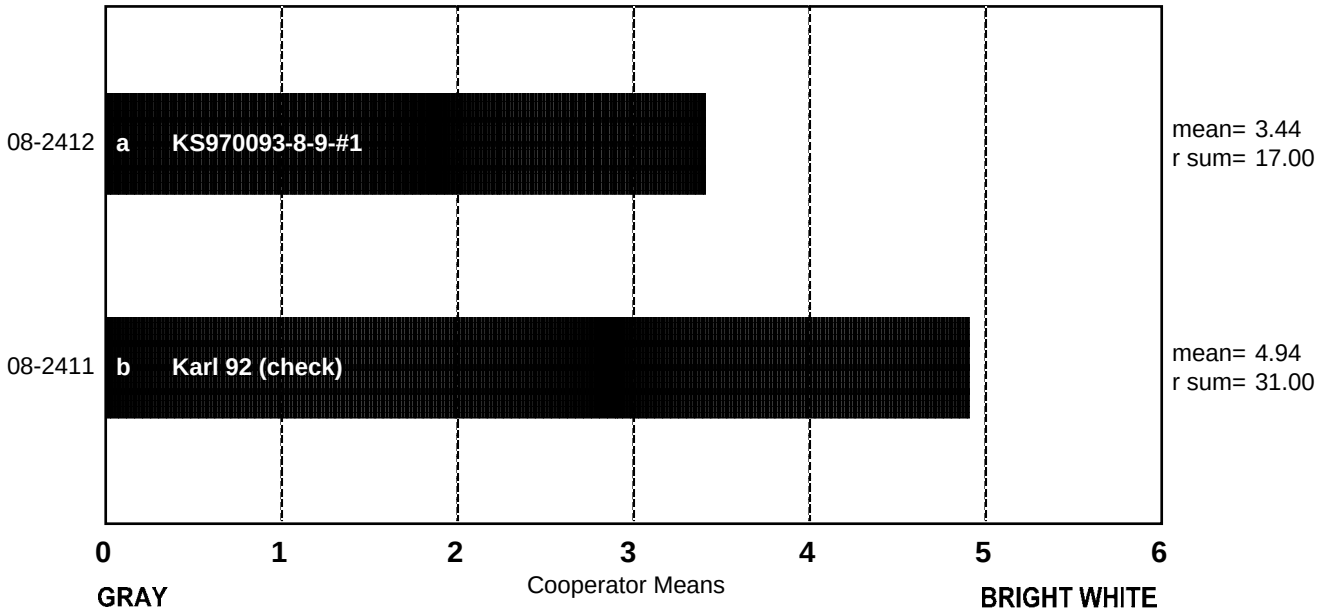
Frequency Table

CRUMB COLOR

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 12.25
chisqc= 12.25
cvchisq= 3.84
crdiff= 4.26

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



CRUMB COLOR, DESCRIBED

(Small Scale) Kansas-Manhattan

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
08-2411 Karl 92 (check)	**1**	**0**	**0**	**0**	**4**	**5**	**6**
08-2412 KS970093-8-9-#1	**1**	**0**	**1**	**8**	**3**	**3**	**0**

Frequency Table

LOAF WEIGHT, ACTUAL

(Small Scale) Kansas-Manhattan

	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
08-2411 Karl 92 (check)	**421.0**		**142.3**	**468.5**	**132.0**	**152.9**	**510.0**	**150.1**	**456.2**	**467.0**	**456.0**	**127.6**	**466.8**	**141.7**	**134.0**	**140.6**
08-2412 KS970093-8-9-#1	**422.0**		**144.6**	**468.7**	**136.3**	**153.4**	**510.0**	**149.4**	**452.3**	**456.0**	**459.0**	**130.6**	**464.4**	**141.4**	**134.0**	**152.2**

Raw Data

LOAF VOLUME, ACTUAL

(Small Scale) Kansas-Manhattan

	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
08-2411 Karl 92 (check)	**3150**	**1025**	**908**	**3162**	**780**	**985**	**2850**	**933**	**2333**	**2700**	**3250**	**1025**	**2713**	**875**	**1028**	**993**
08-2412 KS970093-8-9-#1	**2800**	**1170**	**785**	**2809**	**720**	**960**	**3150**	**845**	**2400**	**2625**	**2900**	**850**	**2650**	**766**	**911**	**865**

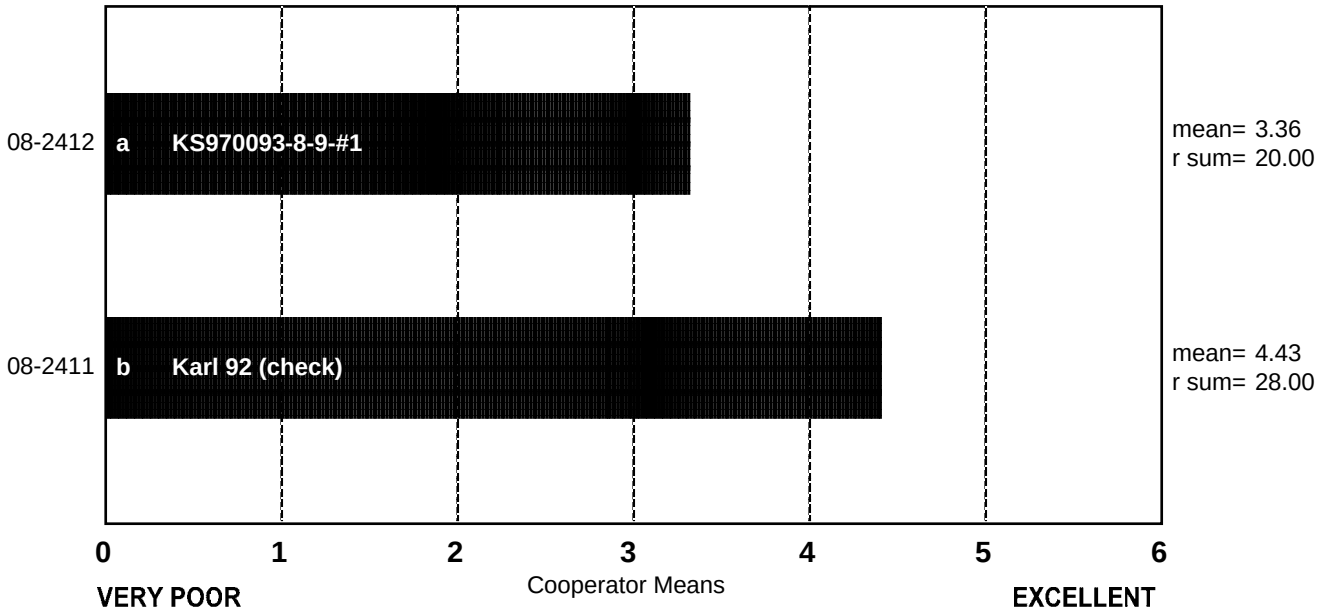
Raw Data

LOAF VOLUME

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 4.00
chisqc= 4.00
cvchisq= 3.84
crdiff= 7.62

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

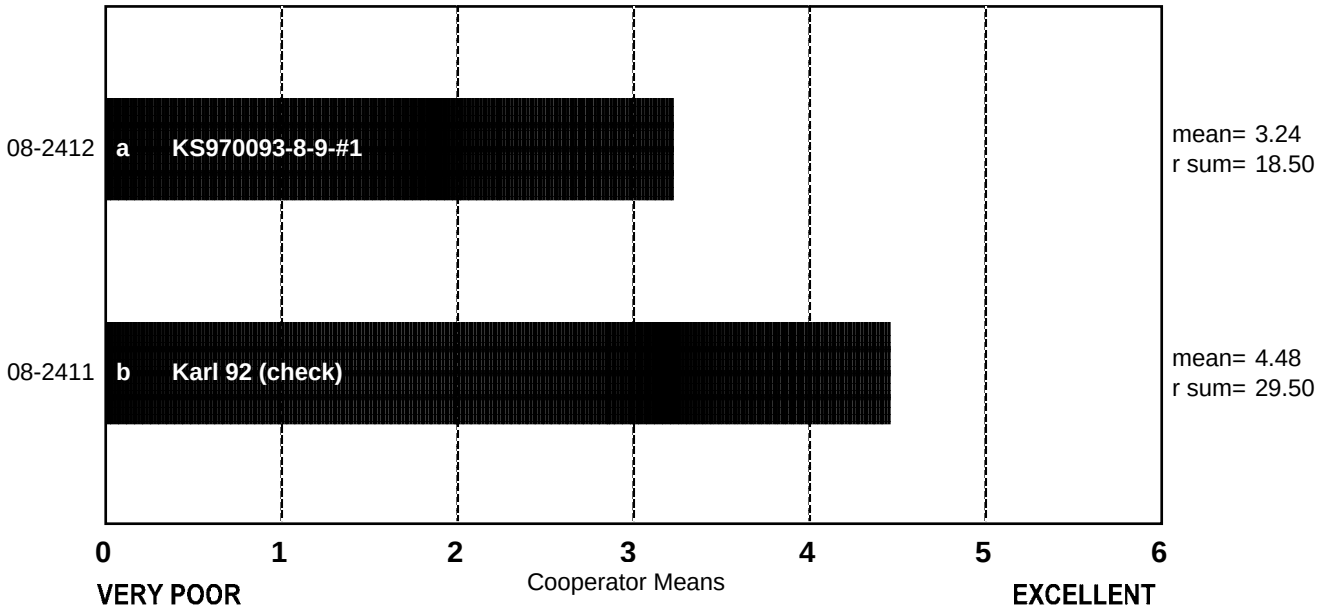


OVERALL BAKING QUALITY

(Small Scale) Kansas-Manhattan

ncoop= 16
chisq= 7.56
chisqc= 9.31
cvchisq= 3.84
crdiff= 5.13

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



COOPERATOR'S COMMENTS
(Small Scale) Kansas-Manhattan

COOP. 08-2411 Karl 92 (Check)

A. Slightly tough, bright color, good volume.
B. No comment.
C. Strong dough, very large loaf volume, open elongated cells, cream crumb, smooth & less resilient texture.
D. Very strong doughs, tight, consistent smooth grain, excellent volume.
E. No comment.
F. Very strong dough, long mixing, good bread performance.
G. Strong flour, low volume.
H. Long bake mix time, excellent dough handling, good tolerance, above satisfactory crumb grain and loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Low absorption, very long mix time, very fine grain, bright white, good volume.
N. Slow dough pick-up during mixing which downgraded the mixing score.
O. Good overall handling on the bench, slightly open grain and slight decrease in tolerance on long mix, white crumb.
P. No comment.

COOP. 08-2412 KS970093-8-9-#1

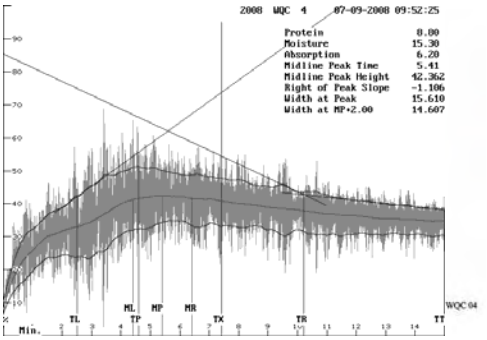
A. Good at panning, short mix for high protein, average volume, close grain, no oven spring.
B. No comments.
C. Soft dough, small loaf volume, fine round cells, yellow crumb, resilient & slight harsh texture.
D. Very open, thick cell walls. Very harsh texture, low volume.
E. Low loaf volume and short mix time.
F. Did not measure up to flour protein, weak mixing, poor crumb grain, low volume.
G. Good absorption, short stability, very high protein.
H. Low bake absorption, short bake mix time, zero tolerance, weak at pan, questionable crumb grain with low loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Good absorption, short mix time, tough dough, open grain, white crumb, average volume.
N. No comment.
O. Very tacky, pliable, poor on bench. Had very poor tolerance, weak doughs across all three mix levels, very low volumes.
P. No comment.

Notes: **A, D, I, J, M, and O** collaborators conducted sponge and dough bake tests

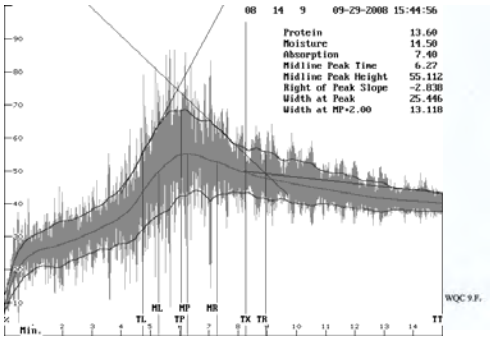
Description of Test Plots and Breeder Entries

Oklahoma State University - Reported by Brett Carver

The 2008 WQC grain samples were produced under irrigation at the Oklahoma Panhandle Research and Extension Center at Goodwell, OK and at the North Central Agronomy Research Station at Lahoma, OK. The grow-out at Goodwell was severely hampered by High Plains virus and barley yellow dwarf virus. Grain yield was proportionately low – in the 40-to-50 bu/ac range – while wheat protein ran high, averaging over 14.5%. Standard pre-plant fertilization practices were conducted, anticipating 90 to 100 bu/ac yields. While Goodwell underachieved for grain yield, the grow-out at Lahoma over-achieved. Average yields at Lahoma were at least 10 bu/ac superior to the pre-plant fertilization target of 50 bu/ac. Consequently, wheat protein levels at Lahoma struggled to make 12%.



OK03522, **Lahoma**, 2008



OK03522, **Goodwell**, 2008

Dough mixing patterns at these two sites, while historically dissimilar, were evermore distinct in 2008, as demonstrated above for one of the OSU entries in the 2008 WQC, OK03522. While curve width at two minutes past peak dough development was not appreciably different between sites (12.7 and 15.1 mm), the corrected mixing times (2.7 vs. 4.7 min) and mixograph stability values (4.8 versus 14.2) painted two very different pictures for the same genotype. These Jekyll-and-Hyde patterns are typically observed at Lahoma and Goodwell, perhaps more so in 2008 than other years.

OK Bullet (check) (08-2413)

We continue to use OK Bullet (*KS96WGRC39/Jagger*) as a WQC check, as it has already consumed some of Oklahoma's wheat acreage previously dedicated to 2174 and Jagger. It is widely adapted and shows excellent green-leaf retention and tolerance to wheat spindle streak mosaic virus (SSMV), soilborne mosaic virus (SBMV), septoria leaf blotch, stripe rust, and moderate tolerance to acidic soils. Where leaf rust races with virulence to *Lr41* have increased, OK Bullet will likely yield some of its acreage. Wheat protein content typically falls between 12.5 and 13.5%, exceeding Endurance by at least one percentage point. OK Bullet combines high test weight with

large kernel size, has above-average milling and baking quality, excels in loaf-internal characteristics but sometimes lacks in mixing tolerance in the form of high mixograph-stability value.

OK03305 (08-2414)

Not to suggest the family tree of our breeding program resembles a utility pole, Ukraine and Pioneer genetics once again appear in the pedigree of this HRW experimental (*N40/OK94P455*). OK03305 is beardless, is well suited for dual-purpose and grain-only production, and is ideally suited to replace Deliver, its beardless cousin also claiming Eastern European ancestry. Much like Deliver, OK03305 breaks all the rules and stereotypes about low test weight and beardless wheat (OK Bullet-type test weight, 0.3 lb/bu>Deliver). In head-to-head comparisons with Deliver, OK03305 has higher yield (+ 4 bu/ac), earlier maturity (-3 days heading), better lodging resistance, slightly better tolerance to acid soils and barley yellow dwarf virus, and similar resistance to leaf rust and SBMV/SSMV. Adult-plant resistance to stripe rust, however, is intermediate and similar to Endurance.

OK03305 was invited back to the WQC for a second year. Its wheat protein content is low but acceptable, averaging 11.8% statewide since 2005. Kernel size is good (31.5 g TKW and 2.4 kernel diameter) and more representative of our genetic materials than OK03522. Baking quality is generally acceptable, often with surprisingly good loaf volumes that do not appear commensurate with flour protein levels. OK03305 is scheduled for a release decision in spring 2009.

OK03522 (08-2415)

A repeat-performer in the WQC, this HRW experimental resulted from a single cross of a line developed by the Institute of Plant Breeding in Odessa, Ukraine (N566) and an OSU experimental line (OK94P597) derived from the Pioneer hard winter wheat program with the pedigree, HBY3598/Fundulea 133//TAM 200. With exception of the drought-stress year of 2006, and with exception of the southwest corner of the state, grain yields have matched or exceeded those of Endurance, OK Bullet, and Duster, with superior performance exhibited in the Enid area, and in the panhandle under irrigation.

Over the past four years, OK03522 has averaged 12.3% wheat protein across Oklahoma (or about 0.5 percentage point lower than OK Bullet), excellent farinograph absorption (>61.5%) and stability (>12 min) with average peak time (5 min), and excellent mixograph stability (<7.0) and high curve width at 2 min past the peak (> 12 mm). Its claim to fame so far has been its physical quality, sporting values for TKW and kernel diameter of >33.5 g and 2.5 mm in the past four years that might actually exceed the adopted HRW quality targets. OK03522 provides adult-plant resistance to stripe rust, seedling and adult-plant resistance to leaf rust, some tolerance to powdery mildew (between Duster and OK Bullet), good tolerance to soil acidity, resistance to the WSBMV/WSSMV complex, and excellent shattering tolerance. Jeers for OK03522 include susceptibility to barley yellow dwarf virus (similar to Deliver), early winter dormancy release (earlier than Jagger), and apparent lack of tolerance to grazing and drought stress.

Current release status will be announced at the WQC annual meeting. It is in a second and final year of foundation seed production.

OK03825-5403-6 (08-2416)

Also released in 2006 as germplasm STARS 0610W from USDA-ARS (Stillwater, OK), we are testing the waters with this HRW experimental (*Custer*3/94M81*) that features dual resistance to Biotypes 1 and 2 of the Russian wheat aphid in seedling tests. Grain yield and test weight history are equivalent to OK03522 and OK03305. OK03825-5403-6 provides good resistance to leaf rust, with powdery mildew resistance as a bonus in the seedling stage. Reactions to stripe rust, SBMV/SSMV, and acid soils are moderately susceptible, at best. Though it would be positioned for the High Plains, OK03825-5403-6 can easily stretch into other areas of the state (unlike Custer).

Functional quality is a stretch, in another sense. Milling quality is quite good if not very good, but.....OK03825-5403-6825 is the unmistakable owner of a 1B/1R translocation. If a wheat variety should ever feel remorse, this is it.

Oklahoma: 2008 (Small-Scale) Samples [a]

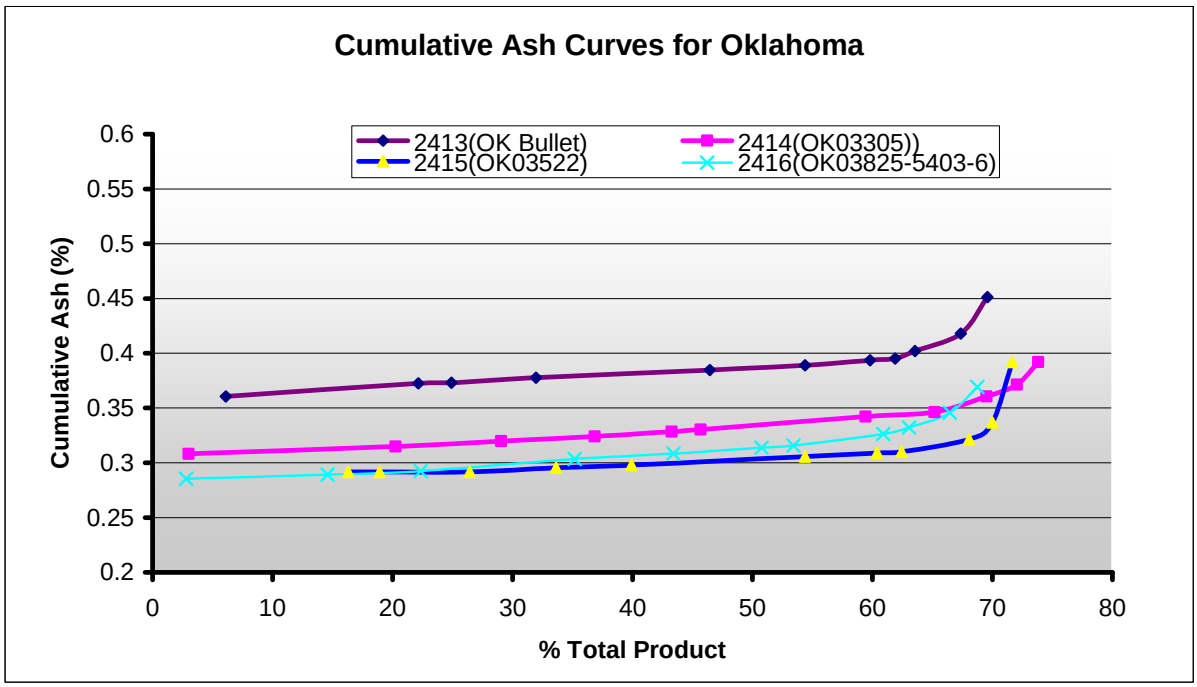
Test entry number	08-2413	08-2414	08-2415	08-2416
Sample identification	**OK Bullet (check)**	**OK03305**	**OK03522**	**OK03825-5403-6**
Wheat Data				
FGIS classification	2 HRW	1 HRW	2 HRW	2 HRW
Test weight (lb/bu)	58.2	60.8	59.9	59.2
Hectoliter weight (kg/hl)	76.6	80.0	78.8	77.9
1000 kernel weight (gm)	26.2	32.5	32.9	29.8
NIR hardness	62	64	63	44
Wheat kernel size (Rotap)				
Over 7 wire (%)	50.4	75.1	63.9	60.3
Over 9 wire (%)	49.4	24.7	35.9	39.6
Through 9 wire (%)	0.2	0.2	0.2	0.1
Single kernel (skcs)				
Hardness (avg /s.d)	78.2/17.1	57.8/15.1	67.0/16.1	61.9/14.6
Weight (mg) (avg/s.d)	25.9/6.8	32.4/8.8	32.6/9.4	27.2/8.3
Diameter (mm)(avg/s.d)	2.60/0.28	2.76/0.31	2.74/0.28	2.60/0.30
SKCS distribution	00-04-07-89	04-18-35-43	02-08-20-70	02-11-28-59
Classification	Hard	Hard	Hard	Hard
Wheat moisture (%)	10.0	10.3	10.0	10.1
Wheat protein (12% mb)	12.1	10.7	11.3	12.0
Wheat ash (12% mb)	1.40	1.25	1.35	1.24
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	69.5	73.8	71.6	68.8
Quadrumat Sr. Mill	69.3	72.5	70.9	69.4
NIR Flour moisture (%)	12.2	12.5	12.2	12.1
NIR Flour protein (14% mb)	12.2	9.3	9.6	10.7
Flour ash (14% mb)	0.48	0.43	0.38	0.419
Glutomatic				
Wet gluten (%)	28.7	25.8	26.2	29.9
Dry gluten (%)	10.0	9.0	9.1	10.1
Gluten index	95.6	85.5	97.3	87.0
Rapid Visco-Analyser				
Peak time (min)	6.2	6.1	6.2	6.3
Peak viscosity (RVU)	219.5	233.4	209.5	221.8
Breakdown (RVU)	75.3	97.1	64.3	75.5
Final viscosity at 13 min (RVU)	269.8	242.8	274.8	259.3
Minolta color meter				
L*	92.22	92.24	92.36	92.77
a*	-1.70	-1.66	-1.65	-1.66
b*	10.00	9.50	9.26	8.70
Falling number (sec)	482	389	441	418
Flour particle size (avg)				
Fisher sub sieve sizer	22.5	21.3	22.5	17.5

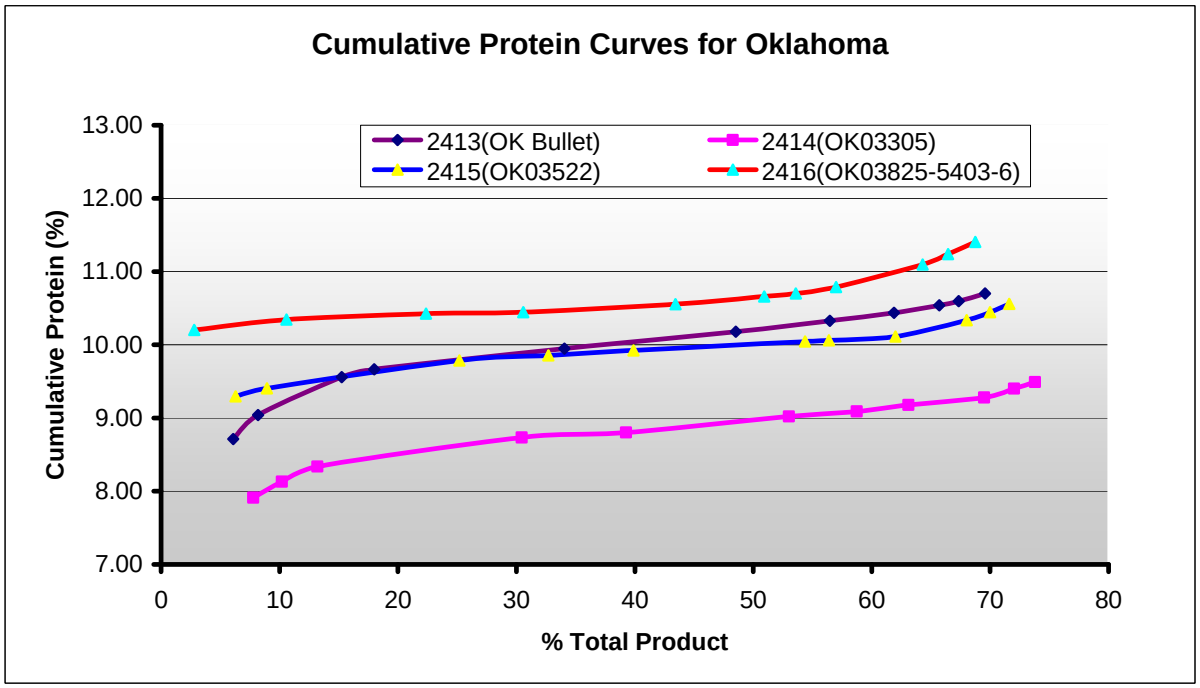
[a] s.d. = standard deviation; skcs = Single Kernel Characterization System 4100.

Oklahoma: Physical Dough Tests and Gluten Analysis For 2008 (Small-Scale) Samples

Test Entry Number	08-2413	08-2414	08-2415	08-2416
Sample Identification	OK Bullet (check)	OK03305	OK03522	OK03825-5403-6
MIXOGRAPH				
Flour Abs (% as-is)	61.7	57.6	60.1	61.0
Flour Abs (14% mb)	59.7	55.9	58.0	58.8
Mix Time (min)	2.63	3.38	3.38	3.50
Mix tolerance (0-6)	2	2	2	1
FARINOGRAPH				
Flour Abs (% as-is)	58.4	54.8	59.2	59.9
Flour Abs (14% mb)	56.3	53.1	57.0	57.7
Development time (min)	6.5	4.5	3.0	8.2
Mix stability (min)	10.8	8.1	9.1	13.1
Mix Tolerance Index (FU)	33	43	28	27
Breakdown time (min)	10.5	8.0	8.1	13.9
ALVEOGRAPH				
P(mm. $_{H2O}$): Tenacity	55	37	79	66
L(mm): Extensibility	95	100	101	93
G($mm_{0.5}$): Swelling index	21.7	22.3	22.4	21.5
W(10^{-4} J): strength (curve area)	160	114	252	211
P/L: curve configuration ratio	0.58	0.37	0.78	0.71
Ie(P_{200}/P): elasticity index	50.7	51.2	54.2	57.8
EXTENSIGRAPH				
Resist (BU at 30/60/90 min)	218/285/315	231/369/430	309/399/419	273/363/391
Extensibility (mm at 30/60/90 min)	170/164/158	179/156/149	169/154/152	145/137/132
Energy (cm^2 at 30/60/90 min)	70/87/90	83/108/113	101/112/115	70/87/88
Resist $_{max}$ (BU at 30/60/90 min)	300/384/412	346/526/569	434/547/563	352/491/515
Ratio (at 30/60/90 min)	1.3/1.7/2.0	1.3/2.4/2.9	1.8/2.6/2.8	1.9/2.6/3.0
PROTEIN ANALYSIS				
HMW-GS Composition	1, 5, 10, 17, 18	2*, 5, 10, 7, 9	1, 3, 12, 7, 8	1, 5, 10, 7, 9
Glu/Gli	0.54	0.66	0.52	0.58
HMW/LMW	0.31	0.30	0.26	0.54
%IPP	41.22	40.52	45.45	47.41
SEDIMENTATION TEST				
Volume (ml)	34.3	34.4	42.1	41.6

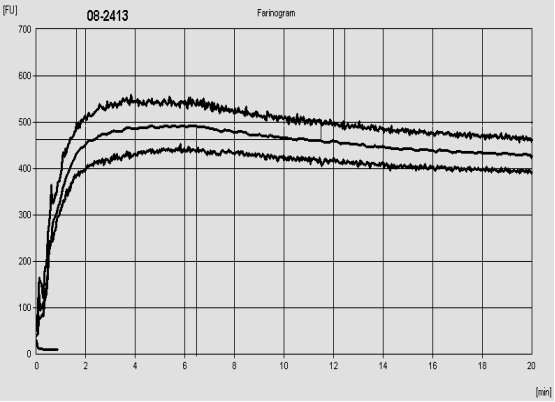
Oklahoma: Cumulative Ash and Protein Curves





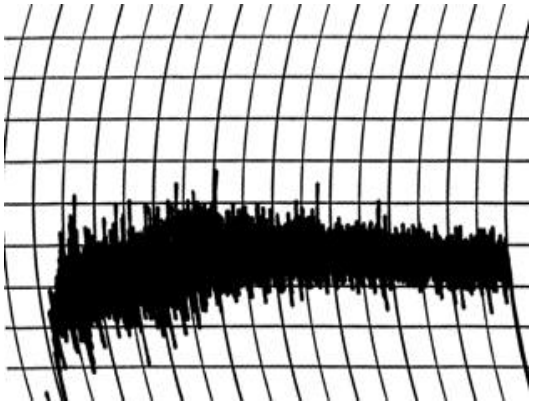
Physical Dough Tests
2008 (Small Scale) Samples - Oklahoma

Farinograms



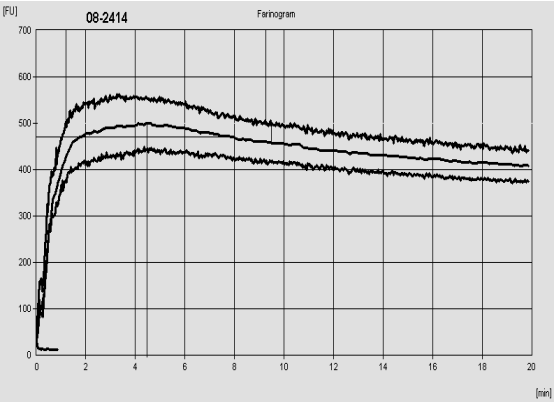
Water Abs. = 56.3%, Peak time = 6.5 min,
Mix Stab. = 10.8 min, MTI = 33 FU

Mixograms

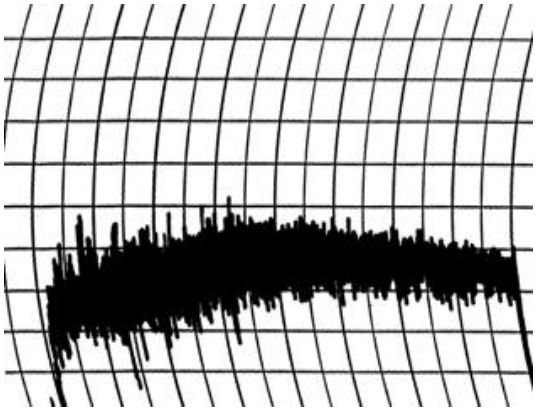


Abs. = 59.7%, Mix time = 2.6 min,
Mix tolerance = 2

08-2413, OK Bullet (check)



Water Abs. = 53.1%, Peak time = 4.5 min,
Mix Stab. = 8.1 min, MTI = 43 FU



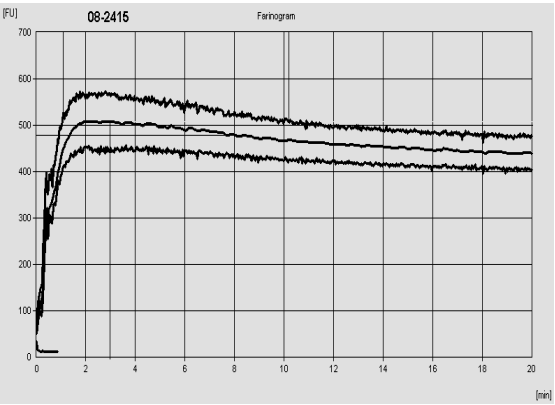
Abs. = 55.9%, Mix time = 3.4 min,
Mix tolerance = 2

08-2414, OK03305

Physical Dough Tests

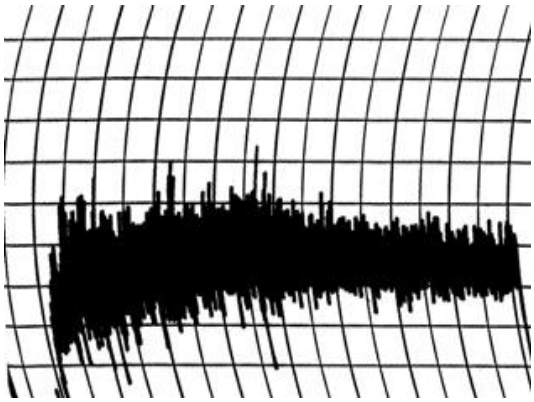
2008 (Small Scale) Samples - Oklahoma (continued)

Farinograms



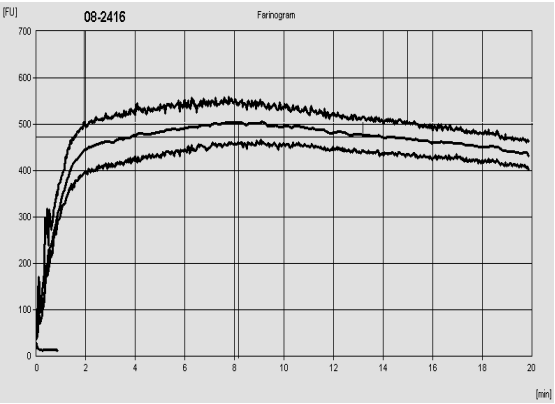
Water Abs.= 57.0%, Peak time = 3.0 min,
Mix Stab. = 9.1 min, MTI = 28 FU

Mixograms

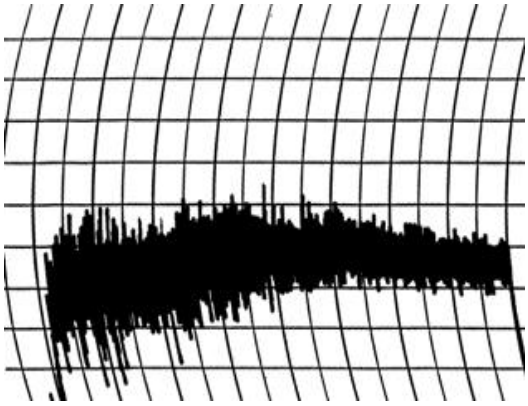


Abs. = 58.0%, Mix time = 3.4 min,
Mix tolerance = 2

08-2415, OK03522



Water Abs. = 57.7%, Peak time = 6.0 min,
Mix Stab.= 13.1 min, MTI = 27 FU

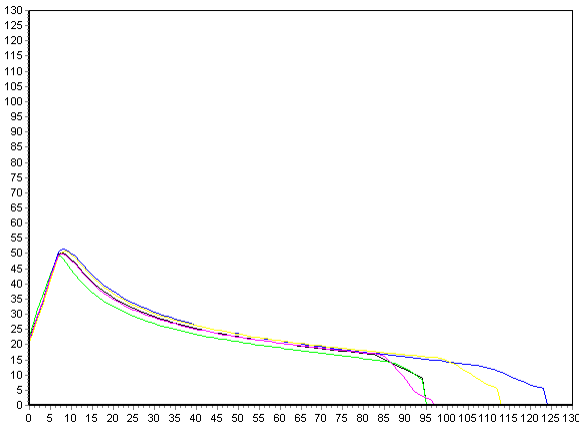


Abs. = 58.8%, Mix time = 3.5 min,
Mix tolerance = 1

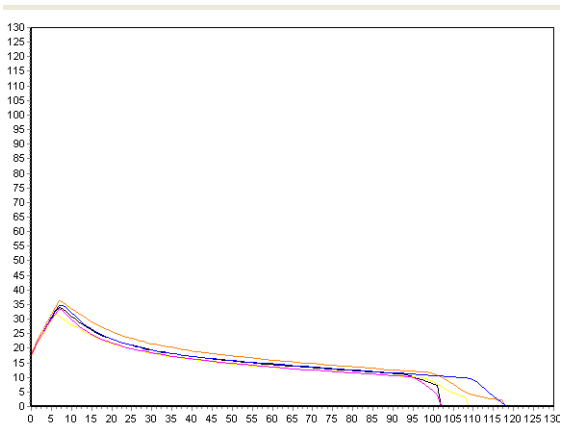
08-2416, OK03825-5303-6

Physical Dough Tests - Alveograph

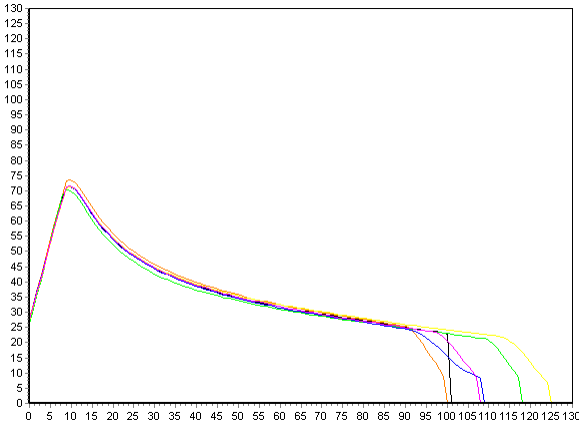
2008 (Small Scale) Samples – Oklahoma



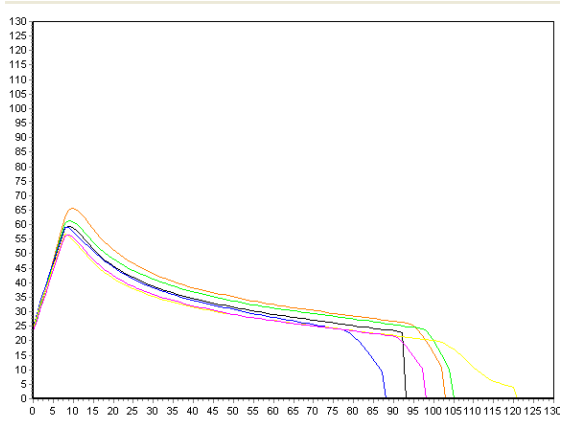
08-2413 (OK Bullet)
P(mm $_{H20}$)=55, L(mm)=95, W(10^{-4} J)=160



08-2414 (OK03305)
P(mm $_{H2}$0)=37, L(mm)=100, W(10^{-4} J)=114



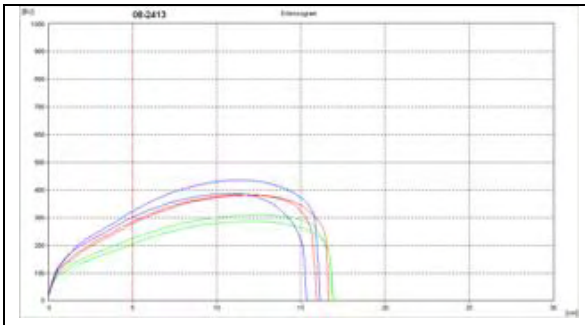
08-2415 (OK03522)
P(mm $_{H20}$)=79, L(mm)=101, W(10^{-4} J)=252



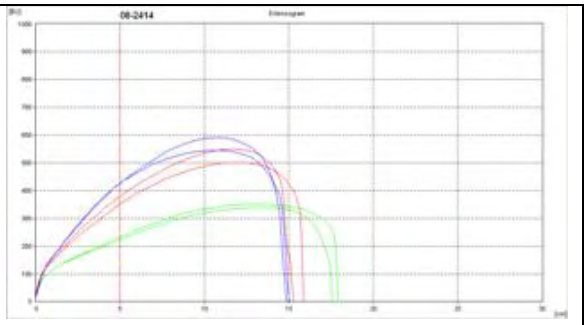
08-2416 (OK03825-5403-6)
P(mm $_{H20}$)=66, L(mm)=93, W(10^{-4} J)=211

Physical Dough Tests - Extensigraph

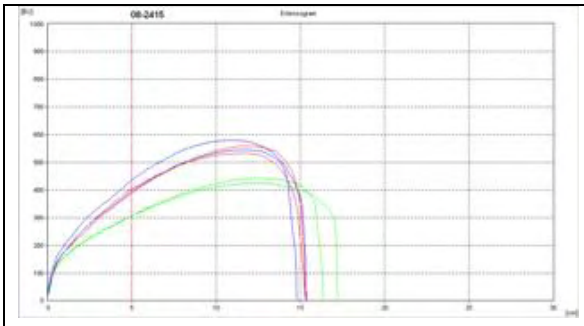
2008 (Small Scale) Samples – Oklahoma



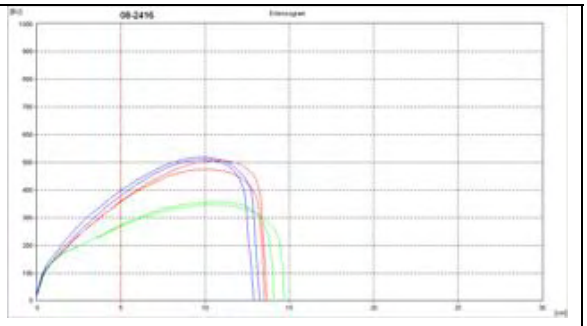
08-2413 (OK Bullet)
R (BU) = 218, E (mm) =170, W (cm^2) = 70
Rmax (BU) = 300, Ratio = 1.3 at 30 min



08-2414 (OK03305)
R (BU) = 231, E (mm) =179, W (cm^2) = 83
Rmax (BU) = 346, Ratio = 1.3 at 30 min



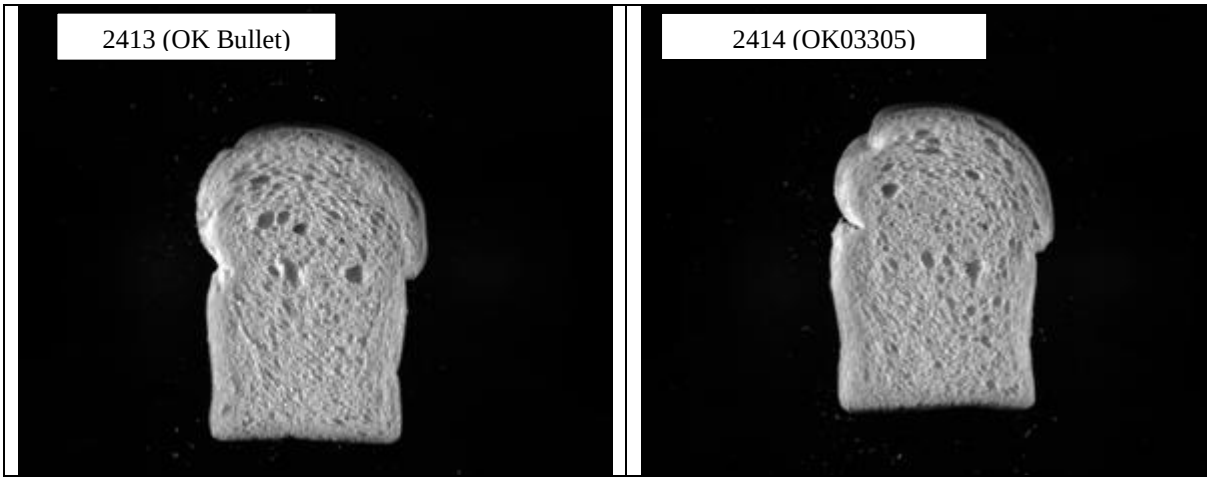
08-2415 (OK03522)
R (BU) = 309, E (mm) =169, W (cm^2) = 101
Rmax (BU) = 434, Ratio = 1.8 at 30 min



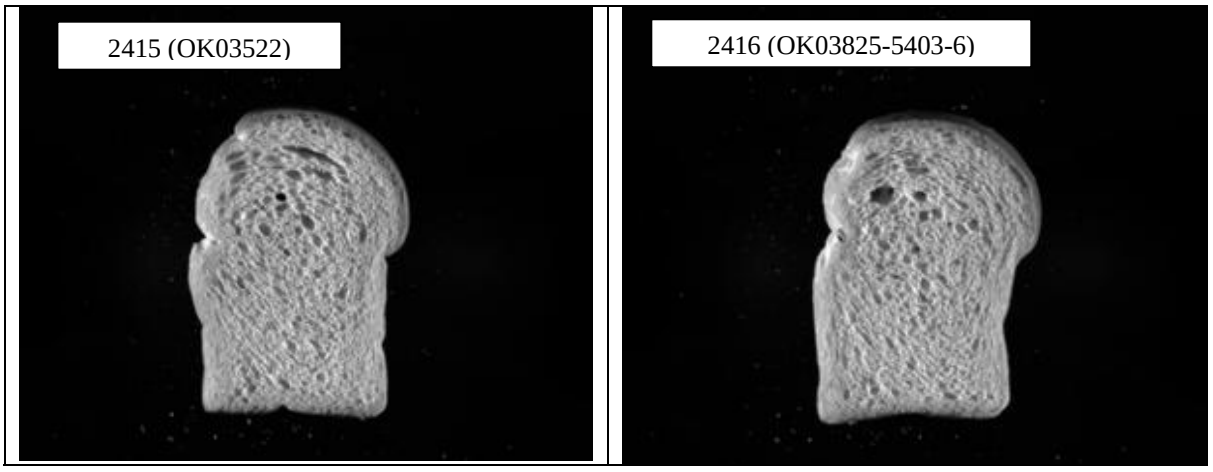
08-2416 (OK03825-5403-6)
R (BU) = 273, E (mm) =145, W (cm^2) = 70
Rmax (BU) = 352, Ratio = 1.9 at 30 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = test at 30 min, Red = test at 60 min, and Blue = test at 90 min.

Oklahoma: C-Cell Bread Images and Analysis for 2008 (Small-Scale) Samples



Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2413	5711	152.3	3701	0.436	1.935	2.276	1.78	-20.8
2414	5392	151.1	3581	0.435	1.808	1.374	1.72	-16.0



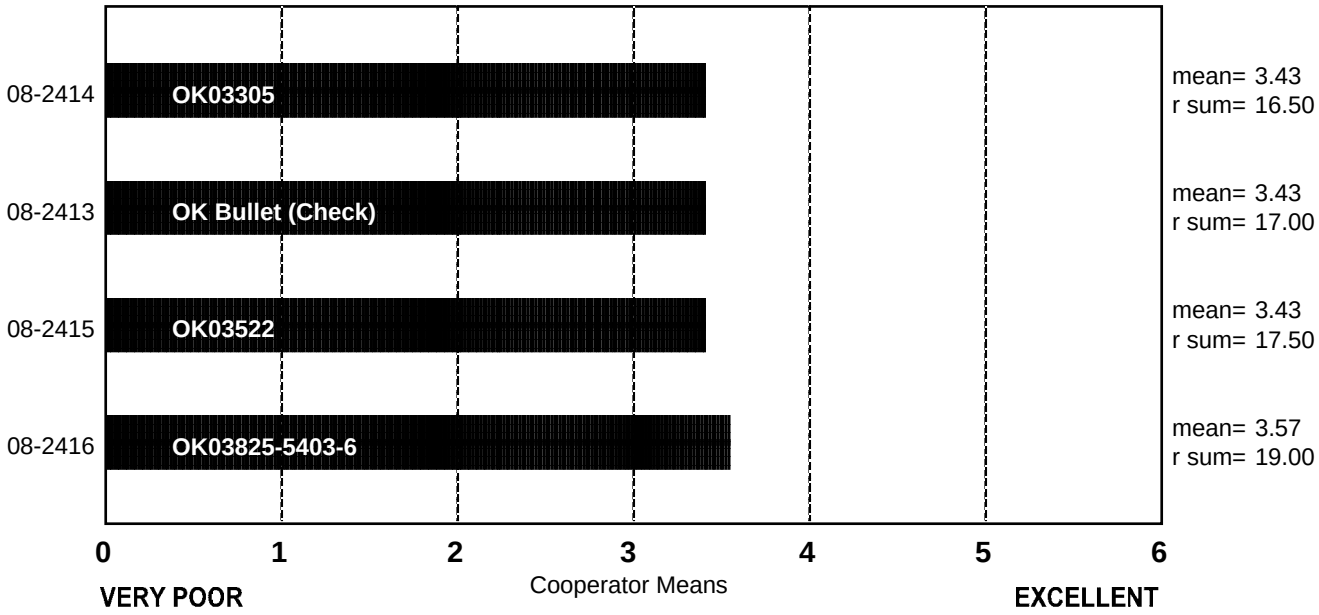
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2415	5570	148.5	3525	0.449	1.967	2.284	1.73	-21.4
2416	5517	149.6	3337	0.452	2.078	2.523	1.74	-15.4

SPONGE CHARACTERISTICS

(Small Scale) Oklahoma

ncoop= 7
chisq= 0.30
chisqc= -0.58
cvchisq= 7.82
crdiff=

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

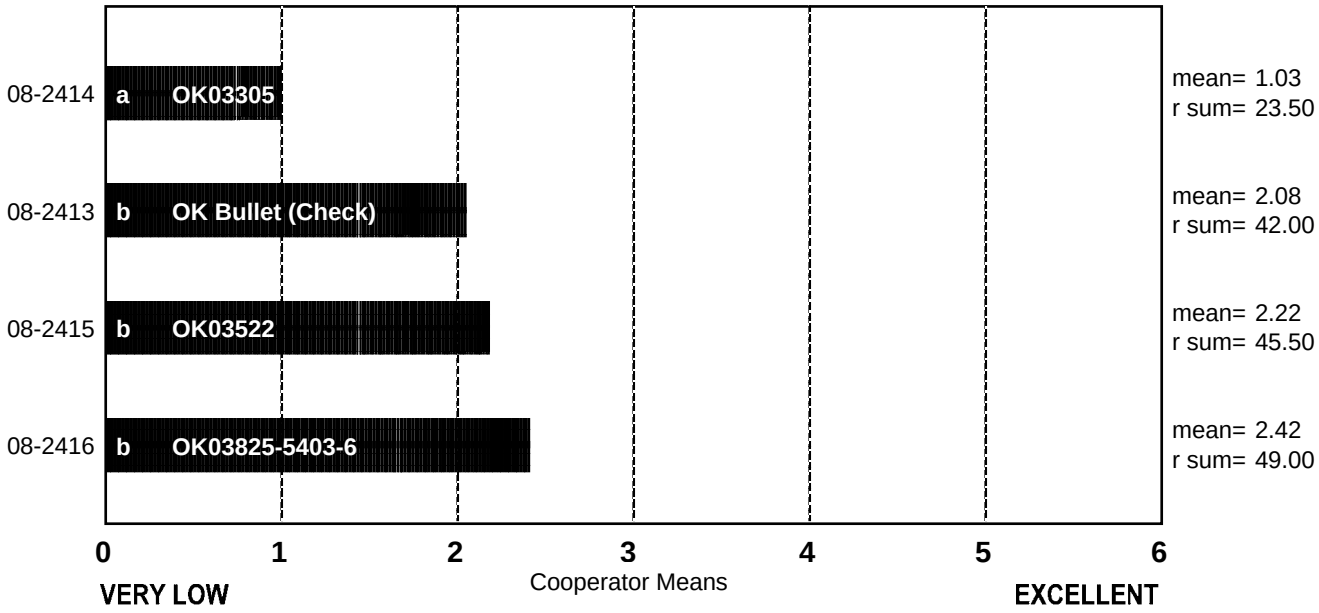


BAKE ABSORPTION

(Small Scale) Oklahoma

ncoop= 16
chisq= 14.53
chisqc= 20.58
cvchisq= 7.82
crdiff= 9.65

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
08-2413 OK Bullet (Check)	**58.0**	**57.9**	**58.4**	**59.0**	**56.4**	**61.1**	**53.0**	**57.7**	**59.3**	**57.0**	**58.3**	**54.8**	**54.0**	**62.3**	**63.0**	**59.1**
08-2414 OK03305	**55.0**	**55.3**	**54.8**	**55.0**	**52.8**	**57.5**	**50.0**	**55.0**	**56.1**	**56.0**	**55.1**	**51.6**	**51.0**	**58.5**	**60.0**	**56.1**
08-2415 OK03522	**56.0**	**57.3**	**59.2**	**59.0**	**57.2**	**60.0**	**53.0**	**59.6**	**60.0**	**58.5**	**59.0**	**55.5**	**55.0**	**60.3**	**60.0**	**57.1**
08-2416 OK03825-5403-6	**57.0**	**57.3**	**59.9**	**59.0**	**57.9**	**60.9**	**54.0**	**59.5**	**60.7**	**59.0**	**59.7**	**56.2**	**56.0**	**61.3**	**60.0**	**58.1**

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
08-2413 OK Bullet (Check)	**8.0**	**2.6**	**5.3**	**12.0**	**1.0**	**3.6**	**5.0**	**4.1**	**3.0**	**9.0**	**7.0**	**3.8**	**5.0**	**3.9**	**3.0**	**2.5**
08-2414 OK03305	**7.0**	**3.2**	**5.2**	**5.0**	**1.0**	**3.3**	**4.0**	**3.6**	**3.0**	**5.0**	**5.5**	**3.5**	**4.0**	**4.3**	**3.0**	**2.5**
08-2415 OK03522	**10.0**	**3.3**	**5.9**	**10.0**	**1.0**	**3.8**	**4.0**	**4.5**	**5.0**	**9.0**	**6.5**	**4.0**	**4.0**	**4.4**	**6.0**	**3.0**
08-2416 OK03825-5403-6	**5.0**	**3.0**	**5.9**	**7.0**	**1.8**	**3.5**	**6.0**	**4.1**	**4.0**	**6.0**	**7.5**	**3.8**	**4.0**	**3.5**	**3.0**	**3.0**

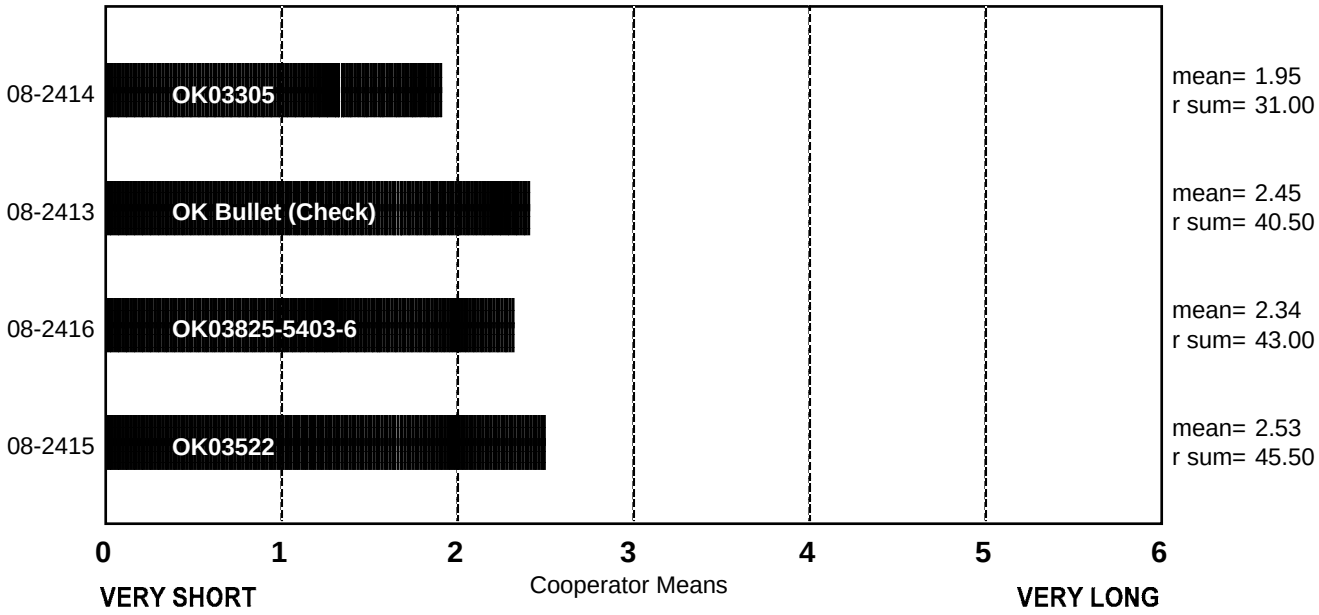
Raw Data

BAKE MIX TIME

(Small Scale) Oklahoma

ncoop= 16
chisq= 4.52
chisqc= 7.16
cvchisq= 7.82
crdiff=

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

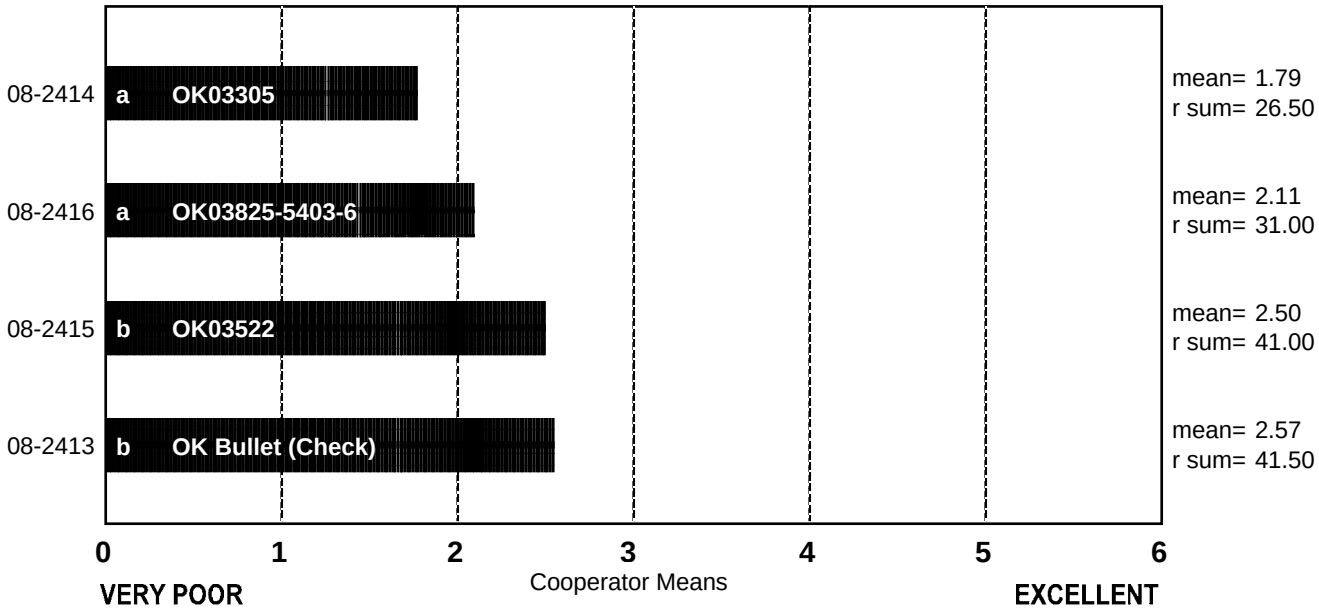


MIXING TOLERANCE

(Small Scale) Oklahoma

ncoop= 14
chisq= 7.14
chisqc= 10.98
cvchisq= 7.82
crdiff= 9.94

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

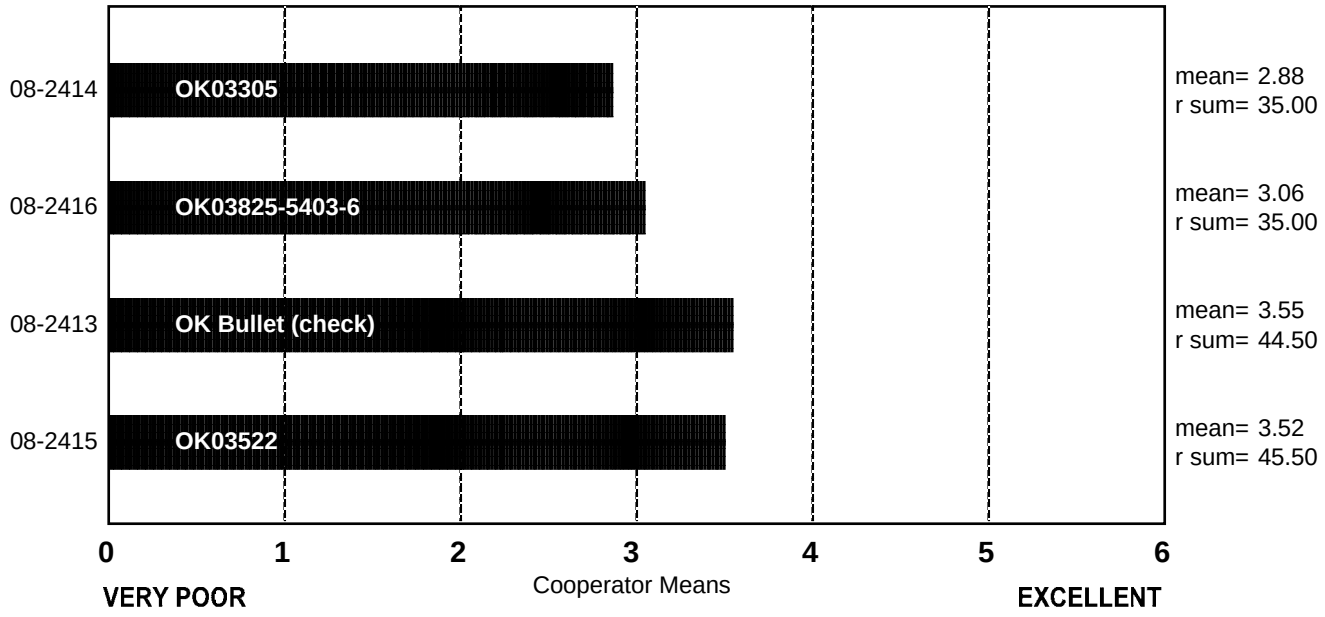


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) Oklahoma

ncoop= 16
chisq= 3.77
chisqc= 5.80
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) Oklahoma

	Sticky	Wet	Tough	Good	Excellent
08-2413 OK Bullet (check)	**6**	**1**	**2**	**6**	**1**
08-2414 OK03305	**8**	**2**	**0**	**6**	**0**
08-2415 OK03522	**5**	**1**	**2**	**6**	**2**
08-2416 OK03825-5403-6	**5**	**2**	**1**	**7**	**1**

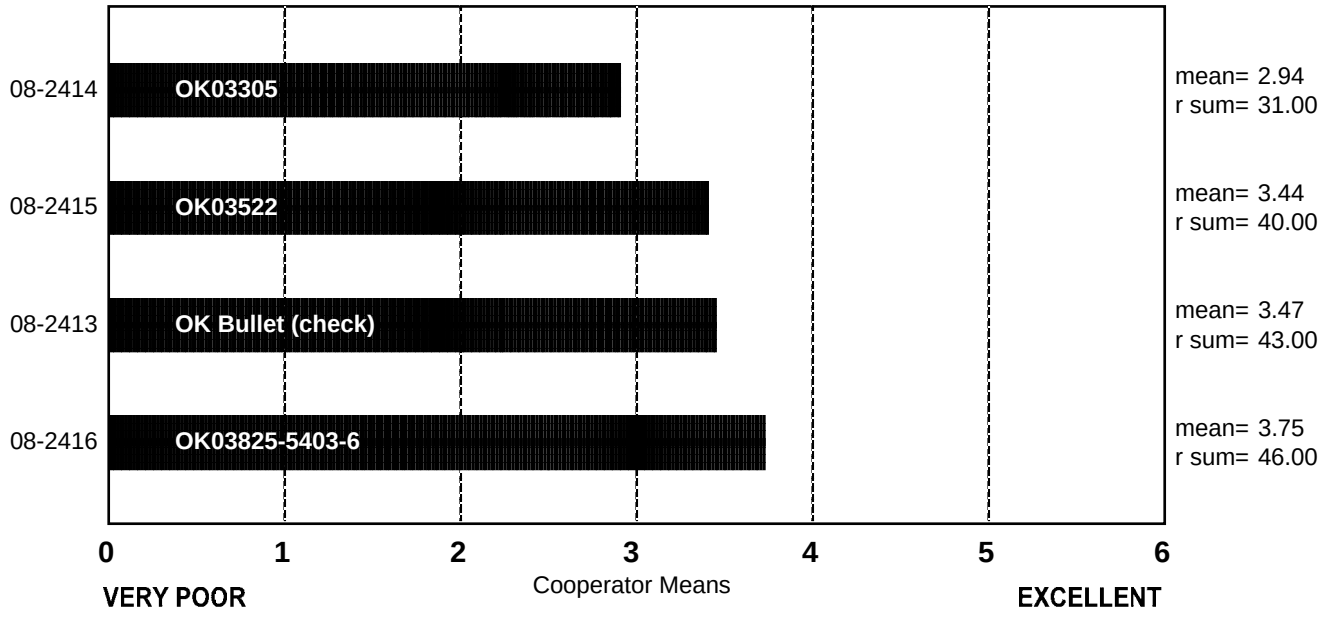
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) Oklahoma

ncoop= 16
chisq= 4.73
chisqc= 6.46
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) Oklahoma

	Sticky	Wet	Tough	Good	Excellent
08-2413 OK Bullet (check)	**3**	**1**	**2**	**8**	**2**
08-2414 OK03305	**3**	**3**	**0**	**9**	**1**
08-2415 OK03522	**0**	**2**	**4**	**10**	**0**
08-2416 OK03825-5403-6	**3**	**1**	**1**	**10**	**1**

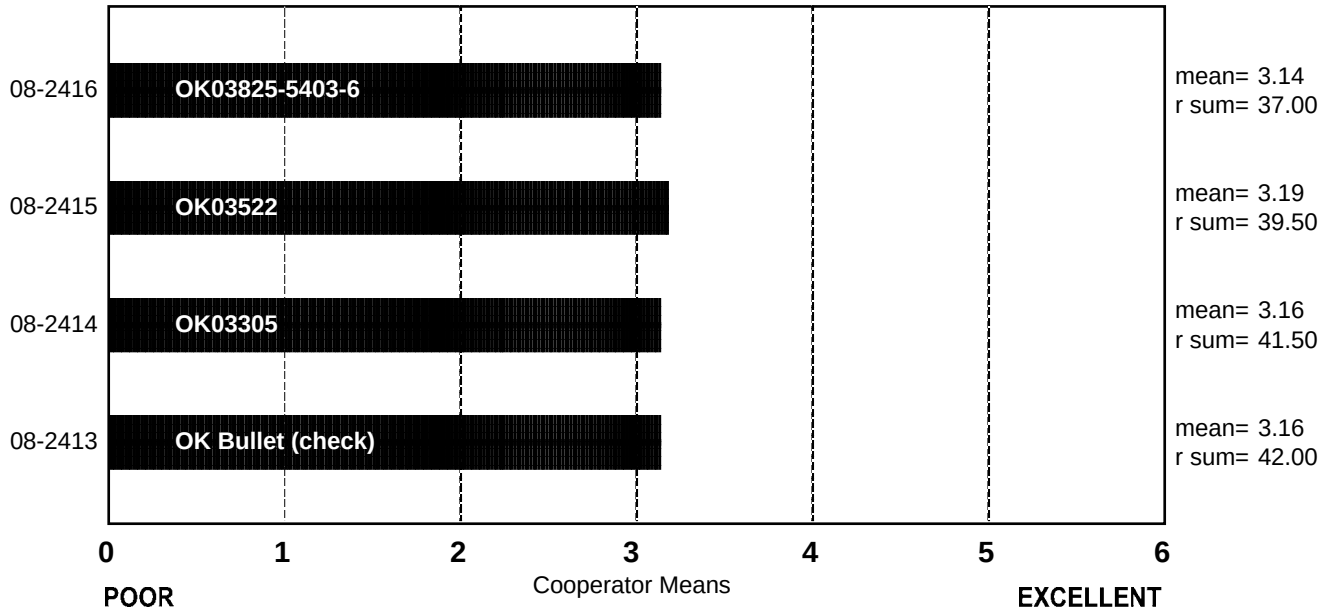
Frequency Table

CRUMB GRAIN

(Small Scale) Oklahoma

ncoop= 16
chisq= 0.58
chisqc= 0.67
cvchisq= 7.82
crdiff=

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



CRUMB GRAIN, DESCRIBED

(Small Scale) Oklahoma

	Open	Fine	Dense
08-2413 OK Bullet (check)	**6**	**6**	**4**
08-2414 OK03305	**7**	**5**	**4**
08-2415 OK03522	**7**	**6**	**3**
08-2416 OK03825-5403-6	**8**	**5**	**3**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) Oklahoma

	Round	Irregular	Elongated
08-2413 OK Bullet (check)	**4**	**8**	**4**
08-2414 OK03305	**7**	**5**	**4**
08-2415 OK03522	**2**	**7**	**7**
08-2416 OK03825-5403-6	**5**	**4**	**7**

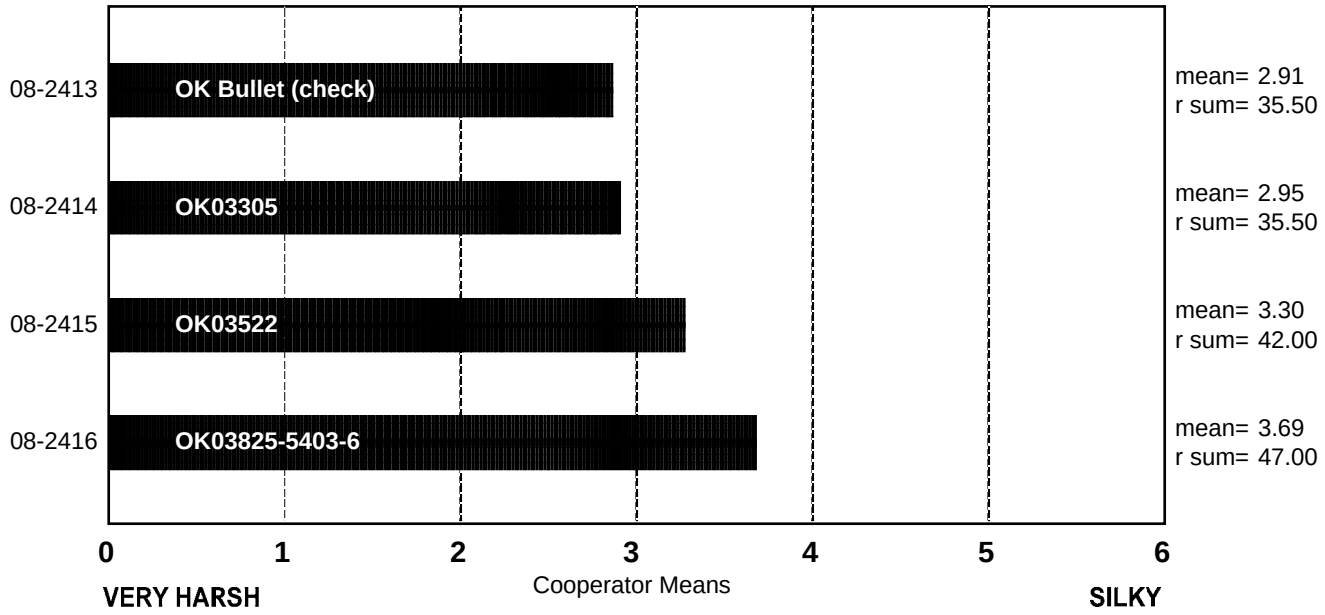
Frequency Table

CRUMB TEXTURE

(Small Scale) Oklahoma

ncoop= 16
chisq= 3.51
chisqc= 5.67
cvchisq= 7.82
crdiff=

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



CRUMB TEXTURE, DESCRIBED

(Small Scale) Oklahoma

	Harsh	Smooth	Silky
08-2413 OK Bullet (check)	**9**	**5**	**2**
08-2414 OK03305	**8**	**5**	**3**
08-2415 OK03522	**6**	**7**	**3**
08-2416 OK03825-5403-6	**4**	**7**	**5**

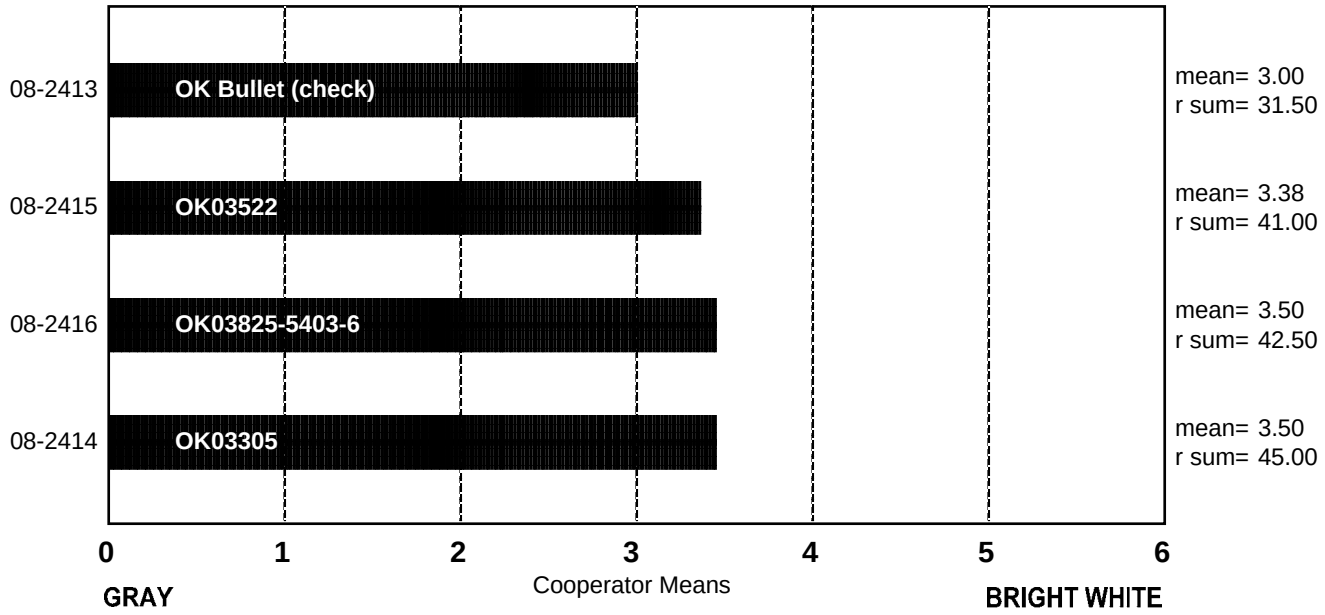
Frequency Table

CRUMB COLOR

(Small Scale) Oklahoma

ncoop= 16
chisq= 3.92
chisqc= 7.65
cvchisq= 7.82
crdiff=

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



CRUMB COLOR, DESCRIBED

(Small Scale) Oklahoma

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
08-2413 OK Bullet (check)	**1**	**1**	**2**	**5**	**7**	**0**	**0**
08-2414 OK03305	**0**	**1**	**1**	**4**	**10**	**0**	**0**
08-2415 OK03522	**1**	**1**	**1**	**5**	**6**	**2**	**0**
08-2416 OK03825-5403-6	**0**	**0**	**1**	**6**	**7**	**2**	**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
08-2413 OK Bullet (check)	**423.0**		**143.9**	**468.9**	**133.1**	**151.4**	**510.0**	**145.1**	**453.1**	**463.0**	**457.0**	**126.8**	**466.9**	**139.0**	**134.0**	**139.7**
08-2414 OK03305	**419.0**		**142.8**	**470.4**	**131.2**	**150.8**	**500.0**	**143.1**	**455.5**	**463.0**	**459.0**	**120.9**	**464.5**	**138.1**	**134.0**	**140.9**
08-2415 OK03522	**413.0**		**144.8**	**468.3**	**133.7**	**150.5**	**500.0**	**147.9**	**453.9**	**457.0**	**460.0**	**127.2**	**464.8**	**138.6**	**134.0**	**144.6**
08-2416 OK03825-5403-6	**417.0**		**141.6**	**469.1**	**131.3**	**152.2**	**500.0**	**146.9**	**450.3**	**463.0**	**460.0**	**127.4**	**464.5**	**138.2**	**134.0**	**138.7**

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
08-2413 OK Bullet (check)	**3050**	**935**	**823**	**3074**	**635**	**880**	**3150**	**865**	**2475**	**2725**	**2775**	**825**	**2663**	**750**	**925**	**808**
08-2414 OK03305	**2850**	**895**	**858**	**2956**	**620**	**905**	**3000**	**825**	**2360**	**2750**	**2700**	**725**	**2763**	**710**	**885**	**770**
08-2415 OK03522	**2900**	**875**	**843**	**3074**	**610**	**900**	**3150**	**860**	**2408**	**2700**	**2725**	**725**	**2738**	**754**	**886**	**830**
08-2416 OK03825-5403-6	**2825**	**920**	**810**	**2633**	**745**	**890**	**3300**	**860**	**2433**	**2700**	**2725**	**825**	**2650**	**785**	**937**	**830**

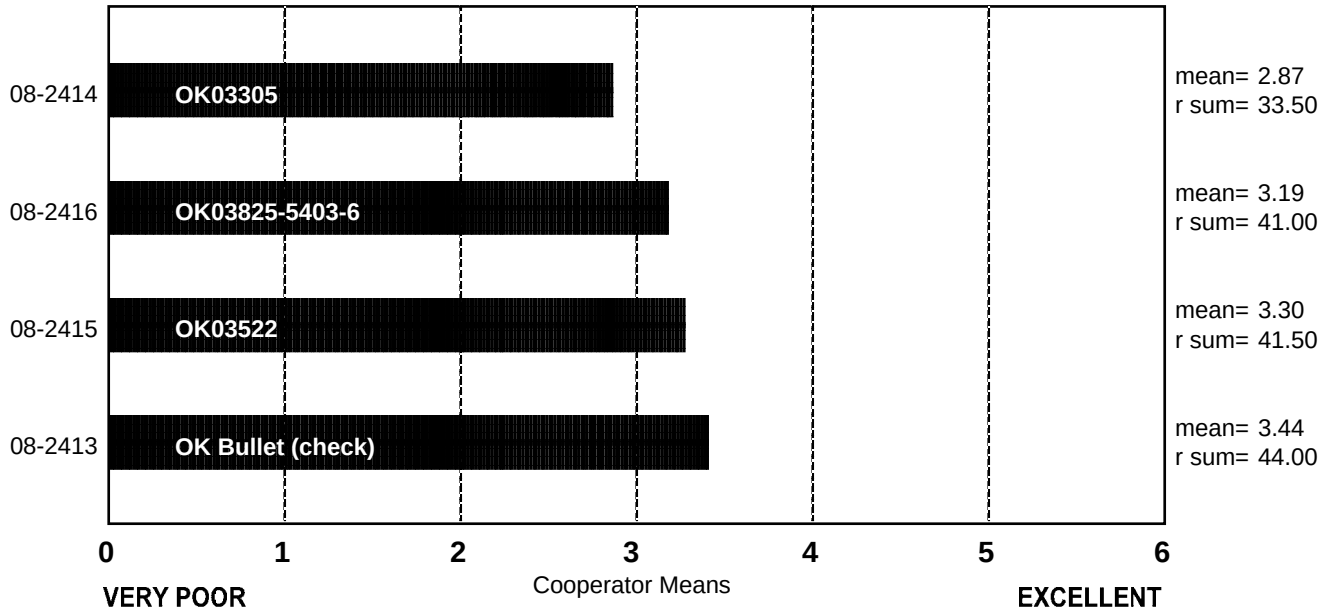
Raw Data

LOAF VOLUME

(Small Scale) Oklahoma

ncoop= 16
chisq= 2.31
chisqc= 3.65
cvchisq= 7.82
crdiff=

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

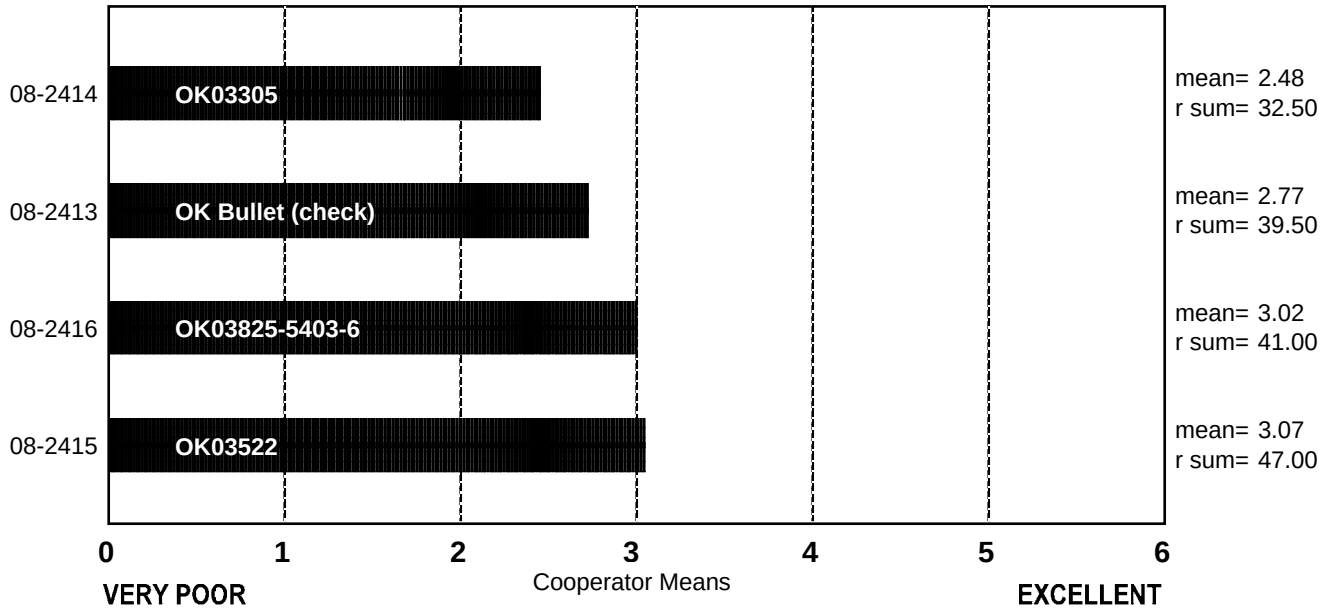


OVERALL BAKING QUALITY

(Small Scale) Oklahoma

ncoop= 16
chisq= 3.99
chisqc= 5.07
cvchisq= 7.82
crdiff=

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



COOPERATOR'S COMMENTS
(Small Scale) Oklahoma

COOP. **08-2413 OK Bullet (Check)**

A. Good, nice interior and short mix.
B. No comment.
C. Soft sticky dough, medium loaf volume, fine irregular cells, yellow crumb, resilient & slight harsh texture.
D. Open, thick cell walls, excellent volume.
E. Low loaf volume, absorption and short mix time.
F. Weaker mixing dough, low absorption, low volume and weaker grain.
G. Low absorption, short stability, very low bake absorption.
H. Low bake absorption, poor tolerance, satisfactory bake mix time, weak at pan, satisfactory crumb grain with low loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, short mix time, sticky dough, good grain, yellow crumb, average volume.
N. Slow dough pick-up during mixing which downgraded the mixing score.
O. Performed very poorly for higher protein sample. Short mix baked with some volume, benched very poorly, poor absorption, wet doughs, no tolerance.
P. No comment.

COOP. **08-2414 OK03305**

A. Very weak and sticky out of mixer, short mix, soft at panning, low protein 9.4, 7 minute mix.
B. Too low protein.
C. Soft sticky dough, large loaf volume, open round cells, slight yellow crumb, resilient & slight harsh texture.
D. Extremely poor mixing time, very poor absorption, above average interior scores, good volume.
E. Low flour protein, loaf volume, absorption and short mix time.
F. Excellent performance for 9.3% protein! Could be strong mixer and very good loaf volume with adequate protein.
G. Very low absorption, short mix, short stability, very low protein, lowest bake absorption.
H. Very low bake absorption, poor tolerance, short bake mix time, questionable crumb grain with low loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, short mix time, sticky dough, good grain, good volume.
N. No comment.
O. Dough handling was soft and putty, very short mix tolerance and open grain, poor mix tolerance and volumes.
P. No comment.

COOP. 08-2415 OK03522

A. Slightly sticky out of mixer, slightly tough at makeup, very shotty grain, low protein 9.8%
B. Too low protein.
C. Wet dough, large loaf volume, fine elongated cells, slight yellow crumb, smooth & resilient texture.
D. Open, very irregular grain, low mixing time, excellent volume.
E. Low flour protein, loaf volume, absorption and short mix time.
F. Excellent performance for 9.6% protein! Could be strong mixer and very good loaf volume with adequate protein.
G. Very weak with a very short mix, short stability, very low protein, very low bake absorption.
H. Low bake absorption, good bake mix time, weak at pan, questionable crumb grain.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, short mix time, tough dough, slightly open grain, white crumb, good volume.
N. No comment.
O. Dough handling was also very soft and putty, slightly more gas in doughs, weak doughs with marginal to poor volume.
P. No comment.

COOP. 08-2416 OK03825-5403-6

A. Soft out of mixer, very sticky and wet, worst, average protein, 5 minute mix, the worst in group.
B. Too low protein.
C. Soft sticky dough, medium loaf volume, fine elongated cells, slight yellow crumb, resilient & smooth texture.
D. Extremely weak flour, very open, harsh grain, poor volume.
E. Low flour protein, loaf volume, absorption and short mix time.
F. Good performance for protein level, probably will have okay dough strength at higher protein levels, good loaf volume performance for protein.
G. Low bake absorption, good volume.
H. Low bake absorption, questionable to satisfactory crumb grain.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, short mix time, sticky dough, open grain, average volume.
N. No comment.
O. Very significant mix tolerance dropoffs, doughs handled well, very open grain, samples baked poorly.
P. No comment.

Notes: **A, D, I, J, M, and O** collaborators conducted sponge and dough bake tests.

Description of Test Plots and Breeder Entries

South Dakota – reported by William Berzonsky

SDSU sent Tandem as a check for the 2008 WQC Trials along with SD05W030. Samples of equal amounts of seed were sent from locations at Wall, Winner, and Brookings, SD. The plots were 5 foot wide by 400 ft long at each location. All three locations had very favorable fall growing conditions and good winter survival. All three experienced a cool, wet spring. Wall had above average rain during the growing season. Brookings experienced average rain, but the conditions in Winner changed from very moist with some aphid pressure to extreme dryness by harvest time. Although there was some leaf rust that appeared in Brookings, it showed up late and did not seem to limit yields.

Tandem (Check) (08-2417)

Tandem, hard red winter wheat, was developed by the South Dakota Agricultural Experiment Station and released in 1997. The line was tested as SD89119 and was selected from the cross Brule/Agate. Kernels are very large with high kernel weight and high protein. Plant height is medium. Tandem is moderately resistant to stem rust, susceptible to leaf rust, tan spot, Septoria leaf blotch and wheat streak mosaic virus.

SD05W030 (08-2418)

SD05W030 is a hard white winter wheat. It is the result of a cross that was made in 2000, having the pedigree SD98W302/NW97S186. Plant height is 2 inches taller than Wesley. Leaf Area Duration is very good and its reaction to leaf rust is MR. In 2008, SD05W030 was among a top yielding group of lines in the SDSU Advanced Yield Trail as well as in the 2007 NRPN. It has above average coleoptile length and above average resistance to preharvest sprouting.

South Dakota: 2008 (Small-Scale) Samples [a]

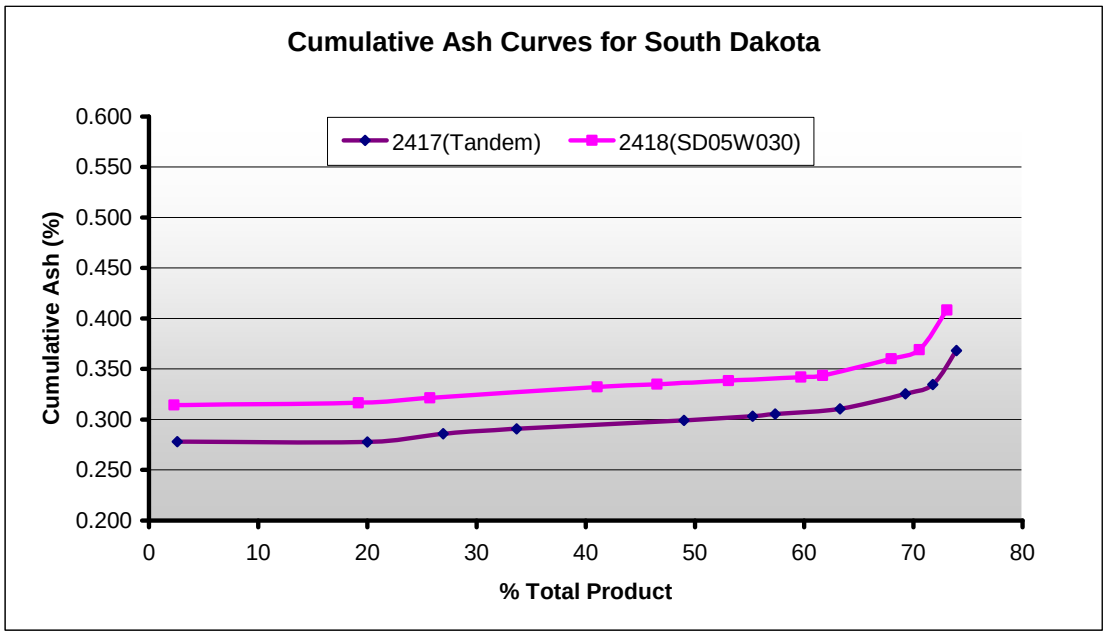
Test entry number	08-2417	08-2418
Sample identification	**Tandem (check)**	**SD05W030**
Wheat Data		
FGIS classification	1 HRW	4HDWH
Test weight (lb/bu)	63.2	63.5
Hectoliter weight (kg/hl)	83.1	83.5
1000 kernel weight (gm)	36.0	32.2
NIR hardness	69	70
Wheat kernel size (Rotap)		
Over 7 wire (%)	79.3	71.5
Over 9 wire (%)	20.6	28.3
Through 9 wire (%)	0.1	0.2
Single kernel (skcs)		
Hardness (avg /s.d)	70.4/14.7	78.9/13.3
Weight (mg) (avg/s.d)	34.7/7.5	29.8/7.6
Diameter (mm)(avg/s.d)	2.84/0.26	2.62/0.30
SKCS distribution	00-04-21-75	00-00-07-93
Classification	Hard	Hard
Wheat moisture (%)	10.3	10.3
Wheat protein (12% mb)	12.3	11.6
Wheat ash (12% mb)	1.58	1.59
Milling and Flour Quality Data		
Flour yield (%, str. grade)		
Miag Multomat Mill	73.9	73.1
Quadrumat Sr. Mill	73.3	71.1
NIR Flour moisture (%)	12.0	12.5
NIR Flour protein (14% mb)	10.6	10.1
Flour ash (14% mb)	0.40	0.46
Glutomatic		
Wet gluten (%)	30.6	28.5
Dry gluten (%)	10.9	9.5
Gluten index	97.9	86.5
Rapid Visco-Analyser		
Peak time (min)	6.3	6.5
Peak viscosity (RVU)	229.8	224.8
Breakdown (RVU)	63.0	54.2
Final viscosity at 13 min (RVU)	297.6	299.1
Minolta color meter		
L*	92.93	92.76
a*	-1.75	-2.01
b*	9.65	10.76
Falling number (sec)	479	502
Flour particle size (avg)		
Fisher sub sieve sizer	20.8	21.3

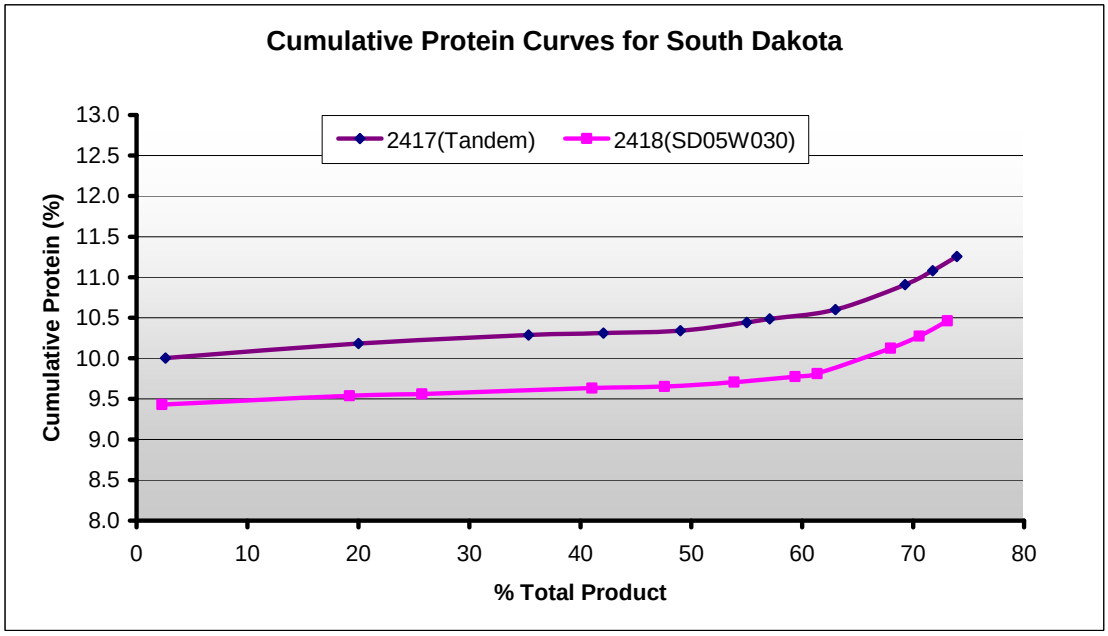
[a]s.d.= standard deviation; skcs = Single Kernel Characterization System 4100.

South Dakota: Physical Dough Tests and Gluten Analysis For 2008 (Small-Scale) Samples

Test Entry Number	08-2417	08-2418
Sample Identification	Tandem (check)	SD05W030
MIXOGRAPH		
Flour Abs (% as-is)	62.8	60.5
Flour Abs (14% mb)	60.6	58.7
Mix Time (min)	4.38	2.58
Mix tolerance (0-6)	4	2
FARINOGRAPH		
Flour Abs (% as-is)	59.9	61.8
Flour Abs (14% mb)	57.5	60.0
Development time (min)	7.0	6.0
Mix stability (min)	30.9	13.5
Mix Tolerance Index (FU)	15	16
Breakdown time (min)	32.3	14.6
ALVEOGRAPH		
P(mm. $_{H2O}$): Tenacity	81	86
L(mm): Extensibility	104	54
G($mm_{0.5}$): Swelling index	22.7	16.4
W(10^{-4} J): strength (curve area)	305	174
P/L: curve configuration ratio	0.78	1.59
Ie(P_{200}/P): elasticity index	63.4	49.6
EXTENSIGRAPH		
Resist (BU at 30/60/90 min)	324/437/511	235/329/391
Extensibility (mm at 30/60/90 min)	181/159/156	144/138/130
Energy (cm^2 at 30/60/90 min)	128/137/158	61/80/84
Resist $_{max}$ (BU at 30/60/90 min)	559/691/813	318/453/500
Ratio (at 30/60/90 min)	1.8/2.8/3.3	1.6/2.4/3.0
PROTEIN ANALYSIS		
HMW-GS Composition	2*, 5, 10, 7, 9	1, 2, 12, 7, 9
Glu/Gli	0.54	0.58
HMW/LMW	0.35	0.50
%IPP	47.68	47.79
SEDIMENTATION TEST		
Volume (ml)	54.7	35.4

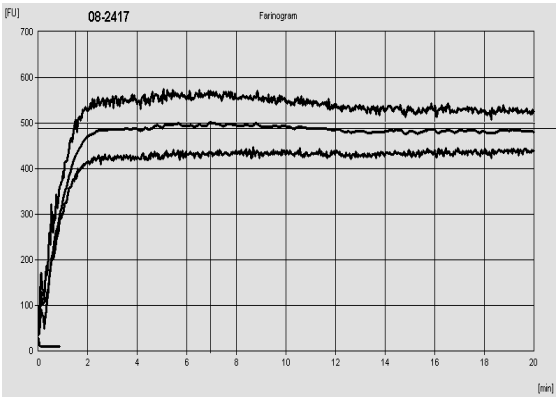
South Dakota: Cumulative Ash and Protein Curves





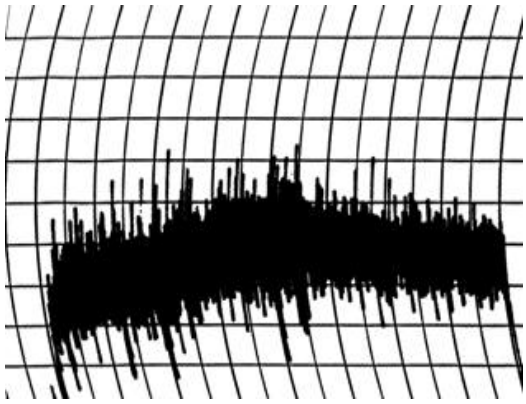
Physical Dough Tests
2008 (Small Scale) Samples – South Dakota

Farinograms



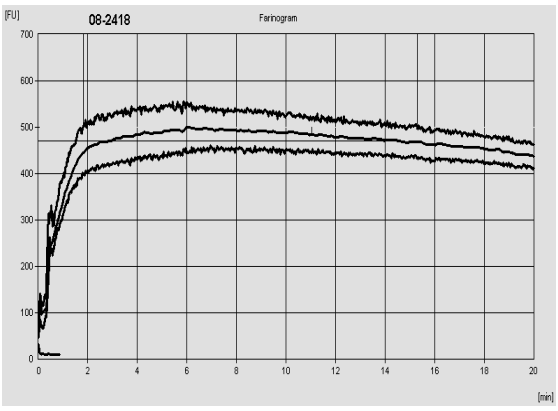
Water Abs. = 57.5%, Peak time = 7.0 min,
Mix Stab. = 30.7 min, MTI = 15 FU

Mixograms

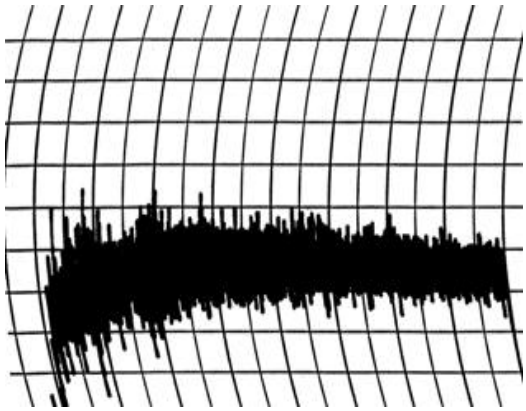


Abs. = 60.6%, Mix time = 4.4 min,
Mix tolerance = 4

08-2417, Tandem (check)



Water Abs. = 60.0%, Peak time = 6.0 min,
Mix Stab. = 13.5 min, MTI = 16 FU

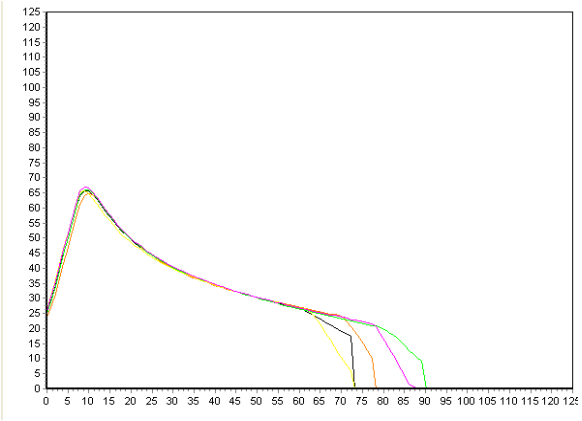


Abs. = 58.7%, Mix time = 2.6 min,
Mix tolerance = 2

08-2418, SD05W030

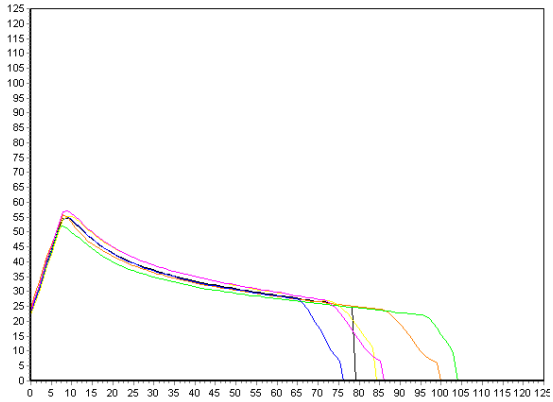
Physical Dough Tests - Alveograph

2008 (Small Scale) Samples – South Dakota



08-2417 (Tandem)

P(mm $_{H20}$)=81, L(mm)=104, W(10^{-4} J)=305

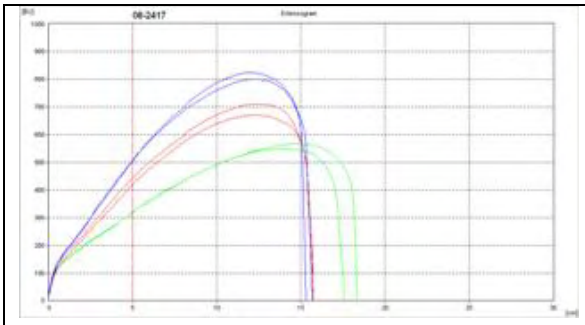
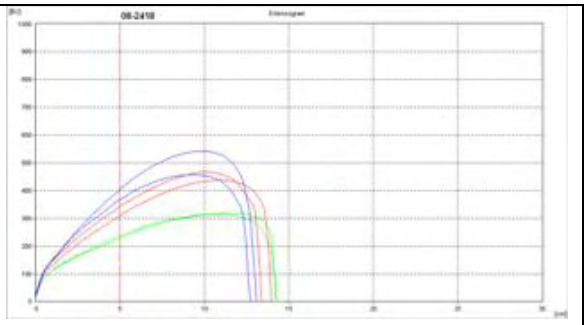


08-2418 (SD05W030)

P(mm $_{H20}$)=86, L(mm)=54, W(10^{-4} J)=174

Physical Dough Tests - Extensigraph

2008 (Small Scale) Samples – South Dakota

	
08-2417 (Tandem) R (BU) = 324, E (mm) =181, W (cm^2) = 128 Rmax (BU) = 559, Ratio = 1.8 at 30 min	**08-2402 (SD05W030)** R (BU) = 235, E (mm) =144, W (cm^2) = 61 Rmax (BU) = 318, Ratio = 1.6 at 30 min

Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = test at 30 min, Red = test at 60 min, and Blue = test at 90 min.

South Dakota: C-Cell Bread Images and Analysis for 2008 (Small-Scale) Samples

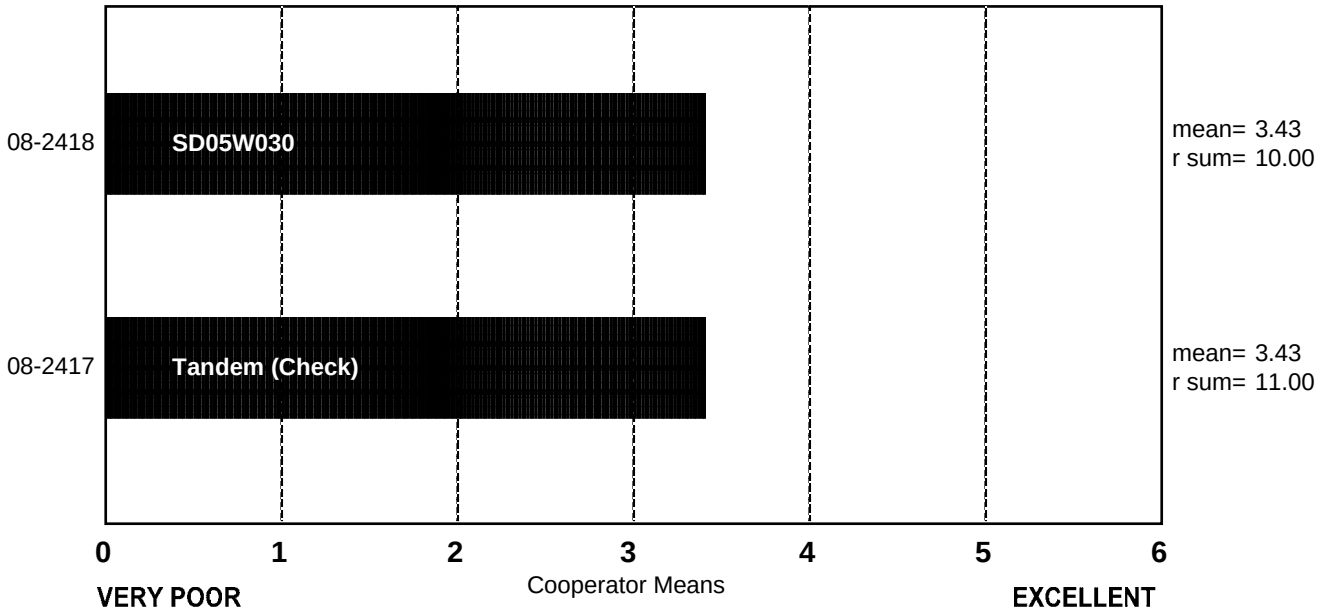
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2417	5431	155.4	3512	0.441	1.954	1.245	1.76	-19.2
2418	5178	157.0	3436	0.436	1.902	0.878	1.71	-18.3

SPONGE CHARACTERISTICS

(Small Scale) South Dakota

ncoop= 7
chisq= 0.14
chisqc= -0.20
cvchisq= 3.84
crdiff=

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

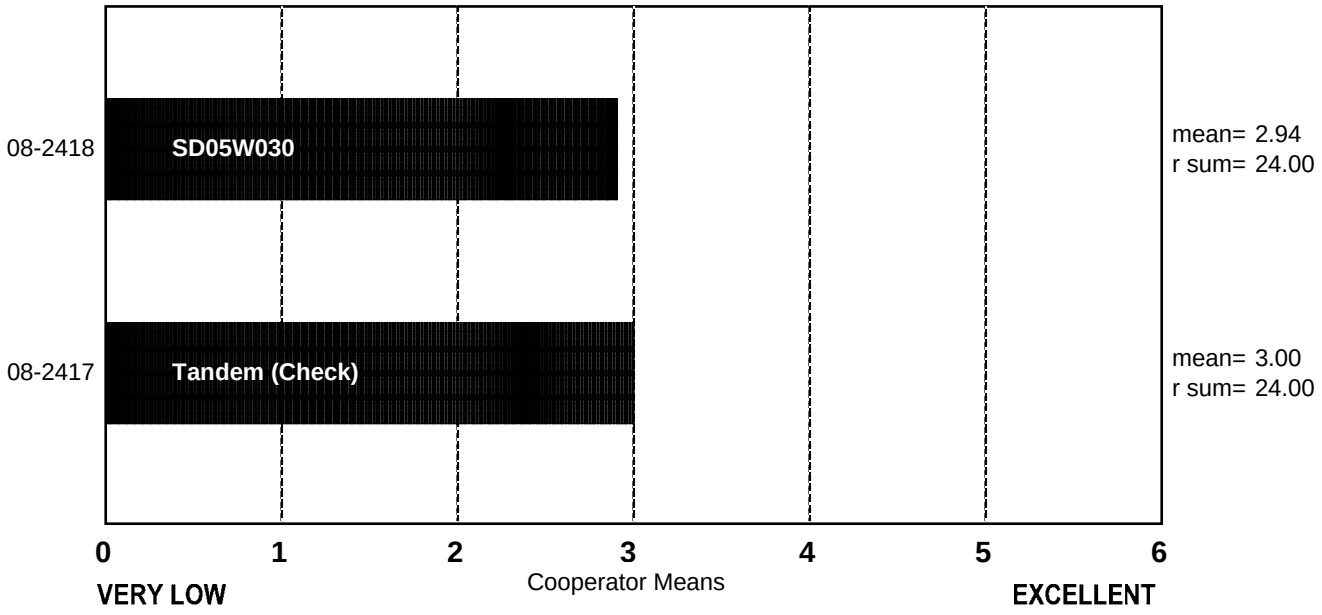


BAKE ABSORPTION

(Small Scale) South Dakota

ncoop= 16
chisq= 0.00
chisqc= 0.00
cvchisq= 3.84
crdiff=

Variety order by rank sum.
No samples 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
08-2417 Tandem (Check)	**57.0**	**61.2**	**59.9**	**59.0**	**57.9**	**64.4**	**55.0**	**60.5**	**60.5**	**58.5**	**59.5**	**56.0**	**56.0**	**62.9**	**60.0**	**60.1**
08-2418 SD05W030	**56.0**	**58.2**	**61.8**	**60.0**	**59.8**	**63.8**	**54.0**	**58.9**	**63.0**	**58.0**	**63.0**	**58.5**	**56.0**	**61.1**	**60.0**	**58.1**

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
08-2417 Tandem (Check)	**20.0**	**3.5**	**6.2**	**25.0**	**1.8**	**5.2**	**6.0**	**5.5**	**10.0**	**17.0**	**8.5**	**4.5**	**9.0**	**4.4**	**6.0**	**4.0**
08-2418 SD05W030	**8.0**	**3.2**	**5.1**	**11.0**	**1.8**	**3.5**	**4.0**	**4.0**	**4.0**	**5.0**	**7.5**	**4.0**	**4.0**	**2.7**	**3.0**	**2.3**

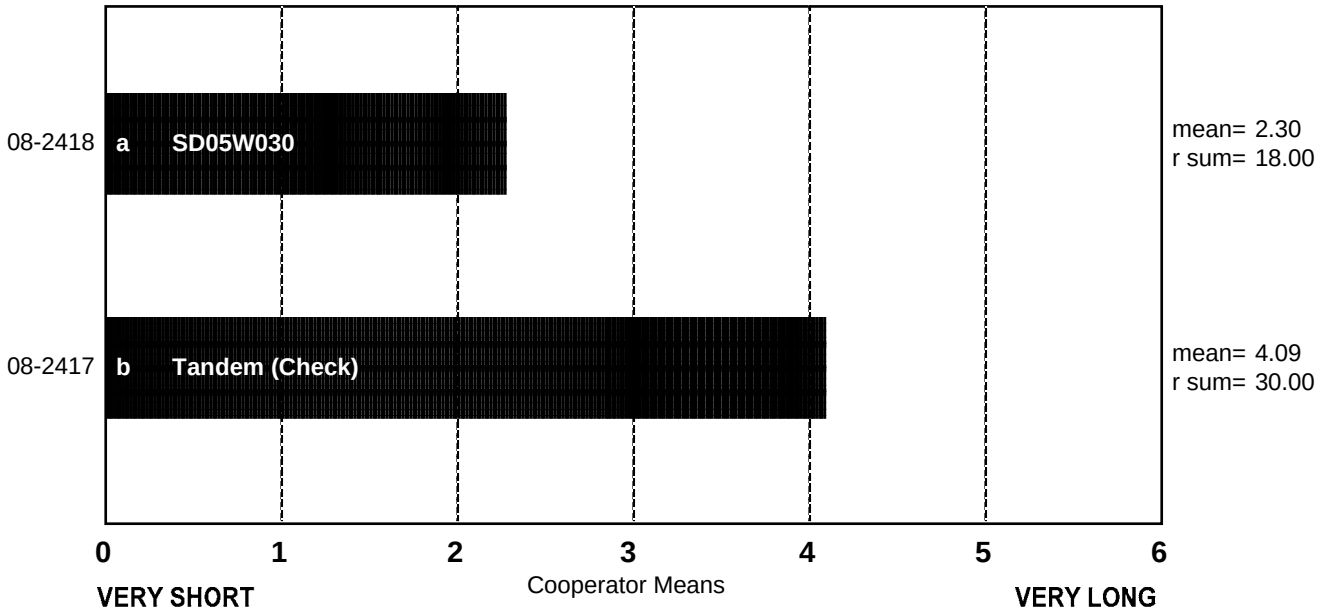
Raw Data

BAKE MIX TIME

(Small Scale) South Dakota

ncoop= 16
chisq= 9.00
chisqc= 12.00
cvchisq= 3.84
crdiff= 3.81

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

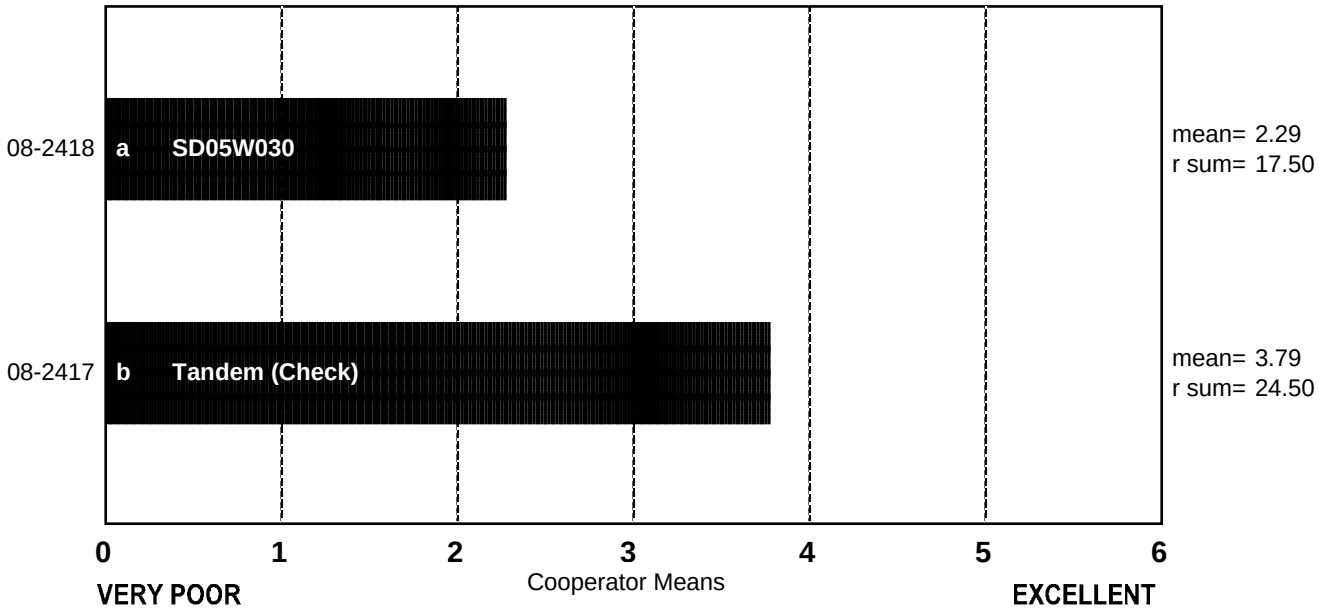


MIXING TOLERANCE

(Small Scale) South Dakota

ncoop= 14
chisq= 3.50
chisqc= 5.44
cvchisq= 3.84
crdiff= 5.26

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

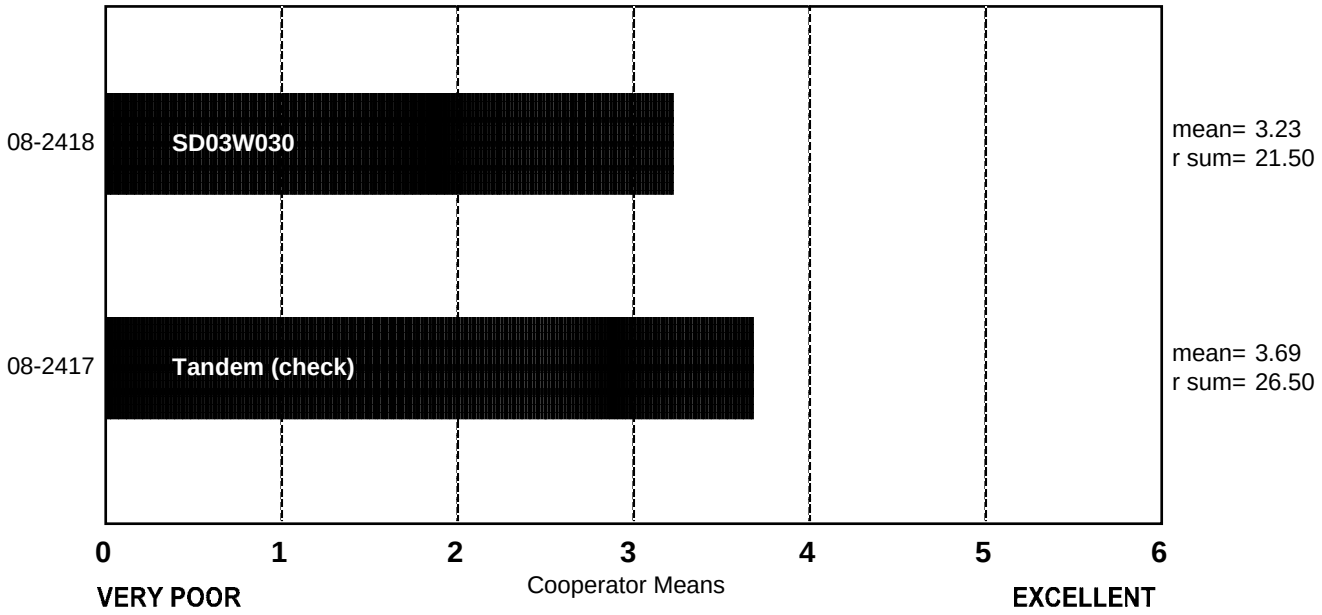


DOUGH CHAR. 'OUT OF MIXER'

(Small Scale) South Dakota

ncoop= 16
chisq= 1.56
chisqc= 2.78
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) South Dakota

	Sticky	Wet	Tough	Good	Excellent
08-2417 Tandem (check)	**1**	**1**	**4**	**9**	**1**
08-2418 SD03W030	**8**	**1**	**1**	**6**	**0**

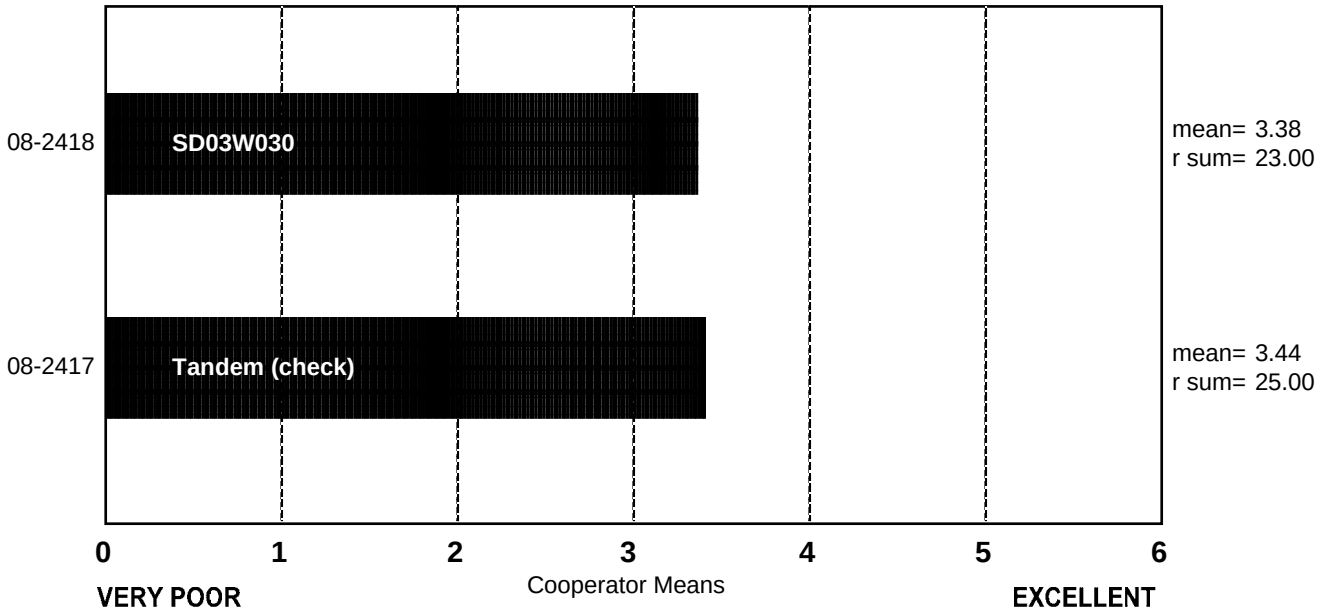
Frequency Table

DOUGH CHAR. 'AT MAKE UP'

(Small Scale) South Dakota

ncoop= 16
chisq= 0.25
chisqc= 0.57
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) South Dakota

	Sticky	Wet	Tough	Good	Excellent
08-2417 Tandem (check)	**1**	**1**	**6**	**8**	**0**
08-2418 SD03W030	**4**	**3**	**0**	**8**	**1**

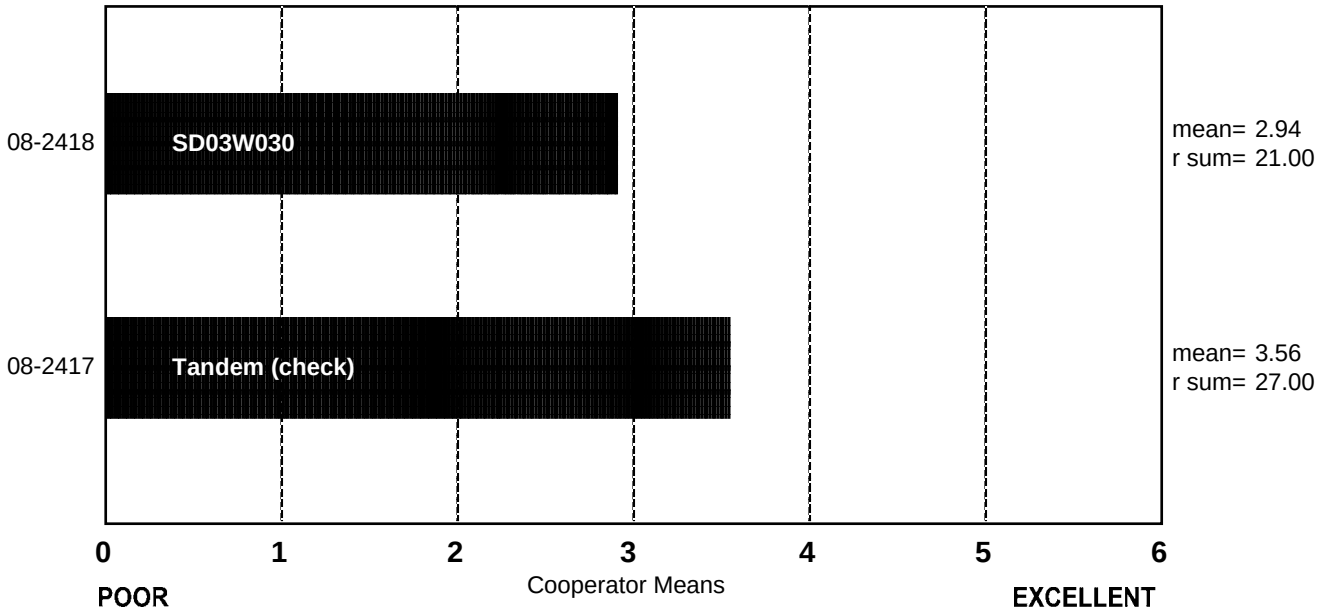
Frequency Table

CRUMB GRAIN

(Small Scale) South Dakota

ncoop= 16
chisq= 2.25
chisqc= 3.27
cvchisq= 3.84
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
08-2417 Tandem (check)	**8**	**5**	**3**
08-2418 SD03W030	**8**	**5**	**3**

Frequency Table

CELL SHAPE, DESCRIBED

(Small Scale) South Dakota

	Round	Irregular	Elongated
08-2417 Tandem (check)	**2**	**9**	**5**
08-2418 SD03W030	**8**	**5**	**3**

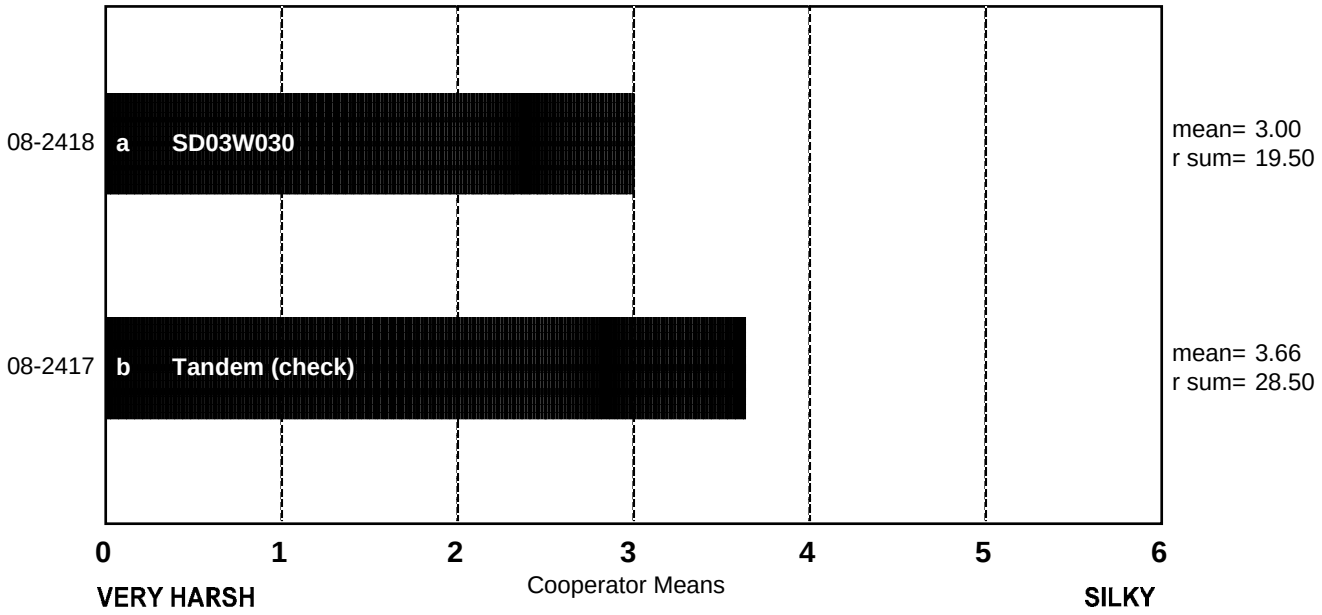
Frequency Table

CRUMB TEXTURE

(Small Scale) South Dakota

ncoop= 16
chisq= 5.06
chisqc= 7.36
cvchisq= 3.84
crdiff= 5.36

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



CRUMB TEXTURE, DESCRIBED

(Small Scale) South Dakota

	Harsh	Smooth	Silky
08-2417 Tandem (check)	**2**	**10**	**4**
08-2418 SD03W030	**8**	**6**	**2**

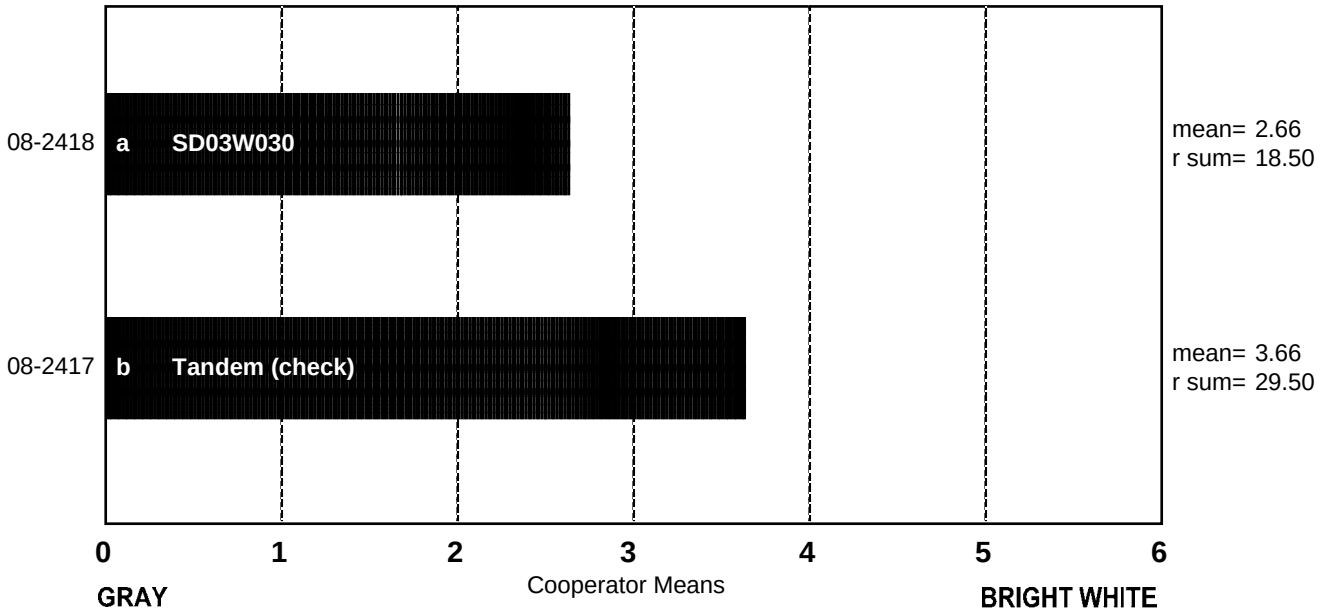
Frequency Table

CRUMB COLOR

(Small Scale) South Dakota

ncoop= 16
chisq= 7.56
chisqc= 11.00
cvchisq= 3.84
crdiff= 4.08

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



CRUMB COLOR, DESCRIBED

(Small Scale) South Dakota

	Gray	Dark Yellow	Yellow	Dull	Creamy	White	Bright White
08-2417 Tandem (check)	**0**	**0**	**1**	**4**	**7**	**4**	**0**
08-2418 SD03W030	**0**	**1**	**8**	**3**	**3**	**1**	**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
08-2417 Tandem (check)	**421.0**		**144.4**	**470.2**	**131.6**	**150.1**	**505.0**	**149.1**	**454.8**	**464.0**	**458.0**	**127.5**	**469.1**	**142.2**	**134.0**	**134.9**
08-2418 SD03W030	**425.0**		**144.8**	**472.1**	**134.8**	**154.5**	**500.0**	**148.6**	**452.8**	**467.0**	**453.0**	**128.1**	**465.0**	**142.8**	**134.0**	**141.1**

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
08-2417 Tandem (check)	**2850**	**1030**	**818**	**3104**	**675**	**905**	**3000**	**850**	**2490**	**2675**	**2800**	**825**	**2550**	**762**	**920**	**900**
08-2418 SD03W030	**2800**	**795**	**778**	**2574**	**675**	**850**	**3050**	**775**	**2167**	**2675**	**2625**	**750**	**2563**	**712**	**923**	**705**

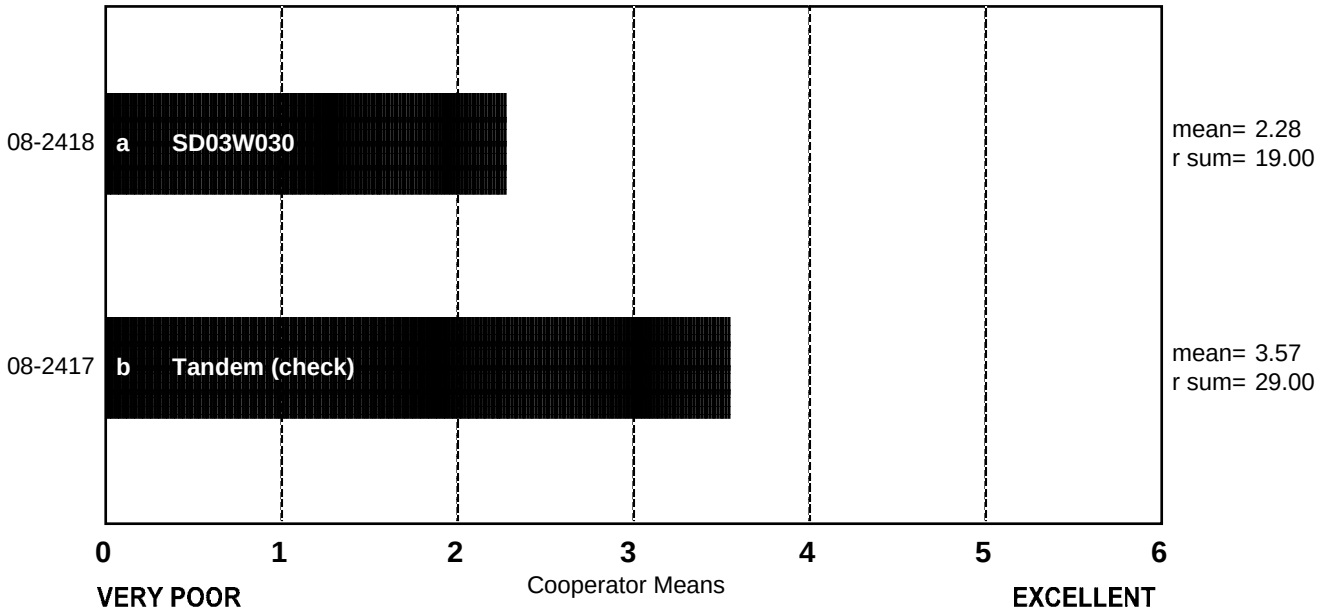
Raw Data

LOAF VOLUME

(Small Scale) South Dakota

ncoop= 16
chisq= 6.25
chisqc= 10.00
cvchisq= 3.84
crdiff= 4.26

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

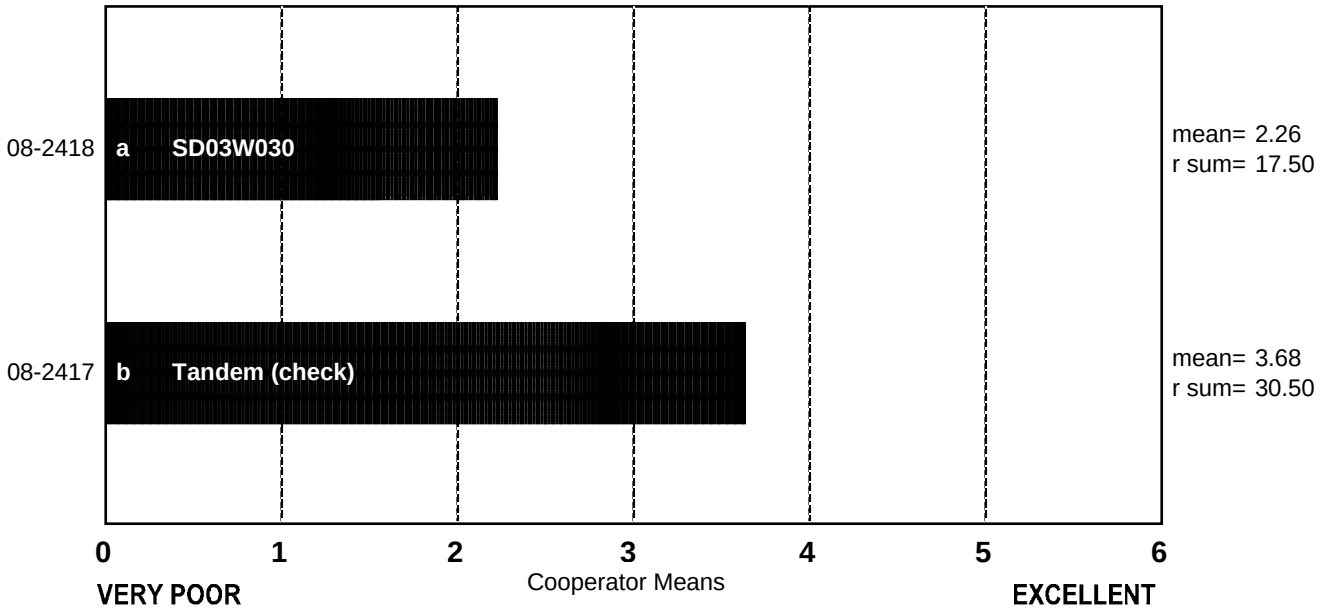


OVERALL BAKING QUALITY

(Small Scale) South Dakota

ncoop= 16
chisq= 10.56
chisqc= 11.27
cvchisq= 3.84
crdiff= 4.64

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. **08-2417 Tandem (check)**

A. Tough, bucky, closed grain, creamy color and one of best grain.
B. Too low protein.
C. Soft dough, medium loaf volume, fine elongated cells, slight yellow crumb, resilient & smooth texture.
D. Very strong flour, open, irregular grain, excellent volume.
E. Low flour protein, loaf volume, absorption and short mix time.
F. Very good dough strength for protein level, good bread and loaf volume potential for protein.
G. Very long stability, low bake absorption.
H. Good dough handling, above satisfactory crumb grain, smooth crumb texture.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, tough dough, very fine grain.
N. No comment.
O. Significant dropoff on long mix tolerance, dough handling was good on all samples, open and somewhat irregular grain.
P. No comment.

COOP. **08-2418 SD05W030**

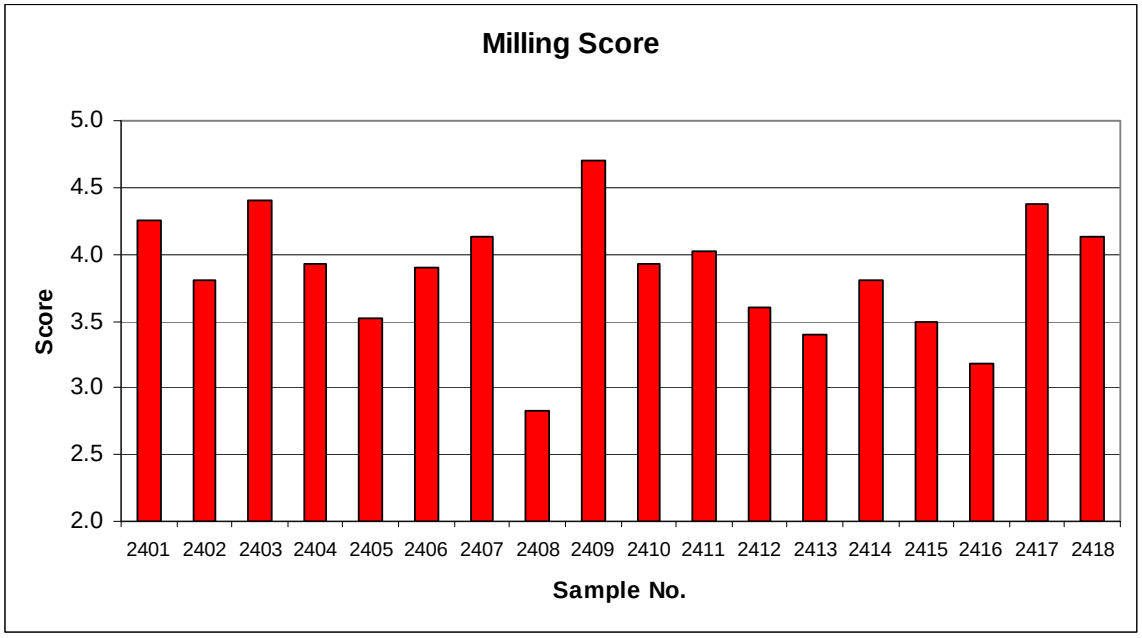
A. Weak, sticky, low protein, closed grain, best, short mix, creamy color and one of best grain.
B. Too low protein. Very weak dough.
C. Soft wet dough, small loaf volume, fine round cells, slight yellow crumb, resilient & slight harsh texture.
D. Very weak flour, very poor volume, thick cell walls.
E. Low flour protein and loaf volume.
F. Good performance for protein level, probably will have okay dough strength at higher protein levels, good loaf volume performance for protein.
G. Very low protein, low bake absorption.
H. Low bake absorption, good bake mix time, good at pan, questionable crumb grain, yellow crumb color with low loaf volume.
I. No comment.
J. No comment.
K. No comment.
L. No comment.
M. Very low absorption, short mix time, sticky dough, open grain, yellow crumb.
N. No comment.
O. Slight dropoff on long mix in volume and dough handling of long mix, good grain, slightly extensible and softer doughs.
P. No comment.

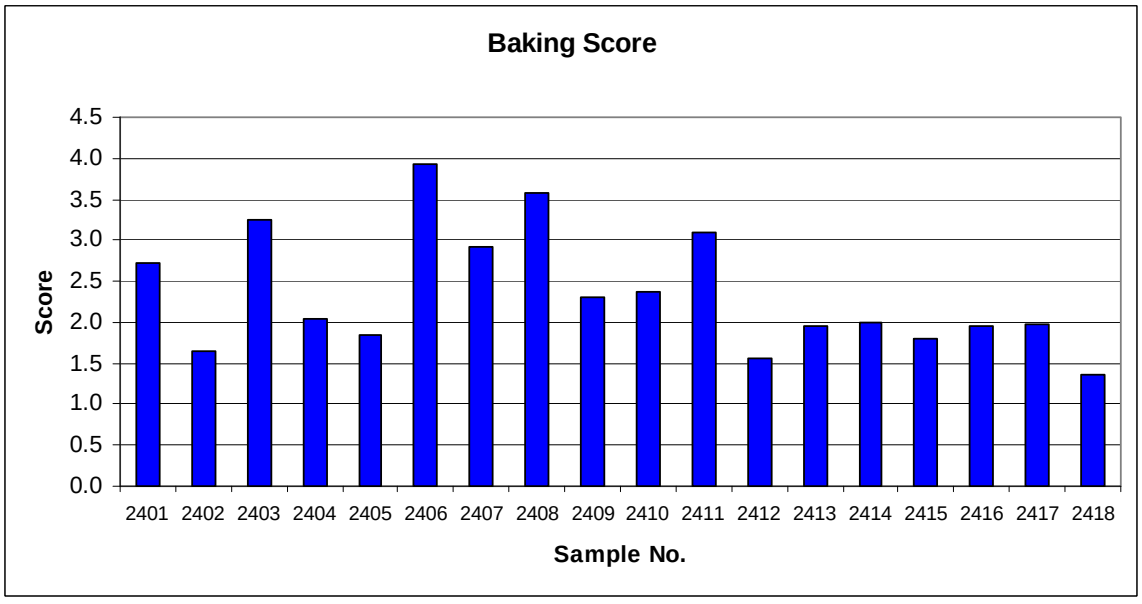
Notes: **A, D, I, J, M, and O** collaborators conducted sponge and dough bake tests.

2008 WQC Milling and Baking Score

2008 WQC Milling & Baking Scores

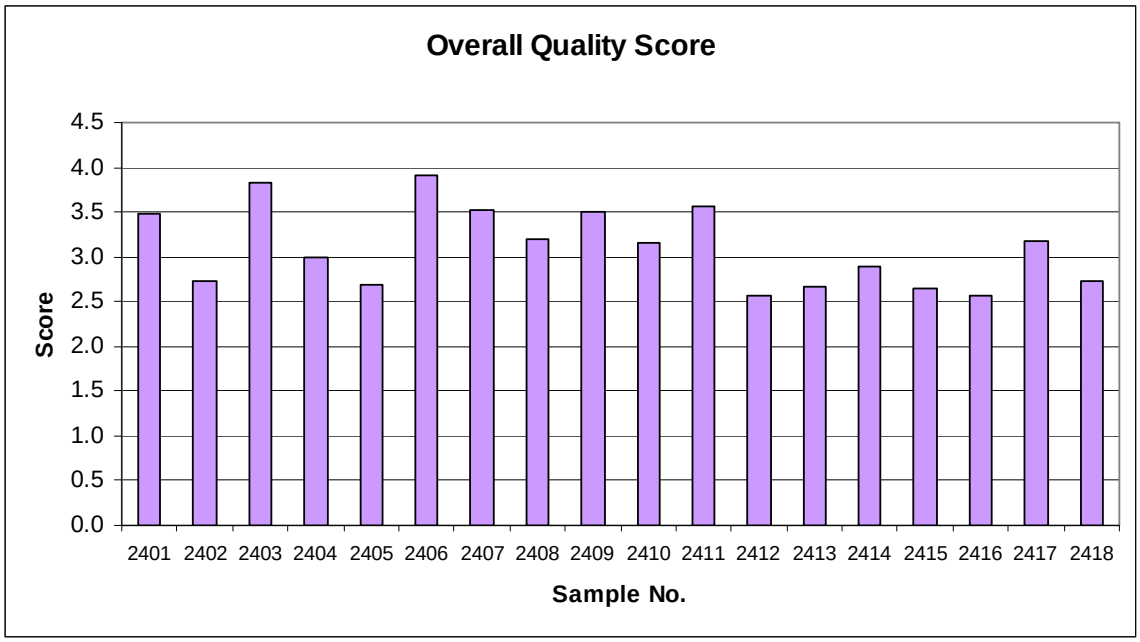
(Based upon HWWQL Quality Data)





2008 WQC Milling & Baking Scores

(Based upon HWWQL Quality Data)



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
2008 WQC Hard Winter Wheat Samples

USDA-ARS Hard Winter Wheat Quality Laboratory
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Alkaline Noodle Quality Report of 2008 WQC Samples

Objectives: Evaluate noodle color and cooking characteristics of 2008 WQC hard winter wheat samples.

Materials: 18 WQC samples harvested in 2008.

Methods:

PPO (Polypenol 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:

100-g flour ← 1-g Na_2CO_3 + 35-mL Water

↓

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

↓

Rest for 30 min in a plastic bag

↓

Plug roll gap with plastic tubing and pour mixed dough

↓

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

↓

Cutting

Measurement of Noodle Dough Color:

Noodle dough color (*L**, lightness; *a**, redness-greenness; *b**, yellowness-blueness) was measured by Minolta Colorimeter (Model CR-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, the TPA of noodle was conducted using 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***: 2405 (83.9), 2418 (83.3), 2415 (82.5)

Noodle Color (*L* value, Higher is better.) ***at 24 hr***: 2418 (74.4), 2415 (71.5), 2417 (70.4)

Delta L (Change of *L* value, Lower absolute value is better.)
2418 (-8.9), 2410 (-10.9), 2415 (-11.0)

PPO (Lower is better.): 2410 (0.223), 2415 (0.243), 2418 (0.361)

Table II shows the following.

Hardness : 2402 (3.11), 2418 (3.00), 2416 (2.92)

Springiness : 2417 (1.058), 2403 (1.056), 2414 (0.978)

Chewiness : 2417 (1.95), 2403 (1.89), 2402 (1.86)

Resilience : 2401 (0.405), 2407 (0.397), 2412 (0.394)

Cohesiveness : 2407 (0.684), 2406 (0.683), 2401 (0.682)

Water Uptake : 2415 (88.5), 2413 (86.3), 2410 (85.4)

Cooking Loss : 2418 (9.8), 2416 (9.6), 2402 (8.0)

Discussion

Sample 2418 showed the highest brightness and yellowness in noodle color at 24 hr, the second highest hardness in texture, and the third lowest PPO level. The bright yellow noodle color after 24 hr production and the firmer texture after cooking are considered as desirable characteristics for alkaline noodles. Thus, sample 2418 would be most favourable for alkaline noodle. Sample 2415 showed the second brightest noodle color at 24 hr, the second lowest PPO level, the highest water uptake and soft texture after cooking, therefore, sample 2415 would be a good noodle flour for white salted noodle (Japanese Udon type), which is supposed to have bright creamy white color, and smooth and soft texture. Sample 2417 showed the third brightest noodle color at 24 hr, the highest springiness and the highest chewiness.

Table I. Noodle Color and PPO Level

Sample	*L* @ 0	*L* @ 24	*a* @ 0	*a* @ 24	*b* @ 0	*b* @ 24	delta *L*	delta *a*	delta *b*	PPO
2401	80.00	65.33	-1.41	-0.31	21.53	25.10	-14.68	1.10	3.57	0.510
2402	80.64	66.74	-1.87	-0.28	24.03	26.57	-13.90	1.60	2.54	0.718
2403	80.30	66.85	-1.28	-0.27	21.02	25.00	-13.45	1.01	3.99	0.554
2404	80.00	66.53	-1.97	-0.40	23.00	26.35	-13.47	1.57	3.35	0.625
2405	83.88	67.98	-1.44	-0.02	17.33	23.40	-15.90	1.42	6.07	0.479
2406	81.21	64.08	-2.29	-0.03	20.75	24.95	-17.13	2.26	4.20	0.639
2407	77.37	61.09	-2.01	0.24	24.52	25.47	-16.28	2.25	0.95	0.650
2408	79.32	64.09	-1.21	0.57	21.63	25.26	-15.23	1.77	3.63	0.594
2409	81.45	66.61	-2.12	-0.53	20.26	24.92	-14.84	1.59	4.66	0.568
2410	80.12	69.23	-1.83	-0.59	21.19	23.80	-10.90	1.24	2.61	0.223
2411	81.35	68.81	-1.25	-0.31	18.31	22.96	-12.54	0.94	4.65	0.737
2412	78.91	64.11	-1.35	0.12	19.90	24.54	-14.80	1.47	4.64	0.684
2413	79.98	68.07	-2.04	-0.74	22.81	26.34	-11.91	1.30	3.53	0.682
2414	80.05	67.83	-2.07	-0.56	21.21	25.31	-12.22	1.52	4.10	0.616
2415	82.45	71.45	-2.08	-1.56	19.52	26.42	-11.00	0.52	6.90	0.243
2416	80.57	67.91	-1.98	-1.04	20.66	26.04	-12.66	0.94	5.39	0.702
2417	81.84	70.41	-2.09	-1.00	21.52	26.67	-11.43	1.09	5.16	0.537
2418	83.30	74.43	-2.66	-1.88	22.75	28.64	-8.87	0.77	5.89	0.361
Average	80.71	67.31	-1.83	-0.48	21.22	25.43	-13.40	1.35	4.21	0.562

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

Sample	Hardness	Springiness	Chewiness	Resilience	Cohesiveness	Water uptake	Cooking loss
	N	ratio	no unit	ratio	ratio	%	%
2401	2.79	0.971	1.85	0.405	0.682	80.4	7.1
2402	3.11	0.943	1.86	0.350	0.633	76.6	8.0
2403	2.69	1.056	1.89	0.393	0.665	77.3	7.5
2404	2.67	0.939	1.55	0.333	0.618	81.5	7.9
2405	2.76	0.947	1.72	0.377	0.661	73.9	7.6
2406	2.52	0.978	1.68	0.394	0.683	76.7	6.7
2407	2.47	0.970	1.64	0.397	0.684	76.1	6.6
2408	2.77	0.968	1.78	0.377	0.665	74.6	7.0
2409	2.74	0.953	1.69	0.372	0.649	82.0	7.3
2410	2.54	0.963	1.63	0.388	0.667	85.4	6.1
2411	2.59	0.953	1.62	0.375	0.659	78.7	7.2
2412	2.70	0.966	1.75	0.394	0.670	84.9	5.8
2413	2.81	0.959	1.63	0.335	0.606	86.3	7.4
2414	2.75	0.978	1.66	0.345	0.617	84.6	7.5
2415	2.60	0.976	1.63	0.358	0.641	88.5	6.8
2416	2.92	0.933	1.69	0.329	0.622	73.0	9.6
2417	2.79	1.058	1.95	0.382	0.662	74.3	7.9
2418	3.00	0.962	1.72	0.330	0.596	75.9	9.8
Average	2.74	0.970	1.72	0.368	0.649	79.5	7.4

TORTILLA BAKING TEST I

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TORTILLA BAKING TEST of 2008 WQC SAMPLES

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(January 2009)

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 2008 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

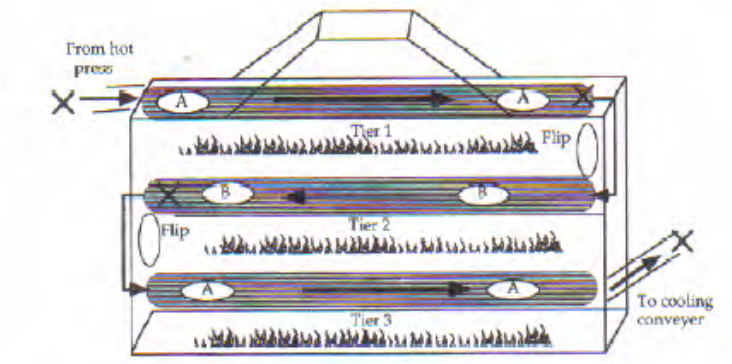
PROOF
5 min, 32°C, 70% RH

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.

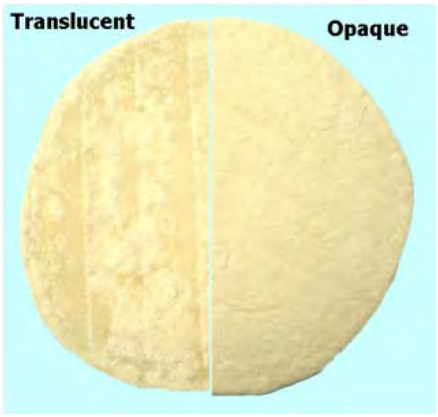
1. Weight
Ten tortillas are weighed on an analytical balance. The weight of one tortilla is calculated by dividing total weight by 10. This ranges from 39 to 41 g.

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. Opacity
Ten tortillas are evaluated subjectively for opacity using a continuous scale of 0-100: 0 = 100% translucent, 100 = 100% opaque. Values vary widely; desired value is > 70%.



6. 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.

7. 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.

9. 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.

10. Objective rheological test

Extensibility of two tortillas is measured on 0, 4, 8 and 12 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 (TA-108a, 7/16" diameter cylinder with a rounded edge) pushes into the tortilla during the test. Deformation modulus, force, work and distance required to rupture are measured.

WHEAT QUALITY COUNCIL - 2008 DATA WORKSHEET

COOPERATOR NAME:	J.N. Alviola, J.M. Awika and L.W. Rooney
COOOPERATOR TYPE: MILLER, BAKER, QUALITY LAB	TAMU, Wheat 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 (%, 14% mb)	Mix Time (min)	Mix Tolerance (scale of 1-6)	Devt. Time (min)	Stability (min)	Tolerance Index (FU)	Breakdown (min)
2401	12.7	3.88	3	7.1	17.9	15	16.2
2402	12.2	2.38	2	6.5	13.1	20	13.8
2403	12.4	4.75	5	6.3	15.8	28	11.4
2404	11.2	2.88	2	4.0	10.5	25	9.8
2405	12.1	4.38	3	9.3	28.1	2	30.0
2406	12.8	9.00	6	30.3	39.7	1	43.5
2407	12.7	4.50	3	11.0	25.0	5	23.3
2408	12.2	9.38	5	8.0	24.3	17	16.3
2409	11.2	2.63	2	6.5	9.8	37	10.1
2410	11.8	4.50	4	8.8	22.4	17	21.3
2411	12.5	5.38	5	8.7	25.9	20	17.3
2412	14.2	2.25	0	6.4	9.5	36	9.1
2413	12.2	2.63	2	6.5	10.8	33	10.5
2414	9.3	3.38	2	4.5	8.1	43	8.0
2415	9.6	3.38	2	3.0	9.1	28	8.1
2416	10.7	3.50	1	8.2	13.1	27	13.9
2417	10.6	4.38	4	7.0	30.9	15	32.3
2418	9.9	2.58	2	6.0	13.5	16	14.6

*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**	Dough Temp	Smooth-ness	Soft-ness	Force to Extend	Extensi-bility	Press Rating
	%	(min)	(°C)	(Rating)	(Rating)	(Rating)	(Rating)	(Rating)
Tortilla Ref.	52	6	30.7	2.0	2.3	3.5	3.0	2.3
2401	52	5	33.4	2.0	2.3	3.3	3.5	2.3
2402	51	4	33.2	2.0	2.3	3.3	2.5	2.3
2403	52	5	32.9	2.0	2.3	3.3	3.0	2.0
2404	49	4	32.1	1.5	2.3	3.0	3.3	2.3
2405	51	5	32.6	2.0	2.5	3.5	3.0	2.0
2406	55	7	32.6	2.3	2.5	3.8	2.5	2.8
2407	52	5	33.0	2.0	2.0	3.3	3.5	1.8
2408	51	7	32.7	2.0	2.8	3.8	3.0	2.8
2409	51	4	33.1	1.5	1.8	3.3	3.5	2.0
2410	47	5	33.0	2.0	2.3	3.5	3.0	2.3
2411	51	5	34.3	2.0	1.8	3.0	4.3	2.0
2412	54	4	33.0	1.5	1.8	2.8	4.3	1.5
2413	48	4	32.1	1.5	2.5	3.3	2.8	2.3
2414	45	5	31.6	1.5	2.3	3.3	3.0	2.0
2415	49	5	31.7	2.0	2.8	3.8	2.8	2.5
2416	50	5	32.6	2.0	2.5	3.3	3.0	2.0
2417	50	5	32.8	1.8	2.3	3.3	3.8	2.3
2418	52	4	32.4	1.3	2.0	3.0	3.0	2.0
HSD (α = 0.05)			*4.7*	*0.6*	*1.2*	*1.2*	*1.9*	*1.2*
Descriptors or Scale	record actual absorption		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.

All doughs were generally easy to process (i.e., no excessive stickiness or firmness). Samples 2406 and 2408, however, were slightly firm and hard to press (to the stainless steel plate) and round.

Table 3. Physical properties of tortillas

TEST No.	Moisture	Weight	Thickness	Diameter	Opacity	Sp. Volume	Lightness*
	%	g	mm	mm	%	cm^3/g	L-value
Tortilla Ref.	34.4	41.3	2.76	164	72	1.4	82.5
2401	32.6	40.8	3.16	156	53	1.5	83.8
2402	32.4	40.3	3.03	165	78	1.6	85.2
2403	32.9	40.5	3.01	160	54	1.5	83.4
2404	31.0	38.9	3.13	171	88	1.8	85.6
2405	31.8	39.6	3.12	157	75	1.5	84.9
2406	34.1	41.8	3.48	134	35	1.2	81.1
2407	33.0	41.1	3.17	153	69	1.4	84.1
2408	32.5	41.8	3.19	149	34	1.3	82.8
2409	31.9	39.2	2.95	174	84	1.8	86.0
2410	32.0	40.4	3.08	151	51	1.4	84.7
2411	32.9	40.5	2.96	155	51	1.4	83.7
2412	33.0	41.0	2.85	173	77	1.6	83.5
2413	31.1	39.6	3.20	170	91	1.8	84.9
2414	29.7	38.5	3.18	170	91	1.9	85.4
2415	31.4	38.9	3.24	165	91	1.8	84.9
2416	31.7	39.9	3.20	165	86	1.7	84.8
2417	32.2	40.7	2.99	165	73	1.6	84.9
2418	32.4	40.0	3.14	171	88	1.8	85.7
HSD (α = 0.05)	*1.6*	*4.8*	*0.6*	*16.4*	*31.9*	*0.5*	*2.2*
Descriptors or Scale	Calculate using two-step method	Record actual weight	Record actual thickness	Record actual diameter	*from 0%* = Trans-lucent to 100% = Opaque	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

Ten samples had the desired diameter (at least 165 mm) and opacity (> 70%). Generally, those with small diameters had corresponding low opacity and specific volume (<1.5 cm3/g; less fluffy). Specifically, 2406 and 2408 had very small diameters, and were thick 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 12	Force day 12	Distance day 12	Work day 12
	(N/mm)	(N)	(mm)	(N.mm)	(N/mm)	(N)	(mm)	(N.mm)
Tortilla Ref.	0.7	9.3	22.8	76.9	1.0	7.6	11.7	27.6
2401	0.7	10.2	23.3	97.2	1.0	9.9	13.4	52.4
2402	0.7	7.9	21.2	59.9	0.9	7.4	12.0	30.6
2403	0.7	9.9	23.8	95.6	1.0	8.1	12.2	35.6
2404	0.6	7.7	21.2	57.9	0.8	6.7	12.1	28.2
2405	0.7	9.2	22.5	77.7	1.1	8.8	11.9	39.0
2406	0.7	12.1	25.8	142.4	1.0	12.2	16.4	87.7
2407	0.6	9.6	25.6	99.6	0.9	9.4	14.1	52.3
2408	0.8	12.3	26.4	140.9	1.1	11.8	14.5	68.4
2409	0.6	7.4	23.5	66.4	0.9	6.8	11.5	28.8
2410	0.8	11.2	25.0	118.6	1.1	9.6	12.2	44.8
2411	0.7	11.0	25.8	121.5	1.2	11.4	13.1	56.2
2412	0.6	8.0	24.3	76.4	0.7	7.8	13.8	37.5
2413	0.7	8.1	20.4	58.7	0.8	6.2	11.4	25.5
2414	0.7	7.5	20.6	51.0	1.0	6.1	10.0	24.5
2415	0.7	8.5	22.1	64.2	1.0	6.7	10.5	26.3
2416	0.6	8.4	22.3	64.9	1.1	7.3	10.6	28.9
2417	0.7	8.6	21.7	73.7	1.0	8.2	11.6	34.9
2418	0.6	7.1	20.9	51.2	0.7	6.1	11.7	24.8
HSD (α = 0.05)	*0.2*	*2.4*	*7.2*	*45.3*	*0.7*	*2.8*	*3.5*	*23.6*
Descriptors or Scale	Determine parameters using texture analyzer on day of processing				Determine parameters using texture analyzer after 12 days of storage			

All samples had tortillas that became less extensible with storage. Samples 2406 and 2408 had consistently the highest force, distance and work needed to rupture the tortillas especially after 12 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.	4.5	3.4	2.9	2.8	164	Poor
2401	5.0	4.8	4.1	4.0	156	Poor
2402	3.6	3.1	2.8	2.8	165	Poor
2403	5.0	5.0	4.0	4.0	160	Fair
2404	3.6	2.9	2.3	1.8	171	Poor
2405	5.0	4.6	3.8	3.3	157	Fair
2406	5.0	5.0	4.8	5.0	134	Poor
2407	5.0	5.0	4.6	5.0	153	Poor
2408	5.0	5.0	4.8	5.0	149	Poor
2409	3.8	3.0	2.1	2.0	174	Poor
2410	5.0	4.5	4.0	3.5	151	Poor
2411	5.0	5.0	4.5	4.0	155	Poor
2412	4.9	4.8	3.9	3.3	173	Good
2413	2.9	2.0	1.1	1.0	170	Poor
2414	1.9	1.0	1.0	1.0	170	Poor
2415	2.8	1.8	1.0	1.0	165	Poor
2416	2.5	1.9	1.3	1.0	165	Poor
2417	4.6	3.1	2.3	2.3	165	Poor
2418	3.6	3.1	2.5	2.3	171	Poor
Descriptors or Scale	*from* 1 = breaks when rolled to 5 = rolls easily				Record actual diameter	

*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

Sample 2412 was the only sample that had acceptable diameter and day-16 rollability scores. Samples 2403 and 2405 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).

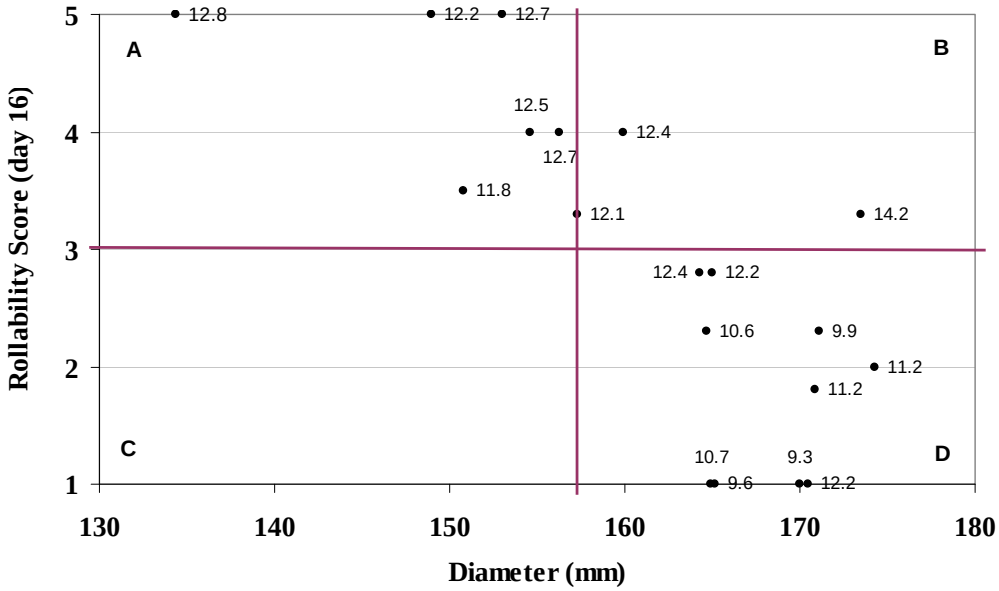


Fig. 1. Relationship of tortilla diameter, rollability score (day 16) and flour protein content (14% mb; shown as numbers inside the box). Quadrant A: good shelf-stability, poor diameter; B: acceptable diameter and shelf-stability; D: good diameter, poor shelf-stability.

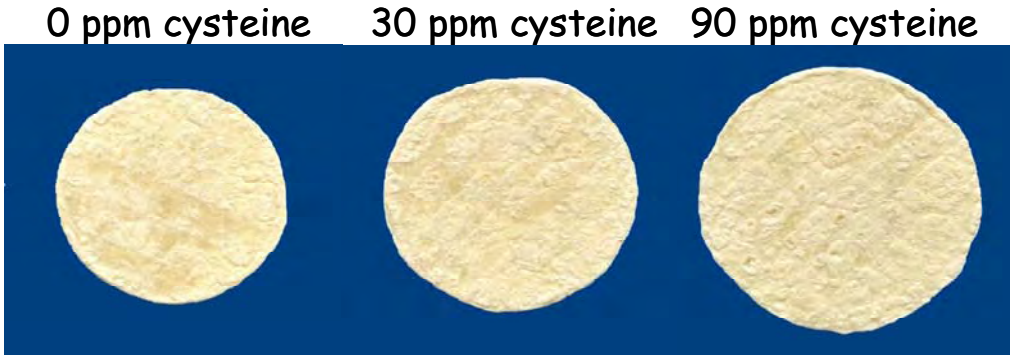


Fig. 2. Tortillas from commercial bread flour (13.3% protein) with and without L-cysteine.

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 2412, which gave the best tortilla quality, does not fall into this category (i.e., has 14.2% 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 4 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 2007 crop year along with the current 2008 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.

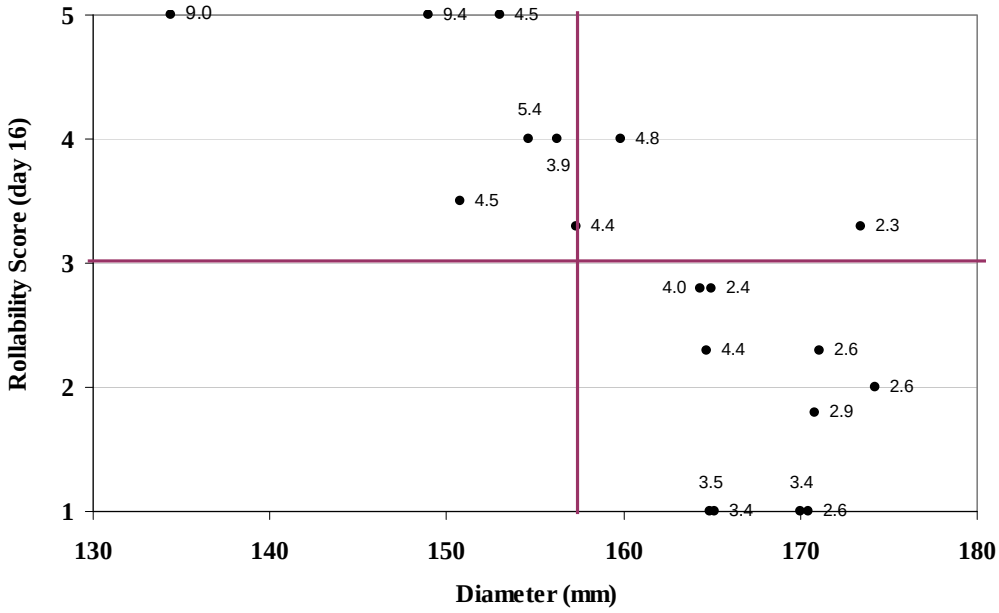


Fig. 3. Relationship of tortilla diameter, rollability score (day 16) and mixograph mixing time (shown as numbers inside the box).

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.

TORTILLA BAKING TEST and FLOUR PROTEIN ANALYSIS

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Grain Marketing and Production Research Center
Grain Quality and Structure Research Unit
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Procedures to Produce and Evaluate Wheat Flour Tortillas Using a Small Hot Press Baking Procedure

I. Tortilla Formulation

Ingredients	*Amount*
Wheat flour	100%
Salt	1.50%
Sodium Stearoyl Lactylate	0.50%
Sodium Propionate	0.40%
Potassium Sorbate	0.40%
All purpose Shortening	6.00%
Sodium Bicarbonate	0.60%
Fumaric Acid - encapsulated	0.33%
Sodium Aluminum Sulfate	0.58%

II. Tortilla Processing

1. Mixing dry ingredients and shortening

Dry ingredients were mixed for 2 minutes at low speed with a paddle in the mixing bowl. Then shortening is added and mixed at low speed for 6 min.

2. Mixing with water

Water was weighed and preheated to 35^0C in a microwave oven. Water was added to the bowl over a period of 1 min at low speed. Then, the paddle was changed by a hook and the dough was mixed for additional 4 min at medium speed. The water absorption was kept constant and it was determined from Mixograph analysis minus 10 units, e.g., if Mixograph absorption was 61%, then the tortilla dough absorption was 51% (61 – 10).

3. First resting of the dough

Dough was placed on a closed plastic container and a thermometer with a probe was used to measure the temperature. The dough was rested for 5 min at room temperature. The dough was then subjected evaluated for smoothness, softness, force to extend and extensibility.

4. Dividing and rounding of dough

The dough was removed from the plastic container, weighted into 40 g and transformed into balls by hand rolled.

5. Second resting of the dough

Additional resting in a proof chamber at 35 °C with 70% RH was maintained for 30 min.

6. Hot pressing

Dough balls were pressed using a tortilla dough press (TXA-SS Tortilla Press, DoughXpress, Pittsburg, KS) with both top and bottom platens set at 71 °C for 10 sec under the "thin" setting.

7. Baking

Immediately after pressing, tortillas were baked on a griddle (DoughPro, model 1520) at 160 °C, for 30 sec on each side, followed by an additional 10 sec on each side.

8. Cooling and packaging

Tortillas were allowed to cool on a metal baking rack for about 5 min, packaged into *zip log* bags and stored at room temperature, protected from light.

III. Evaluation of Dough Properties

The dough properties were evaluated subjectively for smoothness, softness and toughness after the first resting time during processing (step 3).

Smoothness refers to the appearance and texture of the dough surface. It is rated from 1 to 5, 1= very smooth, 5=Rough. The "ideal" smooth dough is rated as 2.0.

Softness refers to the viscosity or firmness of the dough when compressed. It is obtained by pressing the dough with the fingers. It is rated from 1 to 5, 1= soft, less viscous, 5 = firm, more viscous.

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. It is rated from 1 to 5, 1=less tough, less elastic, 5= excessively elastic.

Extensibility refers to the length the dough extends when pulled apart. It is obtained by pulling the dough and is rated from 1 to 5, 1=breaks immediately, 5= extends readily into long thin dough pieces.

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

BOLD values = desired dough properties.

IV. Evaluation of Tortilla Properties

Tortillas were evaluated for weight, diameter, height, opacity and color at day 0 (approximately 2 hours after baking). The pH and moisture were determined at day 1 (one day after baking). Texture measurements were determined subjectively by the rollability test and objectively by the Texture Analyzer at days 4, 8, 12 and 16.

1. Weight

Ten tortillas were weighed on an analytical balance. The weight of one tortilla was calculated by dividing total weight by 10.

2. Diameter

Five tortillas were measured by using a ruler at two points across the tortilla: the larger diameter and the smaller diameter. Values from measurements of five tortillas were averaged.

3. Height

Ten tortillas were stacked and a digital caliper was used to measure their height. The height of one tortilla was calculated by dividing the height by 10.

4. Opacity

Ten tortillas were evaluated subjectively for opacity using a continuous scale of 0-100:
0 = 100% translucent, 100 = 100% opaque.

5. Color Values

The color values of lightness (L*), ±a* (redness and greenness) and ±b* (yellowness and blueness) of 5 tortillas were determined using a handheld colorimeter (model CR-300, Minolta Camera Co., Ltd., Chuo-Ku, Osaka, Japan). The color was determined at 3 points for each tortilla (2 points on one side of the tortilla and 1 point on the other side). The color value of 5 tortillas was averaged.

6. pH

The pH was determined following AACC method 02-52. Briefly: 10 g of grounded tortilla was placed into an Erlenmeyer flask and 100 ml of distilled water was added to the flask. This was agitated for 30 min using a magnetic stirrer. The suspension was settled for 10 minutes and 3 measurements of the pH were determined in the supernatant. The average of the 3 determinations was obtained.

7. Moisture

Moisture was determined using a two-stage procedure of AACC method 44-15A.

8. Specific Volume

Specific volume was calculated by the following equation: $= \pi * (\text{Diameter(cm)}/2)^2 * \text{height(cm)}/\text{weight (g)}$. The specific volume is expressed in cm^3/g.

9.Quality Index

Quality Index (based on Opacity) at 12 day is calculated by the equation: = Opacity * Specific Volume * Rollability Score (12^{th} day of storage).

Quality Index (based on Opacity) at 16 day is calculated by the equation: = Opacity * Specific Volume * Rollability Score (16^{th} day of storage).

Quality Index (based on Light) at 12 day is calculated by the equation: = L-values * Specific Volume * Rollability Score (12^{th} day of storage).

10. Tortilla Rollability Score

Two tortillas were removed from the plastic bag at 4, 8, 12, and 16 days of storage. Rollability score was evaluated by wrapping a tortilla around a dowel (1.0 cm diameter). The cracking and breakage of the tortilla was rated using a continuous scale from 1 to 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

11. Objective rheological test

Two tortillas were removed from the plastic bag at 4, 8, 12, 16 days of storage. The objective extensibility test (Akdogan et al. 2006) was performed using a texture analyzer (model TA.XT.Plus, Texture Technology Corp., Scarsdale, NY). An acrylic template was used to cut tortilla strips 37 mm long and 35 mm wide. A tensile grip probe as used with one grip attached to the moving arm and the other attached to the platform. Four tortilla strips were obtained from each tortilla and were kept in a sealed plastic bag until analysis (taken immediately after cutting the strips). Extensibility test used a trigger force of 0.05 N and pre- and post-test speed of 1 mm/sec to a 15 mm maximum distance. The rupture force (N), distance to tear (mm), initial gradient (modulus of deformation, N/mm) and work to rupture the tortilla (N.sec) were determined. The average of 8 measurements was obtained at each day of analysis.

VI. Flour Protein Analysis

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

Sequential protein extraction:

- 100 mg flour + 1 ml alb/glob buffer (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 12000 rpm. 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 the salt from the pellet. Discard the supernatants
- Pellet + 1 ml 50% 1-propanol- vortex for 5 min, centrifuge for 5 min at 12000 rpm. Discard the supernatant (contains gliadins)
- Repeat the extraction with 50% 1-propanol one more time. Discard the supernatant
- Pellet + 1 ml 50% 1-propanol containing 2% TCEP (reducing agent)- vortex for 30 min, centrifuge for 5 min at 12000 rpm. Collect the supernatant (contains the glutenin: HMW-GS and LMW-GS)
- Use the supernatant to analyze protein in the bioanalyzer (lab-on-a-chip).

2. Determination of HMW-GS to LMW-GS ratio

Protein extraction: same as previous described

Procedure: 300 µl of protein extract was alkylated with 20 µl 4-vinylpyridine for 15 min at 60°C. The resulting protein sample was analyzed by RP-HPLC (Agilent 1100 Series, Agilent Technologies, Palo Alto, CA). Briefly, protein samples (1 µl) were injected into a Poroshell 300SB-C8, 2.1 x 75 mm, 5 µm particle size column (Agilent Technologies, Palo Alto, CA) kept at 65°C. Solvent flow rate was 0.7 ml/min and composed of a non-linear gradient of water (A) and acetonitrile (B), both containing 0.1% trifluoroacetic acid. The gradient was as follow: from 0 to 1 min., 23% B; from 1 to 3 min., the gradient increased from 23 to 30% B; from 3 to 11 min., increased from 30 to 44% B; from 11 to 12 min., the gradient decreased from 44 to 23% B and kept at 23% B until 13 min. Detection of protein peaks was carried out by a UV detector at 206 nm (Naeem and Sapirstein 2007). The areas of the curve corresponding the HMW-GS and LMW-GS were determined by manual integration and the ratio HMW-GS/LMW-GS was calculated.

3. Determination of Glutenin to Gliadin ratio

Protein extraction (Gupta et al 1993**)**:

- 100 mg flour + 1 ml 0.05M Sodium phosphate buffer, ph 6.9, containing 0.5% SDS (w/v)- sonicate for 15 s at power setting 10 W. Collect the supernatant (contains total protein)
- Filter the supernatant in a 0.45 µm filter and analyze by size-exclusion HPLC (SE-HPLC)
- SE-HPLC was conducted using a 300.0 x 7.8 mm BioSep S4000 column (Phenomenex, Torrance, CA), kept at 50°C, with a constant gradient composed of 50 mM Sodium phosphate buffer, pH 7.0, containing 1%SDS, flow rate of 1.0 ml/min during 20 min
- The chromatograms were manually integrated. The area of the first peak corresponds to Glutenin and the area of the second peak to Gliadin. The ratio Glutenin/Gliadin was determined using the areas of the chromatograms.

4. 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 12000 rpm. 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
- Determination of the pellet protein content by 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.

VII. References

Akdogan, H.; Tilley, M.; Chung, O. K. Effect of emulsifiers on textural properties of whole wheat tortillas during storage. *Cereal Chemistry* **2006,** 83, 632-635.

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

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

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

WHEAT QUALITY COUNCIL - 2008 DATA WORKSHEET

COOPERATOR NAME:	Michael Tilley / Val Pierucci
COOOPERATOR TYPE:	USDA, ARS, Wheat Research
BAKE TEST METHOD:	Tortilla Bake Test
DOUGH WEIGHT:	40 gram
RESTING TIME:	30 min
HOT-PRESS TEMPERATURE (top/bottom):	71°C
HOT-PRESS TIME:	10 sec
HOT-PRESS PRESSURE:	“thin settings”
GRILL TEMPERATURE:	160°C
BAKING TIME:	30/30 sec followed by 10/10sec

Table 1. Tortilla Dough Properties

2008 Tortilla TEST No.	*Dough Absorp %*	*Dough Temp °C*	*Smooth-ness Dough Rating*	*Soft-ness Dough Rating*	*Force to Extend Dough Rating*	*Extensi-bility Dough Rating*
IDCODE	**Water**	**Temp**	**Smoothness**	**Softness**	**Force to extend**	**Extensibility**
08-2401	53.1	26.5	3.0	2.0	3.0	2.0
08-2402	48.2	27.8	3.5	2.0	4.0	2.0
08-2403	52.6	26.0	4.0	2.0	4.0	3.0
08-2404	51.6	24.7	2.0	1.0	2.0	3.0
08-2405	52.0	27.2	3.0	3.0	2.0	3.0
08-2406	54.3	27.7	3.0	2.0	2.0	3.0
08-2407	54.1	26.8	2.0	2.0	2.0	3.0
08-2408	53.3	28.5	3.0	3.0	3.0	2.0
08-2409	51.6	28.2	3.0	2.0	3.0	3.0
08-2410	51.6	26.6	3.0	2.0	2.0	2.0
08-2411	53.7	28.5	2.0	2.0	2.0	3.0
08-2412	54.6	26.8	2.0	3.0	3.0	3.0
08-2413	49.7	26.3	2.0	2.0	3.0	2.0
08-2414	45.9	26.2	3.5	3.0	4.0	2.0
08-2415	48.0	28.2	3.0	3.0	3.0	2.0
08-2416	48.8	29.2	2.0	3.0	3.0	2.0
08-2417	50.6	24.5	2.5	3.0	3.0	1.5
08-2418	48.7	25.7	2.0	2.0	3.0	3.0
Descriptors **Or Scale**	**record actual *absorption* added water (%)**	**record actual Temperature (°C)**	***from* 1 = very smooth *to* 5 =very rough**	***viscosity* 1 = soft, less viscous *to* 5 = firm, more viscous**	***elasticity* 1 = less tough, less elastic *to* 5 = excessively elastic**	***Length that dough extend* 1 = breaks imediately *to* 5 = extends to long thin dough**

Table 2. Tortilla Physical Properties

2008 Tortilla TEST No.	*Tortilla Moisture %*	*Tortilla Weight g*	*Tortilla Height mm*	*Measured pH*	*Tortilla Diameter cm*	*Tortilla Opacity %*	*Calc Sp.Vol. cm^3/g*
ID CODE	**Moisture**	**Weight**	**Height**	**pH**	**Diameter**	**Opacity**	**Sp. Volume**
08-2401	32.15	36.32	3.18	5.35	15.2	97.4	1.59
08-2402	30.06	36.39	3.19	5.28	15.3	98.3	1.61
08-2403	32.48	36.64	3.12	5.46	15.1	82.5	1.52
08-2404	29.21	35.17	3.28	5.31	17.0	99.4	2.12
08-2405	31.45	36.26	3.25	5.45	15.2	98.5	1.63
08-2406	33.32	36.38	3.94	5.40	13.8	99.0	1.62
08-2407	30.56	35.35	3.45	5.38	15.8	99.3	1.91
08-2408	32.50	36.29	3.69	5.40	15.7	99.4	1.97
08-2409	30.16	35.42	3.33	5.32	16.4	99.0	1.98
08-2410	31.00	35.50	3.22	5.31	16.0	98.7	1.82
08-2411	31.98	35.81	3.39	5.35	15.4	97.2	1.76
08-2412	31.47	35.50	3.24	5.42	16.0	94.2	1.83
08-2413	29.17	35.36	2.89	5.40	16.9	99.7	1.83
08-2414	28.71	36.13	3.17	5.41	16.0	98.1	1.76
08-2415	29.81	35.72	3.19	5.42	16.1	98.8	1.82
08-2416	31.43	36.56	3.35	5.46	15.2	98.2	1.66
08-2417	30.49	35.73	2.96	5.41	16.1	97.9	1.69
08-2418	28.70	35.96	3.25	5.49	15.9	99.1	1.79
Descript. Or Scale	air dry then oven dry calculate moisture	measure weight of 10 tortillas / 10 = average	measure height of 10 tortillas / 10 = average	record the actual pH	measure 5 tortillas min & max values = average	*from* Translucent = *0%* to Opaque = 100%	π * (Diameter (cm)/2)^2 * height (cm) / weight (g) [cm^3/g]

Table 3. Tortilla Rollability and Overall Rating

2008 Tortilla TEST No.	Rollability Score 4 days	Rollability Score 8 days	Rollability Score 12 days	Rollability Score 16 days	Calc Quality Index (12 d)	Calc Quality Index (16 d)	Calc Quality Index (16 d)	*** Rating	Comments
ID CODE	RS 4	RS 8	RS 12	RS 16	opacity	opacity	Light	Rating	
08-2401	4.9	4.0	4.3	3.0	665.9	464.6	408.5	Fair	
08-2402	4.4	3.7	1.5	1.5	237.4	237.4	211.6	Poor	
08-2403	5.0	4.9	4.9	4.2	614.5	526.7	546.6	Fair	
08-2404	4.8	4.1	1.5	2.0	316.1	421.5	373.6	Poor	
08-2405	4.9	3.9	3.9	4.3	626.2	690.4	616.9	Fair	
08-2406	4.9	4.8	4.1	4.7	657.6	753.8	643.7	Poor	Small diameter
08-2407	5.0	4.9	4.8	4.1	910.4	777.6	671.1	Fair	
08-2408	5.0	5.0	4.9	5.0	959.5	979.1	836.4	Fair	
08-2409	2.3	2.4	2.5	1.0	490.1	196.0	172.6	Poor	
08-2410	3.9	3.4	3.8	3.7	682.6	664.6	581.4	Fair	
08-2411	4.8	4.6	4.0	2.5	684.3	427.7	378.0	Poor	
08-2412	4.7	4.1	4.3	3.3	741.3	568.9	518.5	Fair	
08-2413	2.3	1.5	1.0	1.0	182.5	182.5	160.3	Poor	
08-2414	1.0	1.3	1.0	1.0	172.7	172.7	153.8	Poor	
08-2415	1.8	1.0	1.0	1.0	179.8	179.8	159.3	Poor	
08-2416	2.0	1.1	2.0	1.0	326.0	163.0	142.7	Poor	
08-2417	4.7	4.0	3.2	1.9	529.4	314.4	281.4	Poor	
08-2418	3.5	2.0	1.0	1.0	177.4	177.4	158.8	Poor	
Descript. or Scale	1 = breaks *to* 5 = rollable 4 days	1 = breaks *to* 5 = rollable 8 days	1 = breaks *to* 5 = rollable 12 days	1 = breaks *to* 5 = rollable 16 days	Opacity * Sp.Volume* RS at 12 day (or 16 day)	L-value* Sp.Volume * RS at 16 day	Rating	Comments	

***Rating based on Rollability Score, Opacity, Specific Volume

Table 4. Texture and Color Analysis of Tortillas

2008 Tortilla TEST No.	*Modulus 2-D 12 day*	*Force 2-D 12 day*	*Distance 2-D 12 day*	*Work 2-D 12 day*	*Lightness*	*"b"*	*"a"*
ID CODE	**Mod12**	**Force12**	**Dist12**	**Work12**	***L*-value**	***b*-value**	***a*-value**
08-2401	14.28	13.65	1.12	12.72	85.6	16.80	-1.67
08-2402	17.43	14.90	0.87	10.70	87.6	17.06	-1.64
08-2403	13.70	13.01	1.13	12.15	85.6	14.99	-1.45
08-2404	15.73	12.88	0.78	8.22	88.1	14.60	-1.80
08-2405	13.33	12.15	0.92	9.45	88.0	14.45	-1.50
08-2406	12.90	13.56	1.42	15.94	84.5	18.67	-1.85
08-2407	8.86	9.26	1.21	9.09	85.7	16.46	-1.73
08-2408	8.94	10.17	1.54	12.88	84.9	17.11	-1.18
08-2409	15.49	12.93	0.76	8.02	87.2	13.37	-1.38
08-2410	13.20	11.31	0.85	8.00	86.3	14.15	-1.26
08-2411	15.68	12.83	0.96	9.91	85.9	12.14	-0.68
08-2412	9.93	9.65	1.06	8.40	85.9	13.96	-0.93
08-2413	15.71	13.28	0.76	8.20	87.6	15.84	-1.68
08-2414	16.81	14.45	0.70	8.36	87.4	14.89	-1.51
08-2415	20.63	16.94	0.82	11.25	87.5	14.88	-1.47
08-2416	19.45	15.30	0.83	10.05	86.0	16.24	-1.54
08-2417	18.88	13.34	0.81	8.50	87.6	15.10	-1.70
08-2418	15.23	12.75	0.76	7.99	88.7	15.77	-2.13
Descriptors or Scale	Modulus N/mm 12 days	Force to Rupture N 12 days	Distance to Rupture mm 12 days	Work to Rupture N.sec 12 days	Measured with colorimeter: average of 5 tortillas (3 measurements in each tortilla, taken from both sides)		

Table 5. Analysis of Storage Proteins from Flour

2008 Tortilla TEST No.	*HMW-GS composition*	*Glutenin/Gliadin ratio*	*HMW-GS/LMW-GS ratio*	*%IPP*
ID CODE	**HMW-GS**	**Glu/Gli**	**HMW/LMW**	**%IPP**
08-2401	1 / 2*, 5, 10, 17, 18	0.53	0.35	54.74
08-2402	2*, 5, 10, 7, 9	0.44	0.40	47.01
08-2403	Null, 5, 10, 7, 9	0.41	0.23	50.78
08-2404	1, 2, 12, 7, 9	0.59	0.38	47.56
08-2405	1 / 2*, 5, 10, 7, 8	0.47	0.32	50.81
08-2406	2*, 5, 10, 7, 8	0.42	0.37	58.38
08-2407	2*, 5, 10, 7, 8	0.48	0.25	52.41
08-2408	2*, 5, 10, 7, 9	0.48	0.19	59.18
08-2409	1, 5, 10, 7, 9	0.51	0.28	46.11
08-2410	2*, 5, 10, 7, 9	0.50	0.31	53.01
08-2411	1, 5, 10, 7, 8	0.49	0.33	53.66
08-2412	2*, 5, 10, 7, 9	0.45	0.21	44.10
08-2413	1, 5, 10, 17, 18	0.54	0.31	41.22
08-2414	2*, 5, 10, 7, 9	0.66	0.30	40.52
08-2415	1, 3, 12, 7, 8	0.52	0.26	45.45
08-2416	1, 5, 10, 7, 9	0.58	0.54	47.41
08-2417	2*, 5, 10, 7, 9	0.54	0.35	47.68
08-2418	1, 2, 12, 7, 9	0.58	0.50	47.79
Descriptors or Scale	Determined by bioanalyzer	Determined by SE-HPLC- area of chromatograms	Determined by RP-HPLC- area of chromatograms	Determined by LECO

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
Moisture, Ash, Protein, and Minolta Flour Color	USDA/ARS/HWWQL Manhattan, KS
Mixograph, Farinograph Tests, Extensigraph, and C-Cell Tests	USDA/ARS/HWWQL Manhattan, KS
Glutomatic, 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
Wheat Classification	Federal Grain Inspection Service Kansas City, MO
Falling Number Test and Fisher Flour Granulation	KSU Dept. Grain Science & Ind. Manhattan, KS
Flour Milling (Miag Multomat)	KSU Dept. Grain Science & Ind. 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 & USDA/ARS/GQSRU Manhattan, KS
Alkaline Noodle Evaluation	USDA/ARS/HWWQL Manhattan, KS
Data Compilation and Report Preparation	USDA/ARS/HWWQL Manhattan, KS

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Cereal Food Processors 701 E. 17th Street Wichita, KS 67214	Miller	**Tim Aschbrenner** (316)267-7311 t.aschbrenner@cerealfood.com
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Wheat Marketing Center 1200 NW Naito PRKWY STE 230 Portland, OR 97209	Wheat Quality Lab	Bon Lee (503)295-0823 blee@wmcinc.org

METHODS

Test Weight – AACC Approved Method 55-10. Test weight is the weight per Winchester bushel expressed to the nearest tenth of a pound.

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.

Fisher Flour Granulation - Determinations are made using the Fisher Sub-Sieve Sizer. 1.44 g. of flour is placed in the sample tube, packed to the standard height. The average particle size in microns is read using a porosity of 0.465.

Agtron Flour Color - AACC Approved Method 14-30 (modified to dry flour method). M 400 A model Agtron with modifications to relate values to those from the F2 model. Higher readings indicate brighter (better) color.

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).

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 instrument measures resistance of dough extension, extensibility, maximum resistance, and energy used to run dough tests at 30, 60, and 90 minutes.

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.

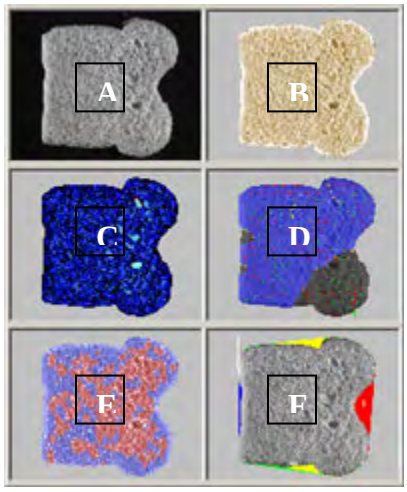
Similarly, cumulative protein curves are determined by arranging millstreams in ascending order of protein content, and tabulating the protein content of the total flour produced with the addition of successive millstreams. Wheat that gives high protein content at low extraction, and a fast rate of protein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

APPENDIX B

Hard Winter Wheat Quality Council
Goals for Hard Winter Wheat Breeders

Hard Winter Wheat Quality Council

2008 Technical Board Officers

CHAIR:	Rollie Sears, AgriPro Wheat
VICE CHAIR:	Kendal McFall, Kansas State University
SECRETARY:	Margo Caley, USDA/ARS/HWWQL
MEMBER:	Becky Miller, Kansas State University
MEMBER:	Jill BryanEhr, Cargill-Horizon Mill

2008 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***

CONTACT:
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Hard Winter Wheat Quality Laboratory
1515 College Avenue, Manhattan, KS 66502-2796
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APPENDIX D

Hard White Wheat Quality Targets Adopted Tentatively 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 Kendall McFall

Annual Meeting Feb. 19-21, 2008

Hard Winter Wheat Quality Council Meeting Minutes
Annual Meeting February 19 – 21, 2008

Minutes of the Hard Winter Wheat Technical Committee Feb. 20, 2008

Tim Aschbrenner called the meeting to order at 8:05 and reported that the minutes had been posted to the website. Greg Fox made the motion to accept the minutes as posted Rollie Sears seconded. Vote to accept minutes as posted passed by voice vote.

Slate of officers for 2008:
Chair: Rollie Sears
Vice Chair: Kendall McFall
Secretary: Margo Caley
Member: Becky Miller
Member: Jill Bryanehr –Nominated by Dave Katzke, Seconded by Scott Baker

Report by Richard Chen on WQC Report

1) Alveograph testing was added to this years report.
2) Wheat Grading Results added by FGIS moved to the front from the back
3) Removed oldest information from the report ie. 1988 – Goals for Breeders
4) Samples included from Montana State University for the first time

Overview of 2007 Milling & Sampling by Kendall McFall

Milling was conducted on the KSU MIAG mill by Dr. Jeff Gwirtz and his technicians. The largest difficulty in this years milling had to with the delayed start from the mill rebuild. $20,000 provided by Dr. Forrest Chumley, KSU Research & Extension, was used to rebuild the mill. Thanks to the USDA lab in Manhattan engineers and machinist in helping on the project. The actual milling was accomplished with minimal problems.

Overview of Milling 2008

No changes are expected in the sample handling or milling for the 2008 samples.

Overseas Varietals Analysis (OVA) Program Review / Changes

Brad Seabourn reported for John Oades who was ill and not able to attend. The OVA sample numbers were down this year and have been trending that way over the last couple of years. This trend led to the idea of dividing the OVA and WQC wheat evaluation programs. Brad reported that for the coming year – 2008, OVA and WQC samples will be submitted separately for evaluation. Breeders will have the option to decide what samples are submitted for OVA and use if they choose a distinct criteria for deciding which samples to submit. This decision process could lead to similar samples as the WQC submissions but not necessarily. There may be other reasons to evaluate

distinct varieties by the overseas collaborators, but it will be breeders choosing. The results of the OVA projects will still be discussed at the annual WQC meeting in KC for convenience, but the project themselves will be separate.

Report from or Scott Haley on CAP

Wheat CAP – Nationally 25 different wheat breeding programs participate in wheat DNA collaboration. The focus of the program is to use marker assisted breeding to do a better job of breeding high quality wheat across the wheat classes.

Report from Jackie Rudd on Nation Wheat Improvement Committee

Trip to Washington DC made up of wheat breeders and industry stakeholders to lobby on behalf of wheat research. The four primary initiatives:

1) Cereal Rust Disease Initiatives
2) Wheat Quality Competitiveness and Security Initiative
3) Wheat Genotyping Lab Initiative
4) Hessian Fly Resistance Initiative

Other Business:

Update on the crop conditions?

Rollie Sears reported his opinion was that the Kansas crop conditions currently being reported more favorably then what he has observed. Southwest Kansas is under extreme pressure, some of the other areas have volunteer acres that are not likely to produce as may have been reported. The crop is ready for the winter to be over – like the rest of us.

Keith Kisling reported his opinion of the Oklahoma crop has some of the same problems as Kansas extending into the central part of OK. High amounts of volunteer wheat also in OK.

Jackie Rudd reported that Texas would produce a crop in the middle of what had been harvested over the last two years. Fifty percent is reported as poor to very poor.

Scott Haley reported that CO has trouble in SE part of the state. NE CO has been improving. Scott introduced Commissioner, Richard Stockenbaum, who reported that his area of the state is looking poor as well.

Ben Hancock – reported that SD had some good looking wheat.

Royce Schaneman of the Nebraska Wheat Board reported that NE had some good looking wheat but with limited moisture in some areas. Looks like it could equal last year's yield.

Chairman Tim Aschbrenner announced the dates for the upcoming Winter Wheat Crop Quality Tour as May 5th through 8th

Theresa Sutton – moved to adjourn, Bert D'Appolonia seconded the motion. Vote to adjourn passed by voice vote. Meeting adjourned at 8:40 am

Thank you very much for reviewing the report. Please let me know if you have any suggestions or recommendations for improving quality of the report for WQC hard winter wheat. I can be reached at (785)776-2750 or by email, Richard.chen@ars.usda.gov