Milling and Baking Test Results for Hard Winter Wheat

Harvested in 2021

72nd Report on Wheat Quality

Hard Winter Wheat Technical Board of the Wheat Quality Council

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

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

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

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WHEAT QUALITY COUNCIL

2021

Milling and Baking Test Results for

Hard Winter Wheats

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The MISSION
of the WHEAT QUALITY COUNCIL:

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

The GOAL
of the WHEAT QUALITY COUNCIL:

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

TABLE OF CONTENTS

2021 WQC MILLING AND BAKING SCORE

ALKALINE NOODLE TEST

TORTILLA BAKING TEST

PROTEIN ANALYSIS

APPENDIX A ---- Credits and Methods

APPENDIX B -- HWWQC Technical Board and Goals for HWW Breeders

APPENDIX C ---- Hard Red Winter Wheat Quality Targets

APPENDIX D ---- Hard White Wheat Quality Targets

APPENDIX E ---- Meeting Minutes

APPENDIX F ---- Historical WQC Hard Winter Wheat Entries

Description of the 2021 Testing Program

Founded in 1949, this is the **72nd** year for the Hard Winter Wheat Milling and Baking Evaluation Program. This program is sponsored by the Wheat Quality Council and coordinated by the USDA-ARS Hard Winter Wheat Quality Laboratory (HWWQL) and Kansas State University Department of Grain Science and Industry. Wheat experimental lines and check varieties (including common check and internal check) were submitted by public and private breeding programs in the Great Plains wheat growing region. This technical report includes GIPSA wheat market classification, physical grain testing, milling, analytical, rheological, and bread baking results.

A total of 21 composite entries this year were grown in two different Uniform Growout Systems including Northern and Southern. Northern has 10 composite entries including 2 checks from 5 breeding programs grown in 3 locations (ND, SD and NE) and Southern has 11 composite entries including 2 checks from 6 breeding programs grown in 5 locations (KS, CO, OK, TX and Limagrain). Wheat samples were milled on the Miag Multomat mill in the Kansas State University Department of Grain Science and Industry (Methods, Appendix A). The flours were distributed to 16 cooperators (14 for bread baking, 1 for tortilla, and 1 for noodle) for end-product quality evaluation. The wheat physical and chemical tests, flour quality analysis, and dough rheological tests (Mixograph, Farinograph, Alveograph, and Extensigraph) were conducted by the HWWQL.

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

2021 WQC HWW Entries & Breeding Programs

Breeding Programs	Entry Number	Sample Identification
NORTHERN	21-2401	Jagalene_CK
	21-2402	19NORD122_ND
	21-2403	19NORD127_ND
	21-2404	10BC329-17-5_AP
	21-2405	NHH17450_NE
	21-2406	NHH17612_NE
	21-2407	SD12DHA01373_SD
	21-2408	SD15035-2_SD
	21-2409	LCH18-7071_LG
	21-2410	SY Monument_CK
SOUTHERN	21-2411	Jagalene-CK
	21-2412	LCH17-4196_LG
	21-2413	SY Monument_CK
	21-2414	OK15MAS8-29_OK
	21-2415	AP Roadrunner_AP
	21-2416	OK15DMAS6-8_OK
	21-2417	CO13007-F6R_CO
	21-2418	CO16D1487_CO
	21-2419	TX15M8024_TX
	21-2420	XE4101_WB
	21-2421	WB4401_WB

CK=Check; AP=Agripro (Syngenta); LG=Limagrain; WB=Westbred (Bayer);
OK15MAS8-29_OK=OK15MASBx7ARS8-29;
OK15DMAS6-8_OK=OK15MASBx7ARS6-8.

2021 Wheat Classification Results from GIPSA

GIPSA Wheat Market Classification

ID	CL	DKG	TW	M	ODOR	HT	DKT	FM	SHBN	DEF	CCL	WOCL	GRADE
21-2401	HRW	0.0	62.4	12.8	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%
21-2402	HRW	0.0	60.9	12.7	OK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%
21-2403	HRW	0.1	59.7	12.6	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.0	U.S. NO. 2 HRW, DKG 0.1%
21-2404	HRW	0.0	60.2	12.8	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%
21-2405	HRW	0.1	60.6	12.8	OK	0.0	0.0	1.7	0.2	1.9	0.0	0.0	U.S. NO. 4 HRW, DKG 0.1%
21-2406	HRW	0.0	61.8	12.6	OK	0.0	0.0	0.0	0.1	0.1	0.0	3.1	U.S. NO. 2 HRW, Light Smutty, DKG 0.4%
21-2407	HRW	0.1	61.1	12.7	OK	0.0	0.0	0.0	0.1	0.1	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%
21-2408	HRW	0.0	61.8	12.7	OK	0.0	0.0	0.0	0.4	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.0%
21-2409	HRW	0.1	60.3	12.7	OK	0.0	0.0	0.0	0.5	0.5	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%
21-2410	HRW	0.0	60.8	12.7	OK	0.0	0.0	0.0	0.5	0.5	0.0	0.0	U.S. NO. 1 HRW,, DKG 0.0%
21-2411	HRW	0.1	63.1	11.2	OK	0.0	0.0	0.0	0.3	0.3	0.4	0.4	U.S. NO. 1 HRW, DKG 0.1%
21-2412	HRW	0.1	61.7	11.4	OK	0.0	0.0	0.0	0.4	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%
21-2413	HRW	0.1	60.7	11.1	OK	0.0	0.0	0.0	0.4	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%
21-2414	HRW	0.2	61.7	11.5	OK	0.0	0.1	0.0	0.1	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.2%
21-2415	HRW	0.3	61.0	11.2	OK	0.0	0.0	0.0	0.5	0.5	0.0	0.0	U.S. NO. 1 HRW, DKG 0.3%
21-2416	HRW	0.0	62.2	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%
21-2417	HRW	0.1	62.6	11.3	OK	0.0	0.0	0.0	0.3	0.3	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%
21-2418	HRW	0.1	61.8	11.2	OK	0.0	0.0	0.0	0.4	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%
21-2419	HRW	0.1	61.0	11.2	OK	0.0	0.0	0.0	0.2	0.2	0.0	0.0	U.S. NO. 1 HRW, DKG 0.1%
21-2420	HRW	0.3	60.7	11.0	OK	0.0	0.7	0.0	0.3	1.0	0.0	0.0	U.S. NO. 1 HRW, DKG 0.3%
21-2421	HRW	0.2	61.3	11.3	OK	0.0	0.1	0.0	0.3	0.4	0.0	0.0	U.S. NO. 1 HRW, DKG 0.2%

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

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

NORTHERN GROWOUT

21-2401	Jagalene_CK
21-2402	19NORD-122_ND
21-2403	19NORD-127_ND
21-2404	10BC329-17-5_AP
21-2405	NHH17450_NE
21-2406	NHH17612_NE
21-2407	SD12DHA01373_SD
21-2408	SD15035-2_SD
21-2409	LCH18-7071_LG
21-2410	SY Monument_CK

CK=Check; ND=North Dakota; AP=Agripro(Syngenta); NE=Nebraska; SD=South Dakota; LG=Limagrain.

Description of Test Plots and Breeder Entries

Northern Growout (NE, SD, ND, AP, and LG)

NEBRASKA by Katherine Frels

Two Nebraska breeding lines were grown in the Northern uniform growout, NHH17450 and NHH17612 (NE16526 was dropped). Six other breeding lines and the check lines Jagalene and SyMonument were grown in Lincoln, NE. No winterkilling was observed due to a mostly mild winter and excellent snow cover during below zero temperatures. The crop progressed normally during the winter and had excellent moisture during the spring. Spring temperatures were cool, so anthesis was slightly delayed compared to an average year. The plots were not sprayed with fungicides but were only mildly infected with stripe rust. No leaf rust was observed. A few spikelets infected with Fusarium head blight were observed in some lines, but the weather was not conducive to the pathogen and little to no spread was observed within the spikes. Lodging was observed in many plots due to a windstorm. Plots were harvested on time and were not exposed to high humidity or heavy rains after maturity.

NHH17450 is a hard red winter wheat derived from the cross Brawl_CL/NHH09655. It is a 2 gene Clearfield line approved for release by BASF. NHH17450 has excellent yield and has performed well in breeding trials and the Nebraska State Variety Trials. Quality is acceptable to slightly weak and lower than NHH17612. It is resistant to SBMV, moderately resistant/moderately susceptible to stripe and stem rust and FHB, and susceptible to leaf rust.

NHH17612 is hard red winter wheat and is a sib line to NHH17450 (also derived from the cross Brawl_CL/NHH09655). It is a 2 gene Clearfield line approved for release by BASF. NHH17612 is similar in yield potential to its sib line, however, it has slightly higher protein and test weight. Baking quality is better than NHH17450. It is later flowering compared to NHH17450 and may perform better in eastern NE and moving north. It is resistant to SBMV, resistant/moderately susceptible to stem rust, moderately resistant to stripe rust and FHB, and moderately susceptible to leaf rust.

SOUTH DAKOTA by Sunish Sehgal

Growing Location and Conditions

A total of 8 entries with two checks (Jagalene and SY Monument) were evaluated under the 2021 Northern Wheat Quality Council (WQC) grow-outs. At Brookings (SD), all entries were timely planted on October 1, 2020, as 150' long and 5' wide strips (7-rows) in oat stubble (no-till). A starter fertilizer 10-34-0 (10 gallons/ac) was applied at seeding. All entries had uniform emergence and good growth going into winter. No visible winter kill was observed. In spring, 28-0-0 (40 gallons/acre) fertilizer was stream-bar applied at Feekes 5 and the strips were also sprayed with 13 oz Bromac + 13 oz Puma. Though a majority of South Dakota experienced a severe drought in the spring and summer of 2021, however, it had a limited impact on the grow-outs at Brookings, SD. The grow-outs were harvested on August 5th, 2021. The grain protein content ranged from 12.1% to 14.4% and the test weight ranged from 58.1 lb/bu – 61.1 lb/bu among the 10 entries.

SD12DHA01373

SD12DHA01373 is a doubled haploid line developed from the cross Radiant/SD06069 and has a medium height and late maturity similar to Ideal. It has good winter hardiness and straw strength. SD12DHA01373 has demonstrated a good yield potential (ranked 19th and 2nd) in the 2019 and 2020 USDA Northern Regional Performance Nursery, respectively. In South Dakota Crop Performance Trials across 41 environments over 3 years, SD12DHA01373 ranked 6th in eastern, 8th in central, and 5th in western SD locations. It has an average test weight and moderate protein concentration. SD12DHA01373 is moderately-resistant to resistant to stripe rust and intermediate response to FHB, leaf, and stem rust. SD12DHA01373 showed overall good milling and baking quality. Across multiple trial locations (2018-2019), its milling quality parameters (average flour yield 69.4 %), mixograph mix time (mins) of 4.0, and mix tolerance of 3.7 and baking quality parameters (average loaf volume 897 cm^3 and specific volume 6.3 cc/g) were better than Overland (average flour yield 68.7%, mix time 2.4 and mix tolerance 1.5, average loaf volume 886 cm^3, and specific volume 5.9 cc/g).

SD15035-2

SD15035-2 is developed from the cross NE05425/SD07184//SD07056. It is a medium-tall variety with medium maturity. It is a high-yielding line with good test weight and grain protein content. Over two years of South Dakota CPT trials (2020 and 2021) it ranked 2nd in eastern, 7th in central, and 6th in western SD. In 2020 NRPN it ranked 5th among 41 entries evaluated across 19 locations. It is moderately resistant to stripe rust and FHB and intermediate response to leaf and stem rust. It also has good milling and baking characteristics. Across multiple trial locations (2018-2019), its milling quality parameters (average flour yield 69.9 %), mixograph mix time of 3.4 and mix tolerance of 2.5 and baking quality parameters (average loaf volume 970 cm^3 and specific volume 6.4 cc/g) were comparable to Winner (average flour yield 66.0%, mix time 3.2 and mix tolerance 2.5, average loaf volume 947 cm^3, and specific volume 6.3 cc/g).

Table 1. Yield, test weight, and grain protein content of some of the lines tested in the South Dakota winter wheat variety performance trial (eastern South Dakota, 2020 and 2021).

Variety	2021			2 year		
	Yield (bu/a)	Test Wt (lbs)	Protein (%)	Yield (bu/a)	Test Wt (lbs)	Protein (%)
SD Andes	71.8	61.4	12.6	76.4	60.8	12.6
SD15035-2	**68.8**	**61.6**	**13.3**	**76.0**	**61.0**	**13.0**
Winner	69.7	60.7	12.8	75.5	60.2	12.6
Ideal	71.4	61.7	12.7	74.8	60.3	12.6
SD12DHA01373	**72.3**	**60.8**	**12.7**	**74.8**	**60.0**	**12.7**
WB4462	70.0	61.2	12.7	74.7	60.3	12.9
SY Wolverine	69.0	60.5	13.1	74.4	59.7	13.1
WB4309	71.0	60.3	13.1	73.9	59.6	13.5
Cowboy	68.2	60.7	12.1	73.8	59.8	12.0
Guardian	68.7	61.8	12.7	73.2	61.1	12.6
LCS Diesel	66.6	61.0	12.9	73.2	60.1	13.0
Draper	66.9	60.5	13.3	73.2	59.5	13.0
Redfield	67.9	60.8	13.6	72.9	60.1	13.3
LCS Helix AX	65.6	61.5	12.4	72.4	61.1	12.3
Oahe	70.8	61.5	12.9	72.4	60.7	12.9
Langin	66.5	60.7	12.5	72.3	60.0	12.4
Thompson	68.6	60.6	12.9	71.0	60.2	12.8
Overland	66.7	61.3	13.1	70.7	60.7	13.0
CP7909	64.7	61.0	12.8	70.5	60.0	12.6
ND Noreen	68.5	61.1	13.4	70.2	61.2	13.2
NE14696	63.9	60.0	13.2	70.1	59.9	13.1
AP 18AX	64.0	60.0	13.0	69.7	59.2	12.8
Crescent AX	60.8	60.9	13.3	69.3	60.5	13.1
SY 517 CL2	57.9	61.7	13.6	65.0	61.1	13.4
Expedition	59.5	61.2	13.7	64.9	60.4	13.4
CP7050AX	56.4	61.2	14.0	63.3	60.9	14.1
Trial Average	66.8	61.0	13.1	72.0	60.3	12.9
LSD (0.05)	4.2	0.8	0.4	5.6	1.1	0.5
CV	7.2	1.1	4.0	6.3	1.4	4.6

NORTH DAKOTA by Francois Marais and Bradley Bisek

General. The 2020 fall planting season was generally unfavorable for winter wheat seeding. Inadequate soil moisture hindered good seedling development and establishment for the winter months, however temperatures were seasonable throughout the state. The winter was generally mild, with continued minimal precipitation among both rain or snow. The drought conditions continued into the spring and North Dakota continued to see extreme drought conditions throughout the summer months, which significantly affected winter wheat yields across the state. The 2021 drill strips were grown at NDSU's Casselton Seed Farm, Clay County, ND where precipitation occurred more regularly. Single 4 X 140 ft strips were planted per entry. The seeding density was 1.2 million seeds per acre. The strips were planted into soy stubble in the previous fall and fertilized with Urea (120 lbs actual N per acre) in the spring of 2021. No fungicide applications were made. Herbicide was applied early in the spring and it became necessary to control grasshoppers during grain filling.

19Nord-122 (pedigree: CM82036/Jerry//Gateway). This line has good leaf rust, stem rust (*Sr24*), and stripe rust resistance. It showed promising yield and acid soil tolerance in early regional tests and its winter-hardiness appeared to be average. In preliminary quality evaluations it had average milling quality and good baking quality.

19Nord-127 (pedigree: Klatt_Line-10//Norstar-*Fhb1*/Jerry). The line is high yielding and has good leaf rust and stem rust resistance but is susceptible to stripe rust. It appears to have good winter-hardiness. In preliminary quality tests its milling and baking quality were average to good.

LIMAGRAIN by Marla Barnett

Growing Location & Conditions

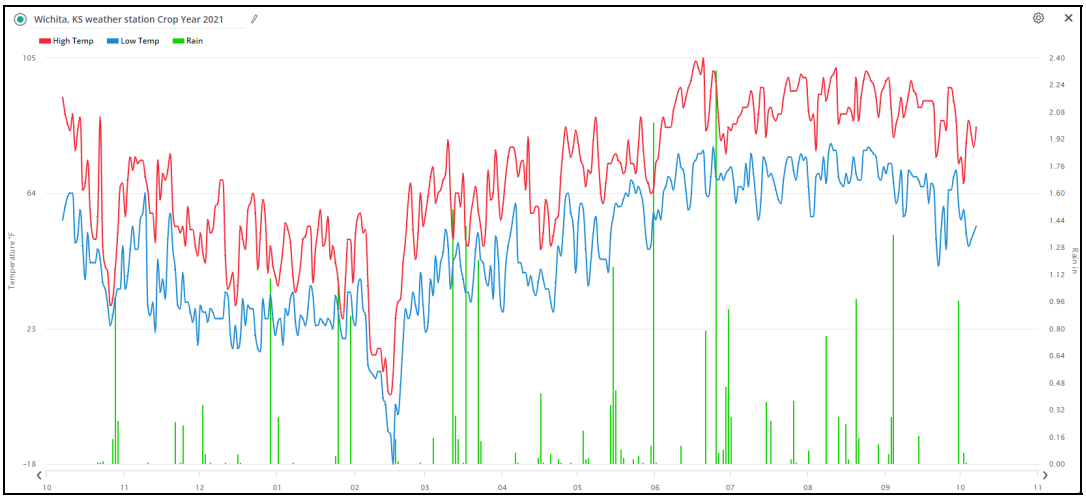
The hard winter Wheat Quality Council samples from Limagrain Cereal Seeds originated from strip increases grown in Wichita, KS located in south central Kansas. The WQC strips were planted on October 7th, 2020 into good soil moisture with good fall stands and decent growth. The field received 120 lbs actual N on March 4th, 2021 at Feekes growth stage 4. No fungicide was applied, and severe stripe rust pressure influenced yields. The mean grain yield of the 11 entries was 59.3 bushels/acre with the lowest yielding entry averaging 51.9 bushels/acre and the highest yielding entry averaging 71.8 bushels/acre (Table 1).

Table 1. Grain yield, test weight, and grain moisture from eleven winter wheat experimental entries and checks grown in Wichita, KS 2021, Limagrain Cereal Seeds.

	Grain Yield (bu/ac)	Test Weight (lbs/bu)	Grain Moisture (%)
Jagalene	51.9	61.9	9.7
CO13007-F6R	71.8	63.8	9.6
CO16D1487	67.1	64.2	9.4
LCH17-4196	59.4	63.8	9.6
OK15MASBx7ARS6-8	59.5	62.1	9.7
OK15MASBx7ARS6-29	58.1	62.6	9.5
SYMonument	55.6	60.5	9.4
APRoadrunner	54.8	62.3	9.7
XE4101	56.4	60.7	9.5
TX15M8024	55.8	62.5	9.6
WB4401	61.8	63.1	10
Mean	59.3	62.5	9.6

Temperatures ranged from -18°F on February 16th, 2021 to 104°F on June 16th, 2021 during the growth season at the location. (Graph 1). No winterkill or winter injury was noted on this winter wheat material; however adjacent Brazilian material did show severe stunting and chlorosis following 14 days below freezing (32°F) during February 2021. The field received 16.23 inches of rainfall (not counting snowfall) from planting (October 7th, 2020) through harvest (June 17th, 2021).

Graph 1. Daily high temperature, daily low temperature, and daily total rainfall from the field location of the 2021 Wheat Quality Council grow out strips at Wichita, KS 2021, Limagrain Cereal Seeds.



Description of Breeder Entries – Limagrain Cereal Seeds

LCH17-4196

LCH17-4196 is a medium maturing hard-red winter wheat with very good yield stability. The pedigree of LCH17-4196 is LCSMint / VA12HRW-27. The pedigree of VA12HRW-27 is TAM303 / KS940786-6-11-2. Excellent yield potential and drought tolerance along with resistance to soil-borne mosaic virus make this medium maturing line very attractive to growers across the Central Plains including the high plains and central corridor regions. LCH17-4196 has a well-rounded disease package. It is moderately resistant to leaf rust, stripe rust, and fusarium head blight, while being resistant to stem rust yet susceptible to Hessian fly. The tillering ability of LCH17-4196 is high; fall ground cover and grazing potential is very good. A medium-tall wheat with excellent winter hardiness and an intermediate growth rate to first hollow stem, LCH17-4196 has better straw strength in high yielding environments than its parent LCS Mint.

This line was tested in the 2020 Southern Regional Performance Nursery. Milling and baking quality data from LCS show acceptable overall quality with most desirable milling attributes and acceptable baking and dough properties.

LCH18-7071

LCH18-7071 is a late maturing hard-red winter wheat with two genes of tolerance to Quizalofop-P-ethyl group 1 ACCase inhibiting herbicides. The pedigree of LCH18-7071 is LCSChrome / ACC7-38. Very high tillering combined with a slow growth rate in the appearance of the first hollow stem makes LCH18-7071 a very attractive line throughout Kansas and Oklahoma where growers want to graze wheat while also controlling winter annual grassy weeds like rye, downy brome, and cheat. LCH18-7071 is susceptible to stem rust and stripe rust while being resistant to leaf rust and soil-borne mosaic virus. The tillering ability of LCH18-7071 is very high; winter hardiness is excellent. A medium-tall, long coleoptile wheat, LCH18-7071 is an excellent grazing option and the latest maturing CoAXium line currently available.

Milling and baking quality data from LCS show acceptable overall quality with acceptable baking qualities and desirable dough and milling properties. The line was ultimately released as LCS Steel AX under the CoAXium wheat production system.

AGRIPRO by Josh Coltrain

Northern uniform growout increase strips were planted on 10/9/20 at our location in Junction City, KS. The strips had very good fall stand establishment. All increases had 80lbs of 11-52-0 applied with the planter with 70lbs of N applied prior to planting. An additional 70lbs of N and 20lbs of Sulfur was top dressed in the spring prior to jointing. All strips were sprayed with a 13.7oz rate of Trivapro at flag leaf to ensure good quality seed. Unfortunately, due to an extremely wide variance on maturities, the earliest group were harvested on 6/22/21 but the later group were not at an acceptable grain moisture level. Prior to the later group drying down, nearly one inch of precipitation fell between 6/24/21 and 6/26/21. As such, the later plots were abandoned since uniformity was no longer possible and no samples were submitted.

10BC329-17-5

AP Bigfoot (10BC329-17-5) was developed from the cross TAM112/CO04393//SY Wolf made in the fall of 2009 in Junction City, KS. It was tested and evaluated under the experimental designation 10BC329-17-5. TAM112 is a PVP variety developed by Texas A&M University from the cross U1254-7-9-2-1/TXGH10440 and released in 2006. CO04393 is an experimental line from Colorado State University with pedigree Stanton/CO950043. SY Wolf is a PVP variety developed by Syngenta Crop Protection AG from the cross of W99-331/97x0906-8 and released in 2007.

AP Bigfoot is a hard red winter wheat broadly adapted to the Central and Western High Plains. The line is short with moderately early maturity and very good test weight. AP Bigfoot has shown very good straw strength and aluminum tolerance. It's fungal disease package is similar to but slightly better than SY Wolf. AP Bigfoot is quite tolerant to leaf rust, and moderately tolerant of stripe rust. It has intermediate tolerance of Wheat Streak Mosaic Virus and Soilborne Mosaic Virus. Milling and baking data compiled over multiple locations in multiple years indicates very good milling and acceptable baking properties with excellent flour yield and protein.

AP Roadrunner

AP Roadrunner was developed from the cross Jackpot/Duster made in the fall of 2008 in Vernon, TX. It was tested and evaluated under the experimental designation AP14T21619. Jackpot is a PVP variety developed by Syngenta Seeds, Inc. from the cross W98-232/KS96WGRC38 and released in 2009. Duster is a PVP variety developed by Oklahoma Agricultural Experiment Station from the cross of W0405D/NE78488/W7469C/TX81V6187 and released in 2007.

AP Roadrunner is a hard red winter wheat broadly adapted to the Central and Western High Plains. The line is medium tall with moderately late maturity. AP Roadrunner has shown excellent aluminum tolerance. It's fungal disease package is very good with excellent tolerance to leaf rust, and stripe rust, though it is susceptible to stem rust. It has intermediate tolerance of Wheat Streak Mosaic Virus but is tolerant of Soilborne Mosaic Virus. Milling and baking data compiled over multiple locations in multiple years indicates excellent milling and baking properties which rival SY Monument in mixing tolerance and loaf volume.

Northern Growout: 2021 (Small-Scale) Samples

Test entry number	21-2401	21-2402	21-2403	21-2404
Sample identification	**Jagalene_CK**	**19NORD122_ND**	**19NORD127_ND**	**10BC329-17-5_AP**
Wheat Data				
GIPSA classification	1 HRW	1 HRW	2 HRW	1 HRW
Test weight (lb/bu)	62.4	60.9	59.7	60.2
Hectoliter weight (kg/hl)	82.0	80.1	78.6	79.2
1000 kernel weight (gm)	32.4	28.8	31.4	32.5
Wheat kernel size (Rotap)				
Over 7 wire (%)	77.1	68.3	65.0	65.5
Over 9 wire (%)	22.8	31.6	34.2	34.0
Through 9 wire (%)	0.1	0.1	0.8	0.5
Single kernel (skcs)[a]				
Hardness (avg /s.d)	79.2/18.6	78.1/18.7	80.9/18.3	69.0/18.7
Weight (mg) (avg/s.d)	32.4/10.8	28.8/10.0	31.4/11.1	32.5/10.8
Diameter (mm)(avg/s.d)	2.60/0.40	2.57/0.41	2.64/0.38	2.63/0.39
Moisture (%) (avg/s.d)	11.8/0.6	11.4/0.7	11.4/0.7	12.0/0.5
SKCS distribution	01-04-11-84-01	01-03-11-85-01	01-03-11-85-01	06-08-14-72-01
Classification	Hard	Hard	Hard	Hard
Wheat protein (12% mb)	12.5	13.0	12.8	12.8
Wheat ash (12% mb)	1.36	1.43	1.45	1.38
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	78.7	77.0	78.0	77.4
Quadrumat Sr. Mill	69.1	67.2	68.9	68.7
Flour moisture (%)	13.8	13.7	13.8	13.8
Flour protein (14% mb)	11.5	12.1	12.0	11.6
Flour ash (14% mb)	0.48	0.50	0.52	0.46
Rapid Visco-Analyser				
Peak time (min)	6.2	6.3	6.2	6.3
Peak viscosity (RVU)	190.4	207.1	195.4	217.5
Breakdown (RVU)	68.7	76.1	73.5	73.0
Final viscosity at 13 min (RVU)	229.5	235.8	226.0	260.5
Minolta color meter				
L*	90.62	91.04	90.78	90.76
a*	-1.32	-1.02	-1.06	-1.25
b*	9.40	7.95	8.34	8.67
PPO	0.454	0.579	0.405	0.756
Falling number (sec)	373	363	354	365
Damaged Starch				
(AI%)	97.8	96.4	96.3	97.4
(AACC76-31)	7.8	6.6	6.5	7.4

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

Northern Growout: 2021 (Small-Scale) Samples (continued)

Test entry number	21-2405	21-2406	21-2407
Sample identification	NHH17450_NE	NHH17612_NE	SD12DHA01373_SD
Wheat Data			
GIPSA classification	4 HRW	2 HRW	1 HRW
Test weight (lb/bu)	60.6	61.8	61.1
Hectoliter weight (kg/hl)	79.7	81.3	80.4
1000 kernel weight (gm)	33.0	31.6	30.0
Wheat kernel size (Rotap)			
Over 7 wire (%)	73.0	65.9	73.6
Over 9 wire (%)	26.8	33.7	25.9
Through 9 wire (%)	0.2	0.4	0.5
Single kernel (skcs)[a]			
Hardness (avg /s.d)	73.6/17.1	66.3/17.1	74.4/21.3
Weight (mg) (avg/s.d)	33.0/10.6	31.6/10.1	30.0/10.0
Diameter (mm)(avg/s.d)	2.67/0.41	2.70/0.38	2.57/0.39
Moisture (%) (avg/s.d)	11.7/0.6	11.5/0.7	11.5/0.6
SKCS distribution	01-04-14-81-01	03-10-22-65-01	03-06-13-78-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb)	12.5	13.0	13.0
Wheat ash (12% mb)	1.37	1.42	1.43
Milling and Flour Quality Data			
Flour yield (%, str. grade)			
Miag Multomat Mill	77.5	76.6	76.7
Quadrumat Sr. Mill	68.9	68.5	69.0
Flour moisture (%)	14.4	14.1	13.9
Flour protein (14% mb)	11.5	11.8	12.0
Flour ash (14% mb)	0.49	0.47	0.50
Rapid Visco-Analyser			
Peak time (min)	6.3	6.1	6.3
Peak viscosity (RVU)	212.9	208.0	203.5
Breakdown (RVU)	76.1	71.8	64.9
Final viscosity at 13 min (RVU)	246.7	254.2	254.2
Minolta color meter			
L*	90.96	90.51	91.06
a*	-1.29	-1.29	-1.26
b*	8.71	8.46	8.17
PPO	0.692	0.717	0.707
Falling number (sec)	385	373	383
Damaged Starch			
(AI%)	96.0	97.4	97.0
(AACC76-31)	6.3	7.4	7.0

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

Northern Growout: 2021 (Small-Scale) Samples (continued)

Test entry number	21-2408	21-2409	21-2410
Sample identification	**SD15035-2_SD**	**LCH18-7071_LG**	**SY Monument_CK**
Wheat Data			
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	61.8	60.3	60.8
Hectoliter weight (kg/hl)	81.3	79.3	80.0
1000 kernel weight (gm)	34.3	30.9	29.7
Wheat kernel size (Rotap)			
Over 7 wire (%)	69.6	55.5	77.6
Over 9 wire (%)	29.8	43.4	22.1
Through 9 wire (%)	0.6	1.1	0.3
Single kernel (skcs)[a]			
Hardness (avg /s.d)	82.1/16.4	75.0/17.1	64.7/19.3
Weight (mg) (avg/s.d)	34.3/10.7	30.9/9.9	29.7/11.4
Diameter (mm)(avg/s.d)	2.74/0.35	2.63/0.43	2.51/0.41
Moisture (%) (avg/s.d)	11.9/0.5	11.9/0.6	11.8/0.6
SKCS distribution	01-03-04-92-01	01-03-16-80-01	05-11-19-65-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb)	13.0	12.1	11.9
Wheat ash (12% mb)	1.40	1.51	1.33
Milling and Flour Quality Data			
Flour yield (%, str. grade)			
Miag Multomat Mill	77.2	76.9	77.3
Quadrumat Sr. Mill	68.7	67.3	69.6
Flour moisture (%)	13.7	13.5	13.7
Flour protein (14% mb)	12.1	11.0	10.9
Flour ash (14% mb)	0.49	0.57	0.54
Rapid Visco-Analyser			
Peak time (min)	6.2	6.2	6.1
Peak viscosity (RVU)	183.3	213.9	207.3
Breakdown (RVU)	56.1	81.1	78.2
Final viscosity at 13 min (RVU)	236.3	240.3	246.7
Minolta color meter			
L*	90.75	90.80	90.06
a*	-1.90	-1.43	-1.06
b*	7.28	9.24	8.79
PPO	0.681	0.750	0.361
Falling number (sec)	398	396	386
Damaged Starch			
(AI%)	97.8	97.8	98.0
(AACC76-31)	7.7	7.7	7.9

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

Northern Growout: Physical Dough Tests and Gluten Analysis 2021 (Small-Scale) Samples

Test Entry Number	21-2401	21-2402	21-2403	21-2404
Sample Identification	Jagalene_CK	19NORD122_ND	19NORD127_ND	10BC329-17-5_AP
MIXOGRAPH				
Flour Abs (% as-is)	64.9	66.5	64.7	61.3
Flour Abs (14% mb)	64.7	66.2	64.4	61.1
Mix Time (min)	4.9	3.8	3.1	6.0
Mix tolerance (0-6)	5	2	1	3
FARINOGRAPH				
Flour Abs (% as-is)	63.1	62.6	62.8	61.0
Flour Abs (14% mb)	62.0	62.2	62.4	60.8
Peak time (min)	4.8	6.0	5.9	12.0
Mix stability (min)	11.5	11.9	8.2	20.4
Mix Tolerance Index (FU)	19	19	28	12
Breakdown time (min)	12.6	14.6	11.1	22.0
ALVEOGRAPH				
P(mm): Tenacity	126	99	99	112
L(mm): Extensibility	62	65	76	52
G(mm): Swelling index	17.5	17.9	19.4	16.0
W(10^{-4} J): strength (curve area)	310	233	243	238
P/L: curve configuration ratio	2.03	1.52	1.30	2.15
Ie(P_{200}/P): elasticity index	60.0	52.9	49.7	57.7
EXTENSIGRAPH				
Resist (BU at 45/90/135 min)	457/635/637	275/370/433	248/340/338	368/637/806
Extensibility (mm at 45/90/135 min)	142/135/142	137/141/132	136/137/133	124/113/88
Energy (cm^2 at 45/90/135 min)	115/152/160	65/93/96	57/80/75	72/105/88
Resist $_{max}$ (BU at 45/90/135min)	642/932/957	353/506/568	307/437/411	441/762/861
Ratio (at 45/90/135 min)	3.2/4.7/4.5	2.0/2.6/3.3	1.8/2.5/2.5	3.0/5.6/9.2
PROTEIN ANALYSIS				
HMW-GS Composition	1,2*, 17+18, 5+10	1,2*, 7+8, 5+10	1,2*, 7+8, 5+10	2*, 7+9, 5+10
TPP/TMP	0.83	0.72	0.66	0.59
SEDIMENTATION TEST				
Volume (ml)	61.4	59.8	51.3	44.9

Northern Growout: Physical Dough Tests and Gluten Analysis 2021 (Small-Scale) Samples (continued)

Test Entry Number	21-2405	21-2406	21-2407
Sample Identification	NHH17450_NE	NHH17612_NE	SD12DHA01373_SD
MIXOGRAPH			
Flour Abs (% as-is)	64.3	66.3	66.0
Flour Abs (14% mb)	64.7	66.5	66.0
Mix Time (min)	3.5	5.6	5.9
Mix tolerance (0-6)	3	5	5
FARINOGRAPH			
Flour Abs (% as-is)	61.2	61.7	61.8
Flour Abs (14% mb)	61.7	61.9	61.8
Peak time (min)	6.5	6.5	7.5
Mix stability (min)	9.3	15.5	14.1
Mix Tolerance Index (FU)	35	22	20
Breakdown time (min)	10.6	15.6	15.4
ALVEOGRAPH			
P(mm): Tenacity	102	135	116
L(mm): Extensibility	70	50	75
G(mm): Swelling index	18.6	15.7	19.2
W(10^{-4} J): strength (curve area)	245	286	334
P/L: curve configuration ratio	1.46	2.70	1.55
Ie(P_{200}/P): elasticity index	51.1	60.0	61.8
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	311/405/447	517/651/748	504/682/755
Extensibility (mm at 45/90/135 min)	151/149/139	144/126/121	138/127/131
Energy (cm^2 at 45/90/135 min)	83/113/111	136/138/143	122/145/153
Resist $_{max}$ (BU at 45/90/135min)	415/594/644	764/905/980	710/946/945
Ratio (at 45/90/135 min)	2.1/2.7/3.2	3.6/5.2/6.2	3.6/5.4/5.8
PROTEIN ANALYSIS			
HMW-GS Composition	1,2*, 7+8, 5+10	1, 7+8, 5+10	2*, 7+8, 5+10
TPP/TMP	0.82	0.76	0.92
SEDIMENTATION TEST			
Volume (ml)	52.2	60.1	66.0

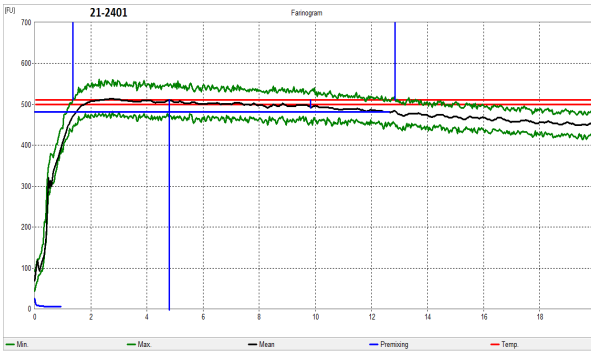
Northern Growout: Physical Dough Tests and Gluten Analysis 2021 (Small-Scale) Samples (continued)

Test Entry Number	21-2408	21-2409	21-2410
Sample Identification	SD15035-2_SD	LCH18-7071_LG	SY Monument_CK
MIXOGRAPH			
Flour Abs (% as-is)	67.8	65.8	66.0
Flour Abs (14% mb)	67.5	65.3	65.7
Mix Time (min)	5.4	5.9	7.1
Mix tolerance (0-6)	5	6	6
FARINOGRAPH			
Flour Abs (% as-is)	64.8	62.7	63.1
Flour Abs (14% mb)	64.4	62.2	62.7
Peak time (min)	7.1	8.5	10.8
Mix stability (min)	14.1	15.2	19.2
Mix Tolerance Index (FU)	18	25	21
Breakdown time (min)	14.7	14.3	20.3
ALVEOGRAPH			
P(mm): Tenacity	148	141	148
L(mm): Extensibility	48	46	30
G(mm): Swelling index	15.4	15.1	12.2
W(10^{-4} J): strength (curve area)	299	269	203
P/L: curve configuration ratio	3.08	3.07	4.03
Ie(P_{200}/P): elasticity index	57.4	53.5	0.0
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	456/567/607	501/729/728	631/838/872
Extensibility (mm at 45/90/135 min)	148/130/140	136/125/120	146/124/125
Energy (cm^2 at 45/90/135 min)	121/128/146	124/151/137	174/168/173
Resist $_{max}$ (BU at 45/90/135min)	662/817/855	727/1023/960	963/1110/1144
Ratio (at 45/90/135 min)	3.1/4.4/4.3	3.7/5.9/6.1	4.3/6.8/7.0
PROTEIN ANALYSIS			
HMW-GS Composition	1, 7+8, 5+10	2*, 7+8, 5+10	2*, 7+9, 5+10
TPP/TMP	0.77	0.97	0.79
SEDIMENTATION TEST			
Volume (ml)	64.8	56.7	59.8

Physical Dough Tests – Farino and Mixo

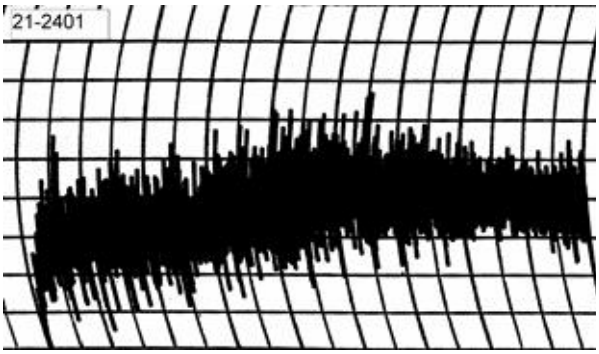
2021 (Small Scale) Samples – Northern Growout

Farinograms



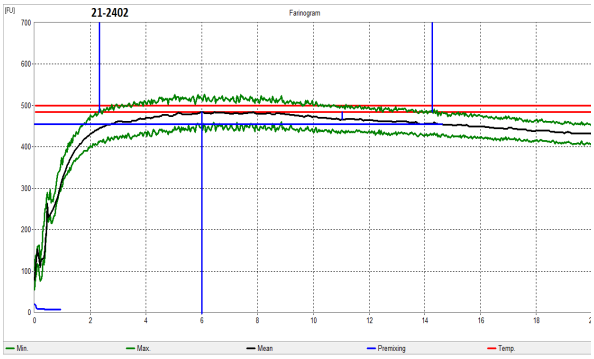
Water abs = 62.9%, Peak time = 4.8 min,
Mix stab = 11.5 min, MTI = 19 FU

Mixograms

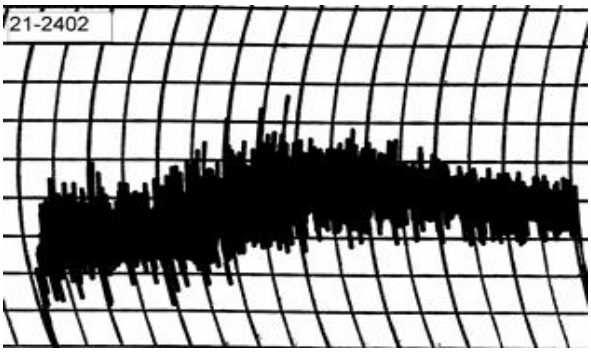


Water abs = 64.7%
Mix time = 4.9 min

21-2401, Jagalene_CK



Water abs = 62.2%, Peak time = 6.0 min,
Mix stab = 11.9 min, MTI = 19 FU



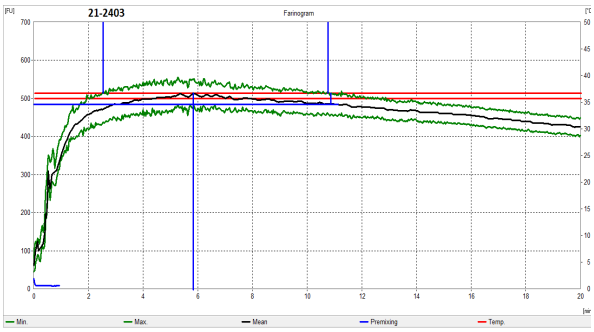
Water abs = 66.2%
Mix time = 3.8 min

21-2402, 19NORD122_ND

Physical Dough Tests – Farino and Mixo

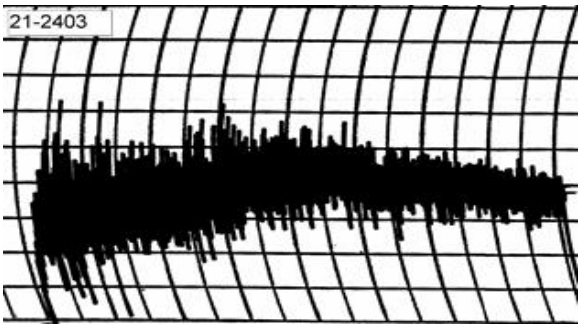
2021 (Small Scale) Samples – Northern Growout (Continued)

Farinograms



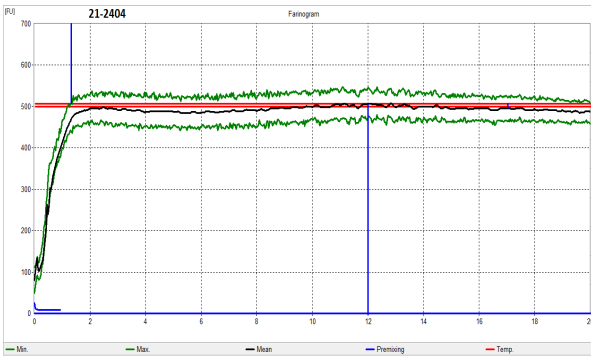
Water abs = 62.4%, Peak time = 5.9 min,
Mix stab = 8.2 min, MTI = 28 FU

Mixograms

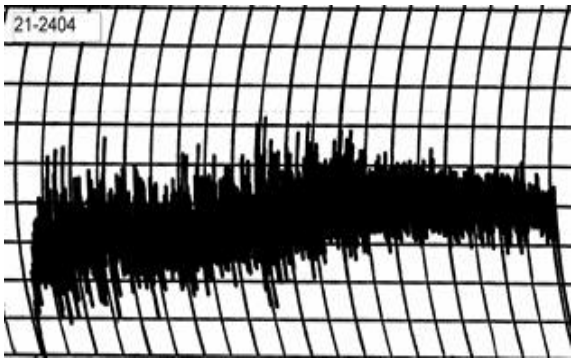


Water abs = 64.4%
Mix time = 3.1 min

21-2403, 19NORD127_ND



Water abs = 60.8%, Peak time = 12.0 min,
Mix stab = 20.4 min, MTI = 12 FU



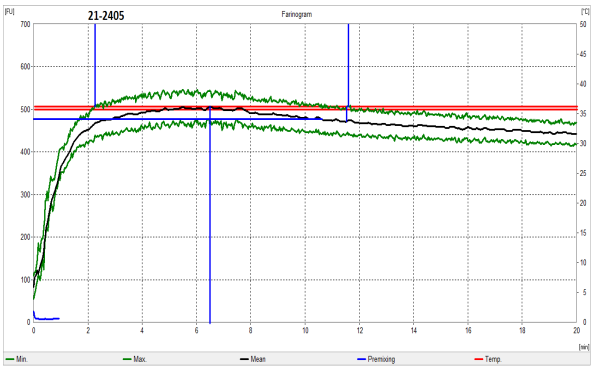
Water abs = 61.1%
Mix time = 6.0 min

21-2404, 10BC329-17-5_AP

Physical Dough Tests – Farino and Mixo

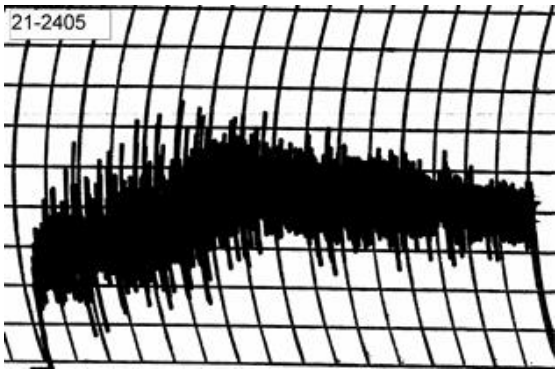
2021 (Small Scale) Samples – Northern Growout (Continued)

Farinograms



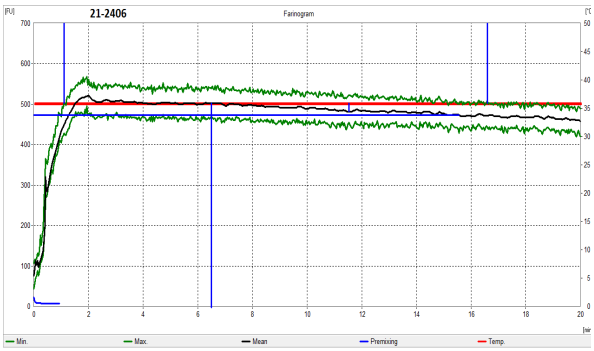
Water abs = 61.7%, Peak time = 6.5 min,
Mix stab = 9.3 min, MTI = 35 FU

Mixograms

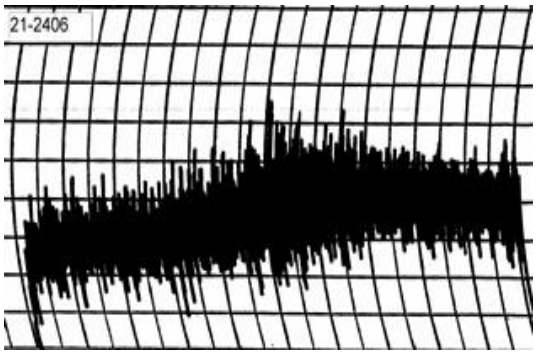


Water abs = 64.7%
Mix time = 3.5 min

21-2405, NHH17450_NE



Water abs = 61.9%, Peak time = 6.5 min,
Mix stab = 15.5 min, MTI = 22 FU



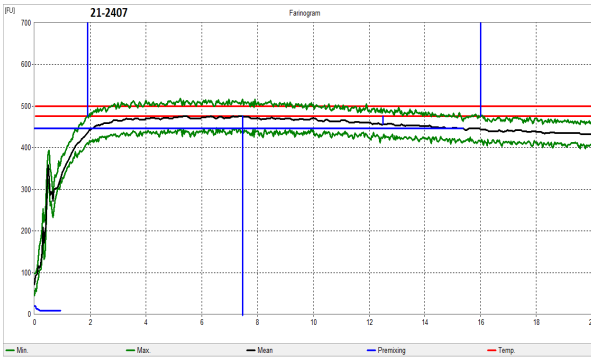
Water abs = 66.5%
Mix time = 5.6min

21-2406, NHH17612_NE

Physical Dough Tests – Farino and Mixo

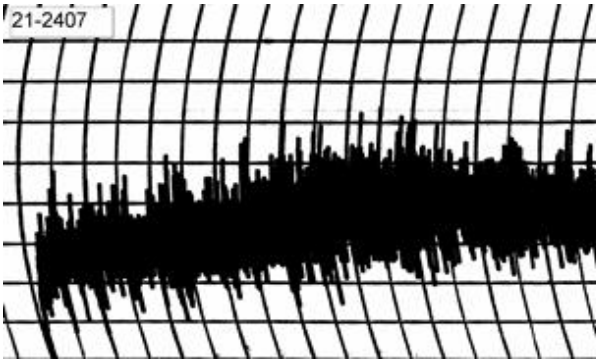
2021 (Small Scale) Samples – Northern Growout (Continued)

Farinograms



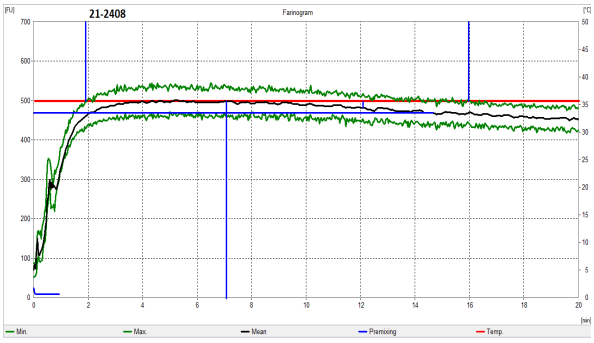
Water abs = 61.8%, Peak time = 7.5 min,
Mix stab = 14.1 min, MTI = 20 FU

Mixograms

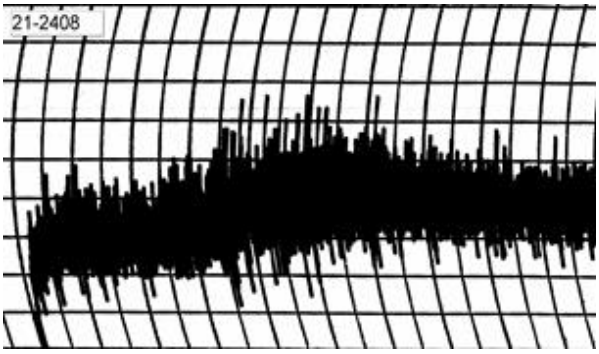


Water abs = 66.0%
Mix time = 5.9 min

21-2407, SD12DHA01373_SD



Water abs = 64.4%, Peak time = 7.1 min,
Mix stab = 14.1 min, MTI = 18 FU



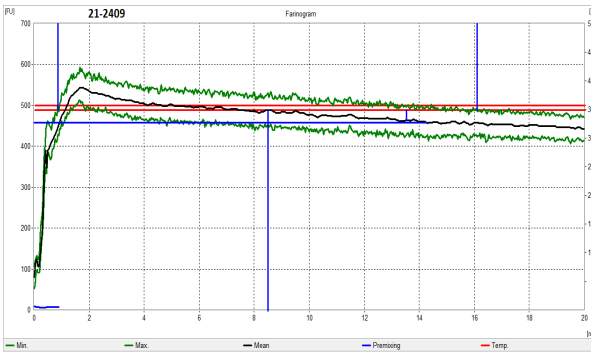
Water abs = 67.5%
Mix time = 5.4 min

21-2408, SD15035-2_SD

Physical Dough Tests – Farino and Mixo

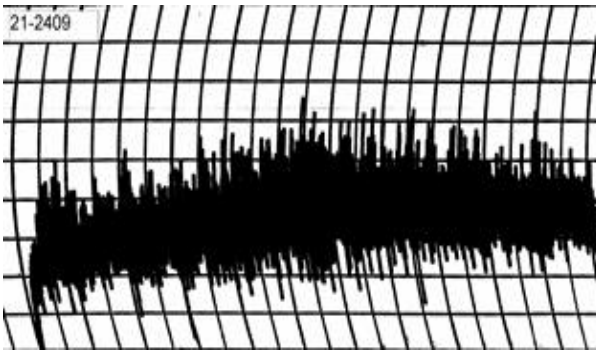
2021 (Small Scale) Samples – Northern Growout (Continued)

Farinograms



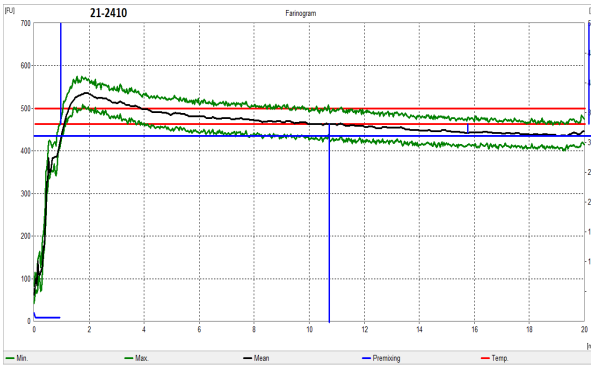
Water abs = 62.2%, Peak time = 8.5 min,
Mix stab = 15.2 min, MTI = 25 FU

Mixograms

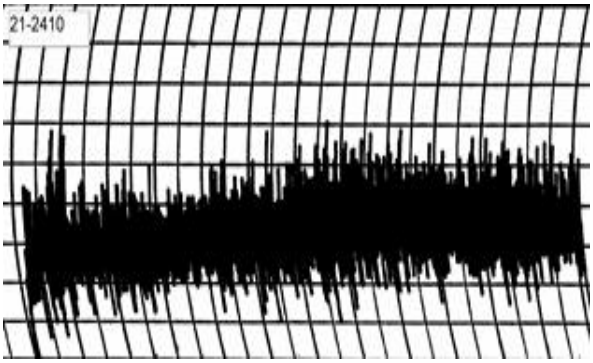


Water abs = 65.3%
Mix time = 5.9 min

21-2409, LCH18-7071_LG



Water abs = 62.7%, Peak time = 10.8 min,
Mix stab = 19.2 min, MTI = 21 FU

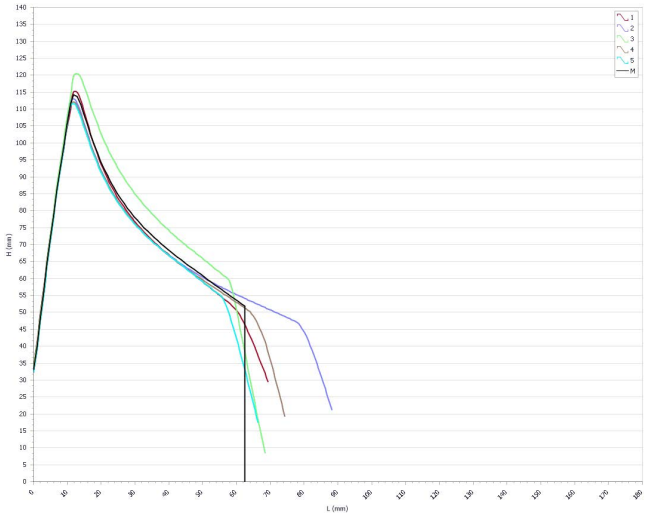


Water abs = 65.7%
Mix time = 7.1 min

21-2410, SY Monument_CK

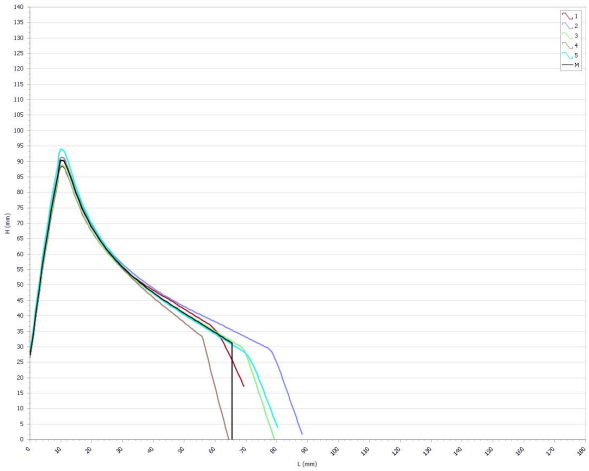
Physical Dough Tests - Alveograms

2021 (Small Scale) Samples – Northern Growout



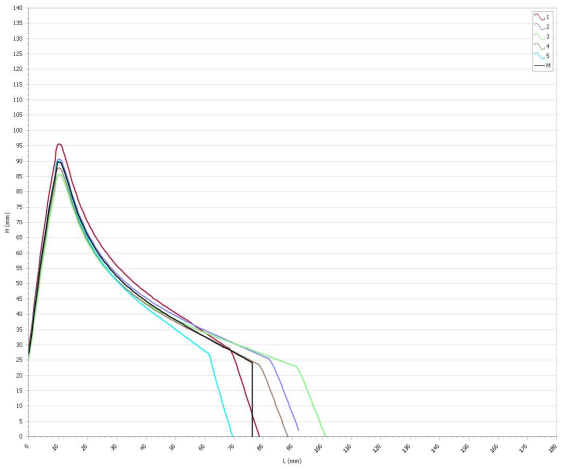
21-2401, Jagalene_CK

P(mm H_20) =126, L(mm) = 62, W($10E^{-4}$ J) = 310



21-2402, 19NORD122_ND

P(mm H_20) =99, L(mm) = 65, W($10E^{-4}$ J) = 233

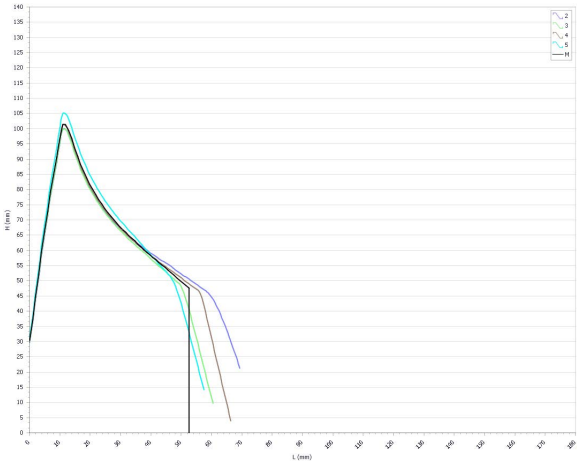


21-2403, 19NORD127_ND

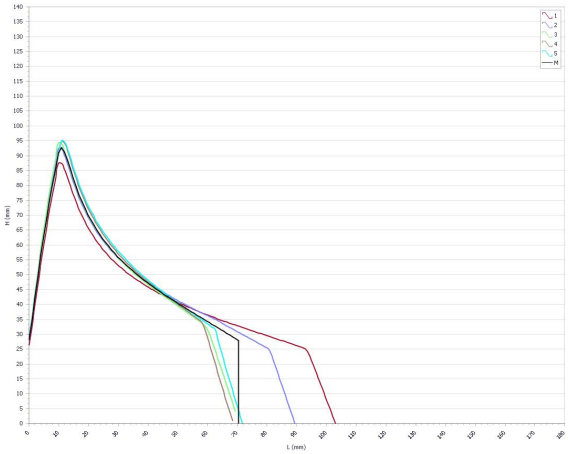
P(mm H_20) =99, L(mm) = 76, W($10E^{-4}$ J) = 243

Physical Dough Tests - Alveograms

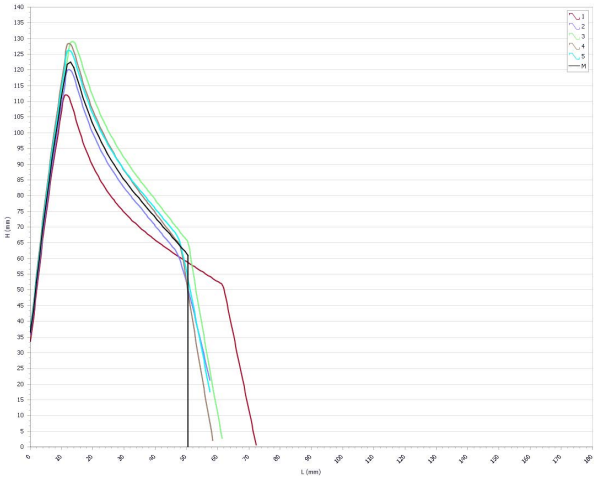
2021 (Small Scale) Samples – Northern Growout



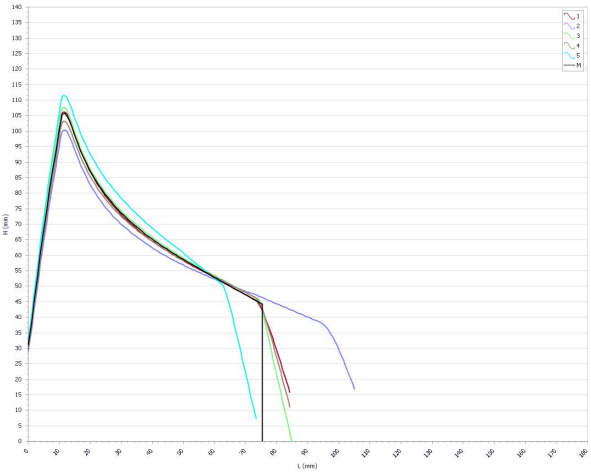
21-2404, 10BC329-17-5_AP
P(mm H_20) = 112, L(mm) = 52, W($10E^{-4}$ J) = 238



21-2405, NHH17450_NE
P(mm H_20) = 102, L(mm) = 70, W($10E^{-4}$ J) = 245



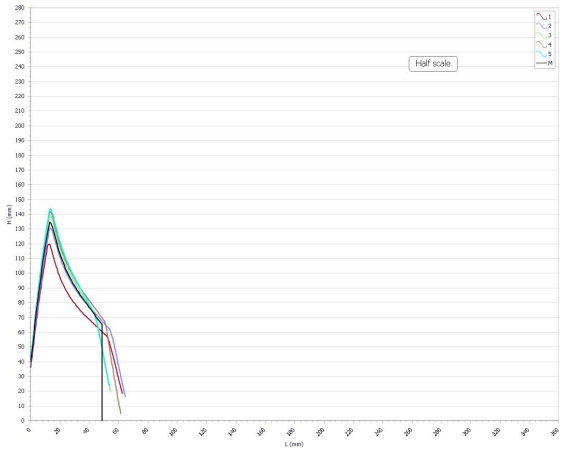
21-2406, NHH17612_NE
P(mm H_20) = 135, L(mm) = 50, W($10E^{-4}$ J) = 286



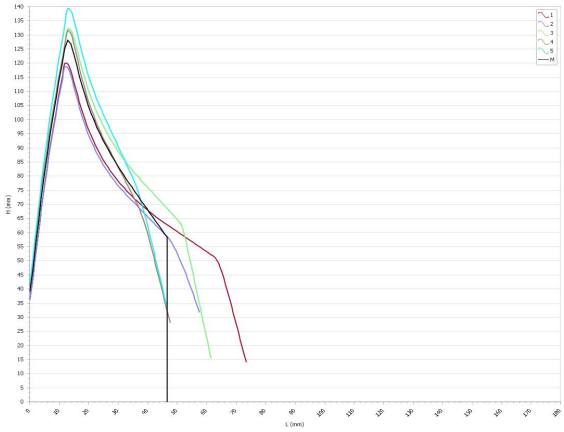
21-2407, SD12DHA01373_SD
P(mm H_20) = 116, L(mm) = 75, W($10E^{-4}$ J) = 334

Physical Dough Tests - Alveograms

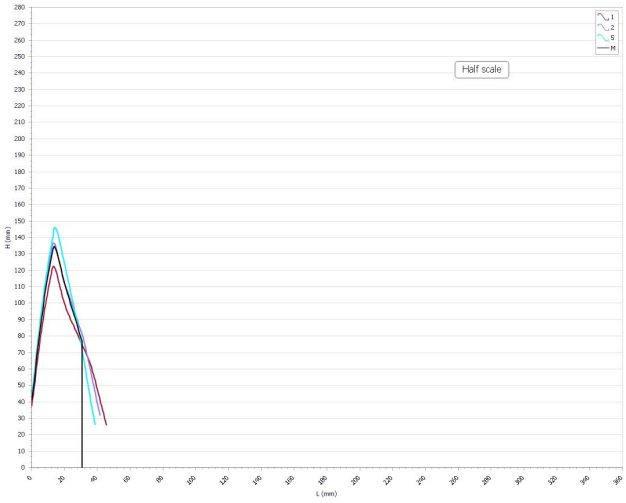
2021 (Small Scale) Samples – Northern Growout



21-2408, SD15035-2_SD
P(mm H_20) = 148, L(mm) = 48, W($10E^{-4}$ J) = 299



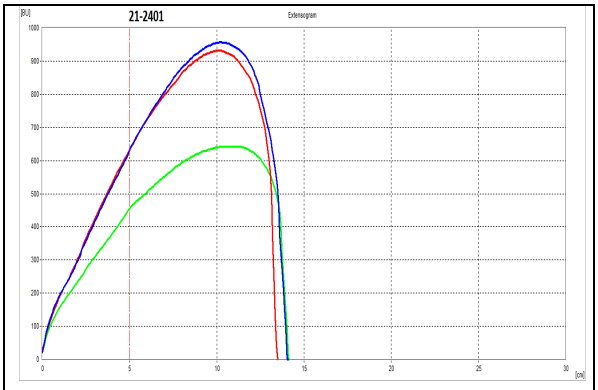
21-2409, LCH18-7071_LG
P(mm H_20) = 141, L(mm) = 46, W($10E^{-4}$ J) = 269



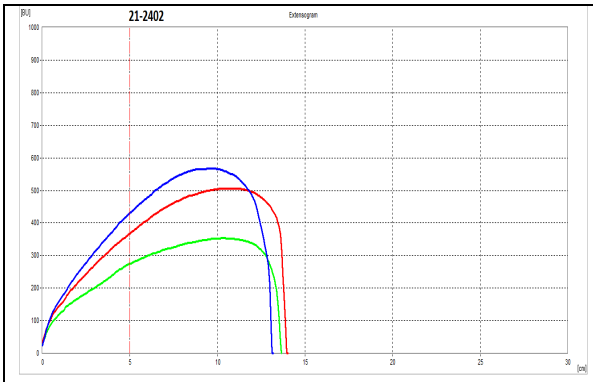
21-2410, SY Monument_CK
P(mm H_20) = 148, L(mm) = 30, W($10E^{-4}$ J) = 203

Physical Dough Tests - Extensigrams

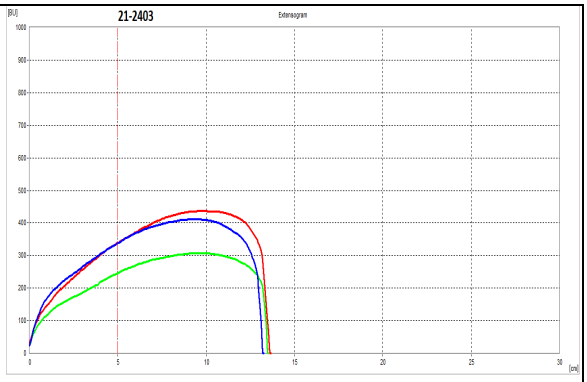
2021 (Small Scale) Samples – Northern Growout



21-2401, Jagalene_CK
R (BU) =635, E (mm) = 135, W (cm^2) = 152
Rmax (BU) = 932, Ratio = 4.7 at 90 min



21-2402, 19NORD122_ND
R (BU) =370, E (mm) = 141, W (cm^2) = 93
Rmax (BU) = 506, Ratio = 2.6 at 90 min

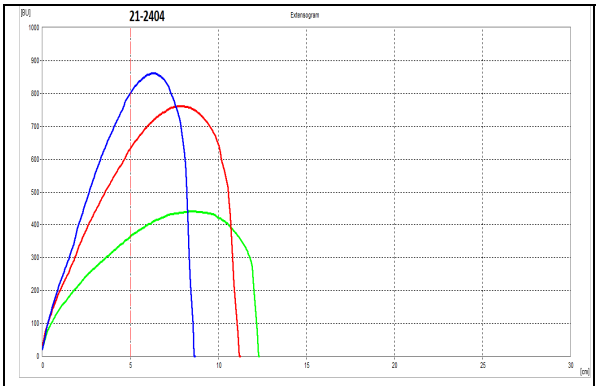


21-2403, 19NORD127_ND
R (BU) = 340, E (mm) = 137, W (cm^2) = 80
Rmax (BU) = 437, Ratio = 2.5 at 90 min

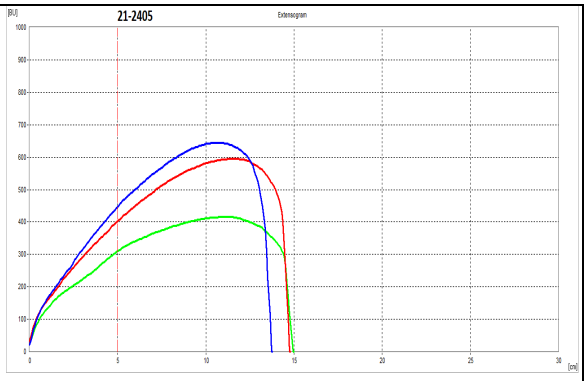
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigrams

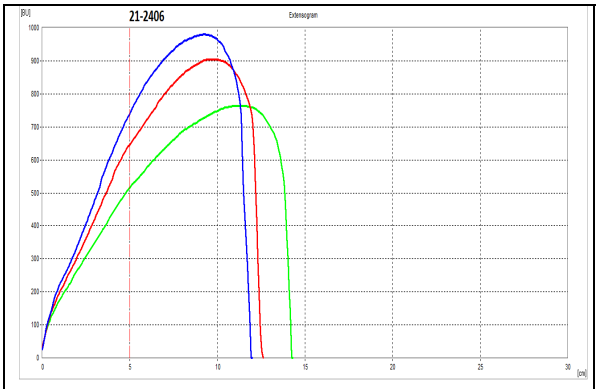
2021 (Small Scale) Samples – Northern Growout



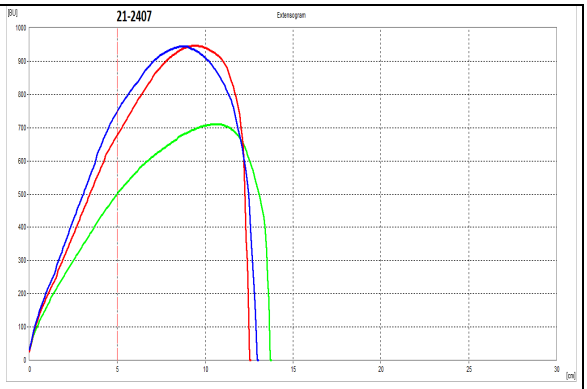
21-2404, 10BC329-17-5_AP
R (BU) = 637, E (mm) = 113, W (cm^2) = 105
Rmax (BU) = 762, Ratio = 5.6 at 90 min



21-2405, NHH17450_NE
R (BU) = 405, E (mm) = 149, W (cm^2) = 113
Rmax (BU) = 594, Ratio = 2.7 at 90 min



21-2406, NHH17612_NE
R (BU) = 651, E (mm) = 126, W (cm^2) = 138
Rmax (BU) = 905, Ratio = 5.2 at 90 min

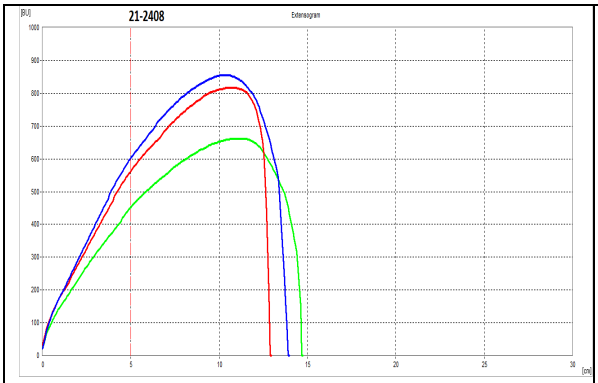


21-2407, SD12DHA01373_SD
R (BU) = 682, E (mm) = 127, W (cm^2) = 145
Rmax (BU) = 946, Ratio = 5.4 at 90 min

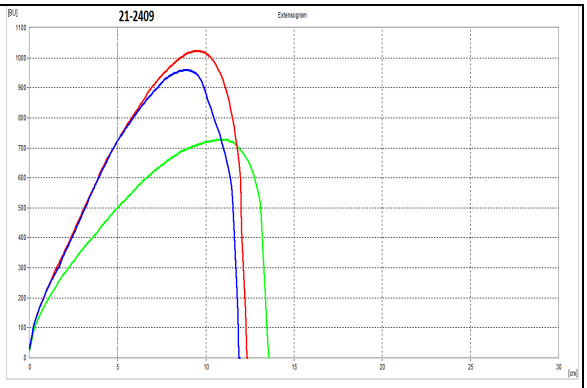
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigrams

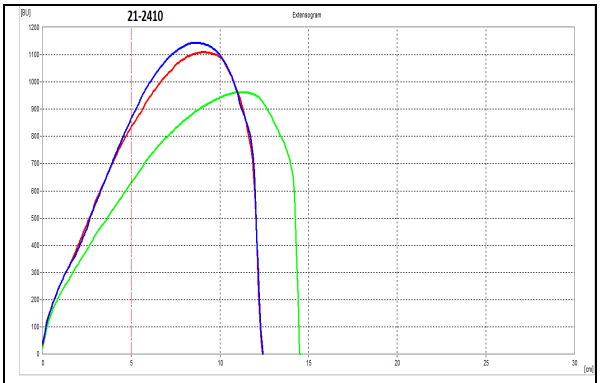
2021 (Small Scale) Samples – Northern Growout



21-2408, SD15035-2_SD
R (BU) = 567, E (mm) = 130, W (cm^2) = 129
Rmax (BU) = 817, Ratio = 4.4 at 90 min



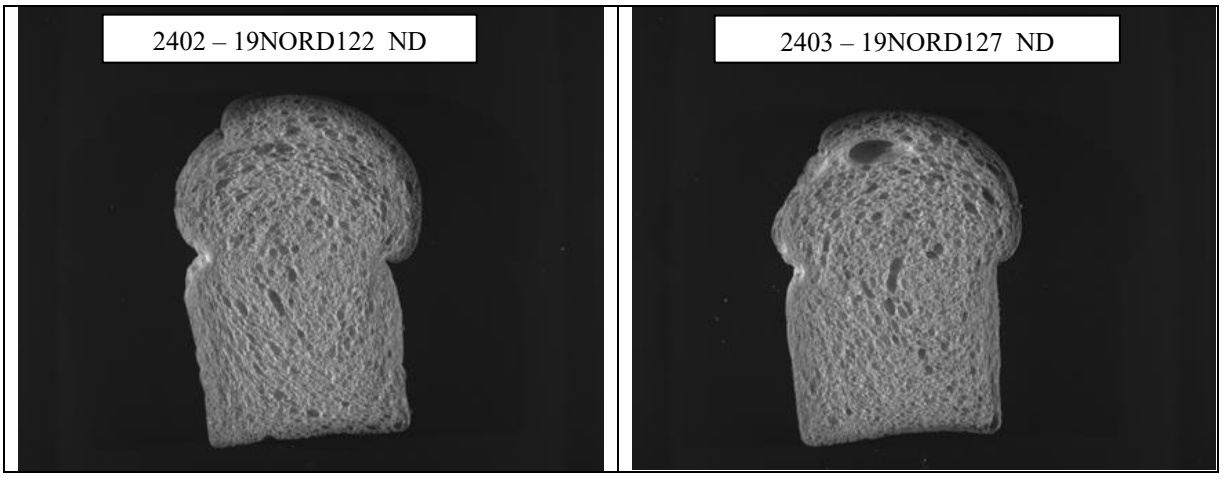
21-2409, LCH18-7071_LG
R (BU) = 729, E (mm) = 125, W (cm^2) = 151
Rmax (BU) = 1023, Ratio = 5.9 at 90 min



21-2410, SY Monument_CK
R (BU) = 838, E (mm) = 124, W (cm^2) = 168
Rmax (BU) = 1110, Ratio = 6.8 at 90 min

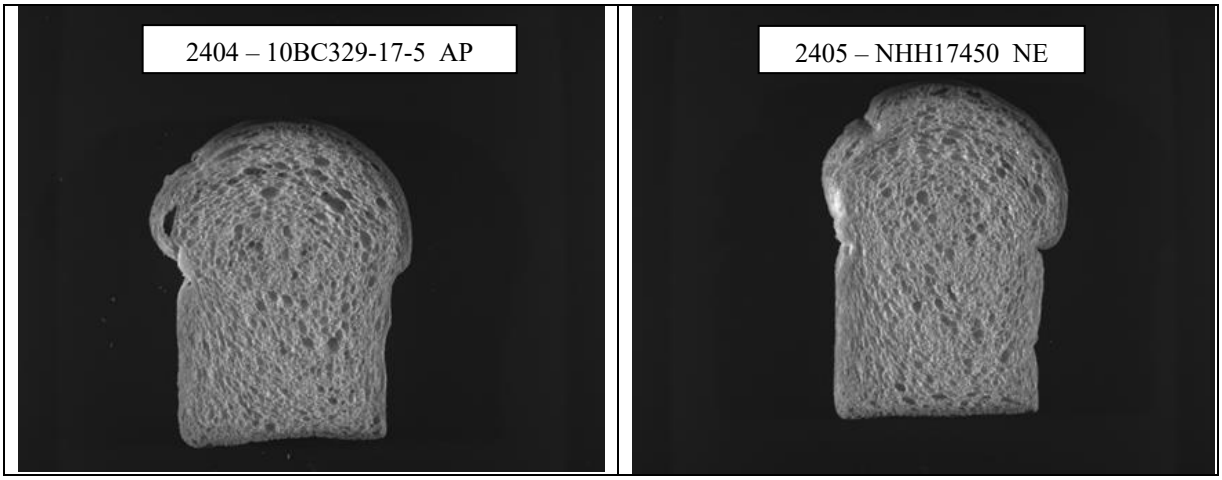
Northern Growout: C-Cell Bread Images and Analysis
2021 (Small-Scale) Samples

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	6448	113	3885	0.423	1.960	5.695	1.805	-6.10

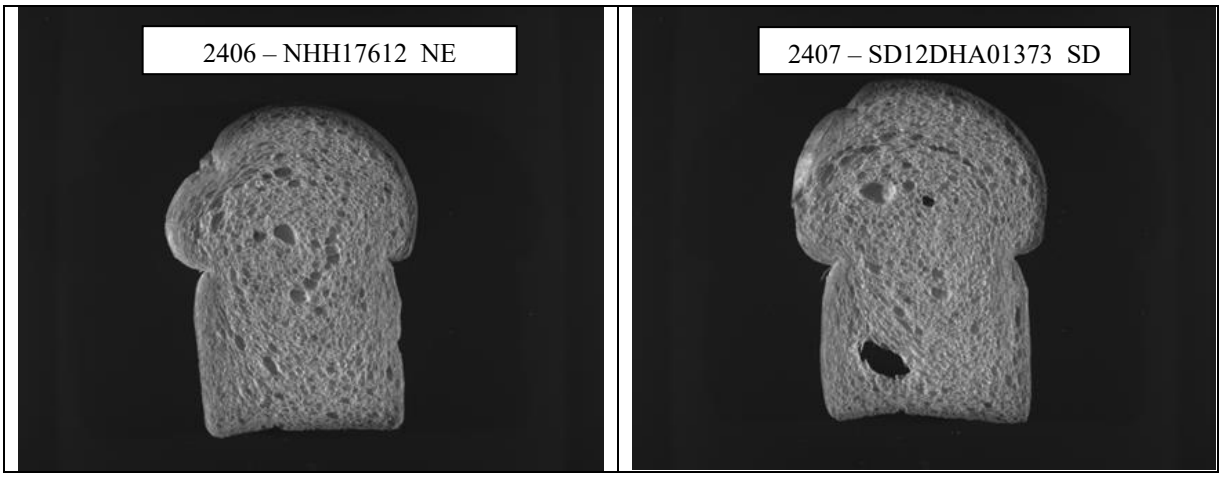


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2402	6963	113	3927	0.428	2.163	11.20	1.788	-5.55
2403	6551	114	4037	0.420	1.990	3.693	1.765	-3.70

Northern Growout: C-Cell Bread Images and Analysis
2021 (Small-Scale) Samples

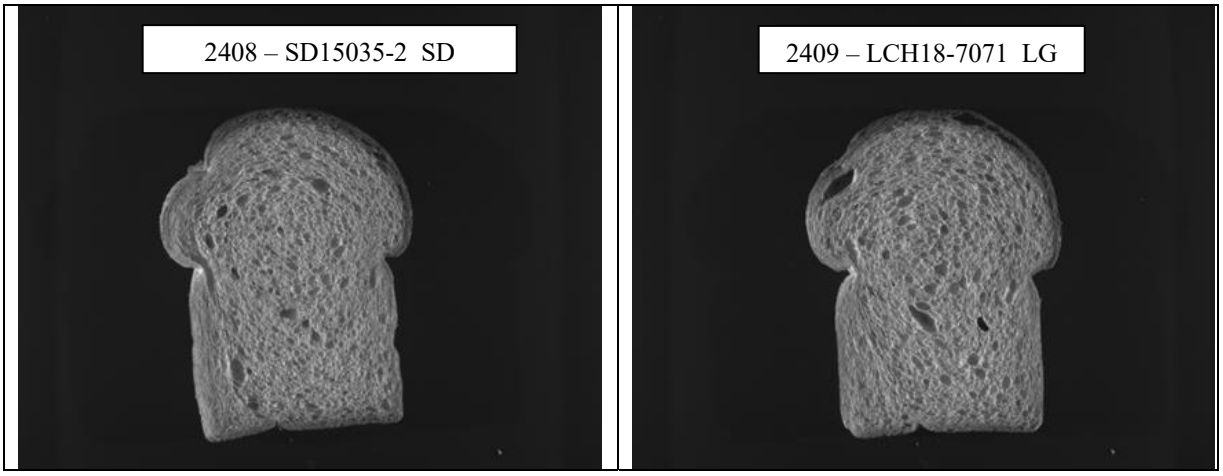


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2404	6473	114	4000	0.420	2.020	2.688	1.790	-7.40
2405	6779	116	4.62	0.428	2.008	3.153	1.788	-7.90



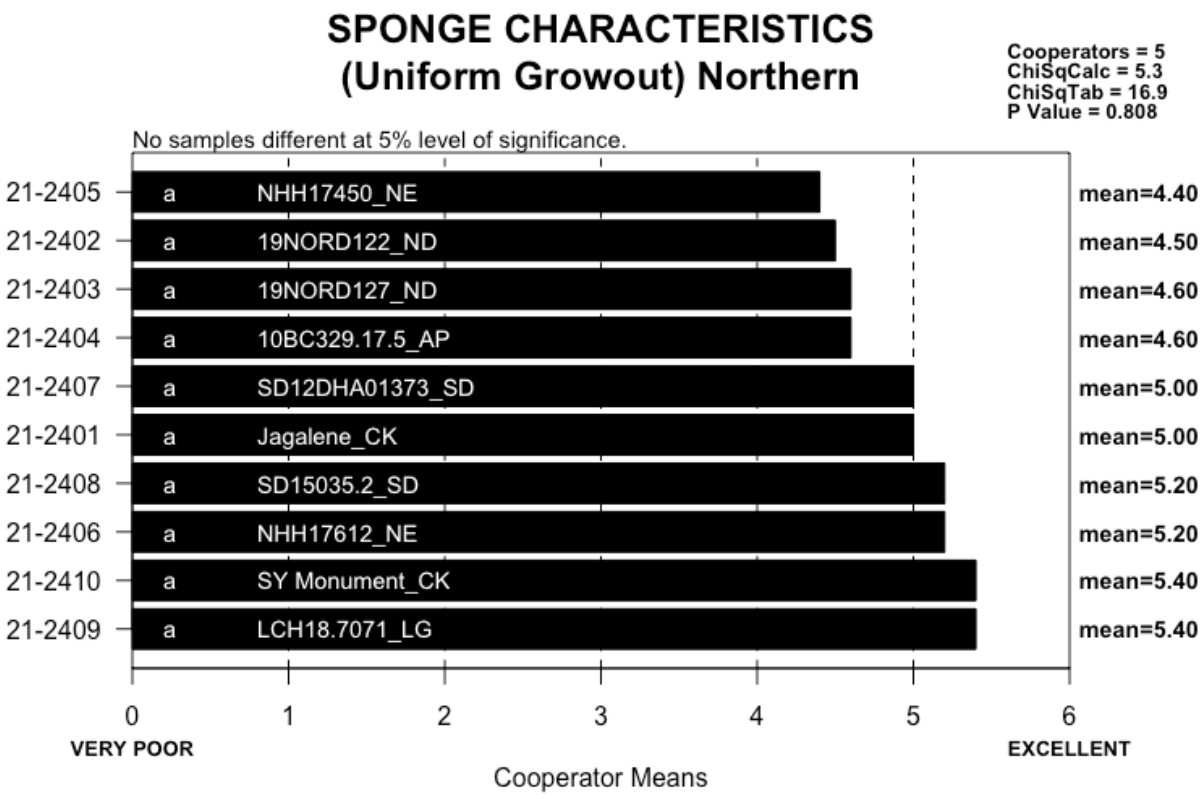
Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2406	6658	111	4107	0.418	1.878	1.925	1.800	-6.23
2407	7055	112	4182	0.423	2.025	14.47	1.753	-10.0

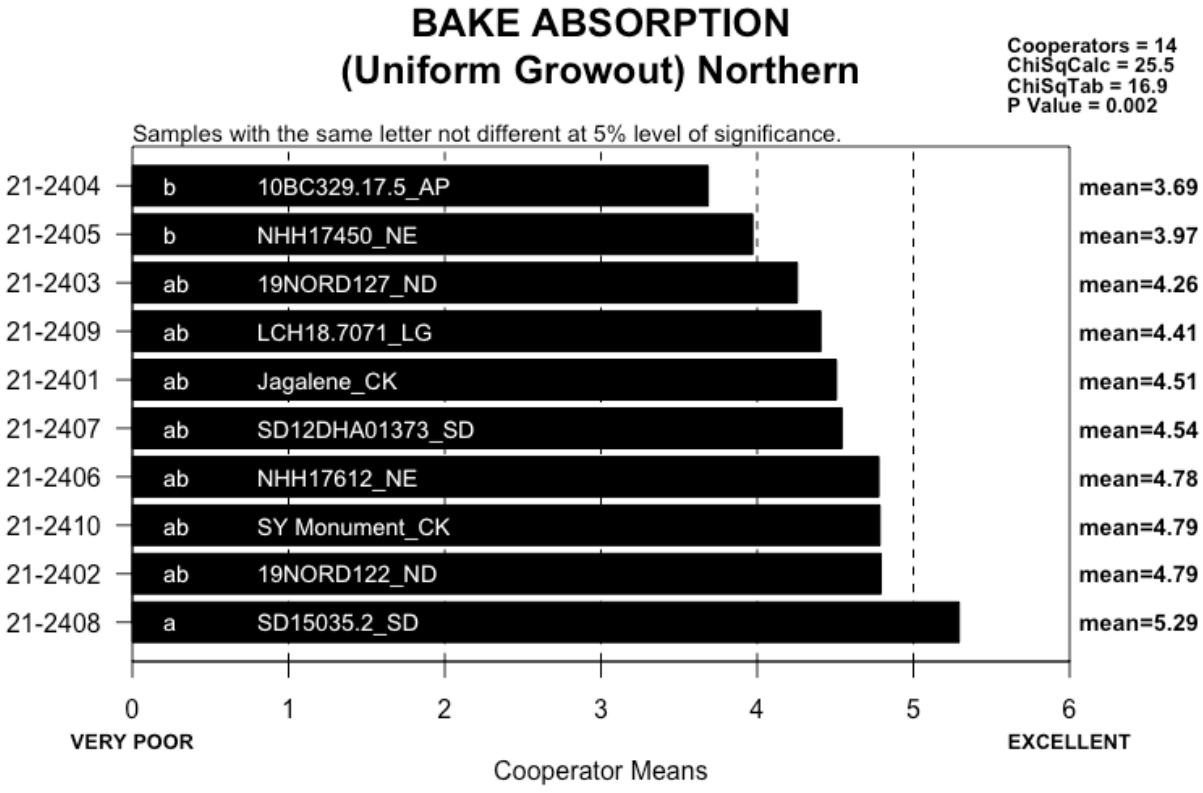
Northern Growout: C-Cell Bread Images and Analysis
2021 (Small-Scale) Samples



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})
2408	6678	114	4258	0.408	1.855	0.783	1.798	-4.80
2409	6459	111	3887	0.420	1.928	2.420	1.808	-3.95

Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2410	6038	106	3754	0.420	1.880	6.935	1.833	-5.38


SPONGE CHARACTERISTICS
(Uniform Growout) Northern
Cooperators = 5
ChiSqCalc = 5.3
ChiSqTab = 16.9
P Value = 0.808
No samples different at 5% level of significance.
21-2405 a NHH17450_NE mean=4.40
21-2402 a 19NORD122_ND mean=4.50
21-2403 a 19NORD127_ND mean=4.60
21-2404 a 10BC329.17.5_AP mean=4.60
21-2407 a SD12DHA01373_SD mean=5.00
21-2401 a Jagalene_CK mean=5.00
21-2408 a SD15035.2_SD mean=5.20
21-2406 a NHH17612_NE mean=5.20
21-2410 a SY Monument_CK mean=5.40
21-2409 a LCH18.7071_LG mean=5.40
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

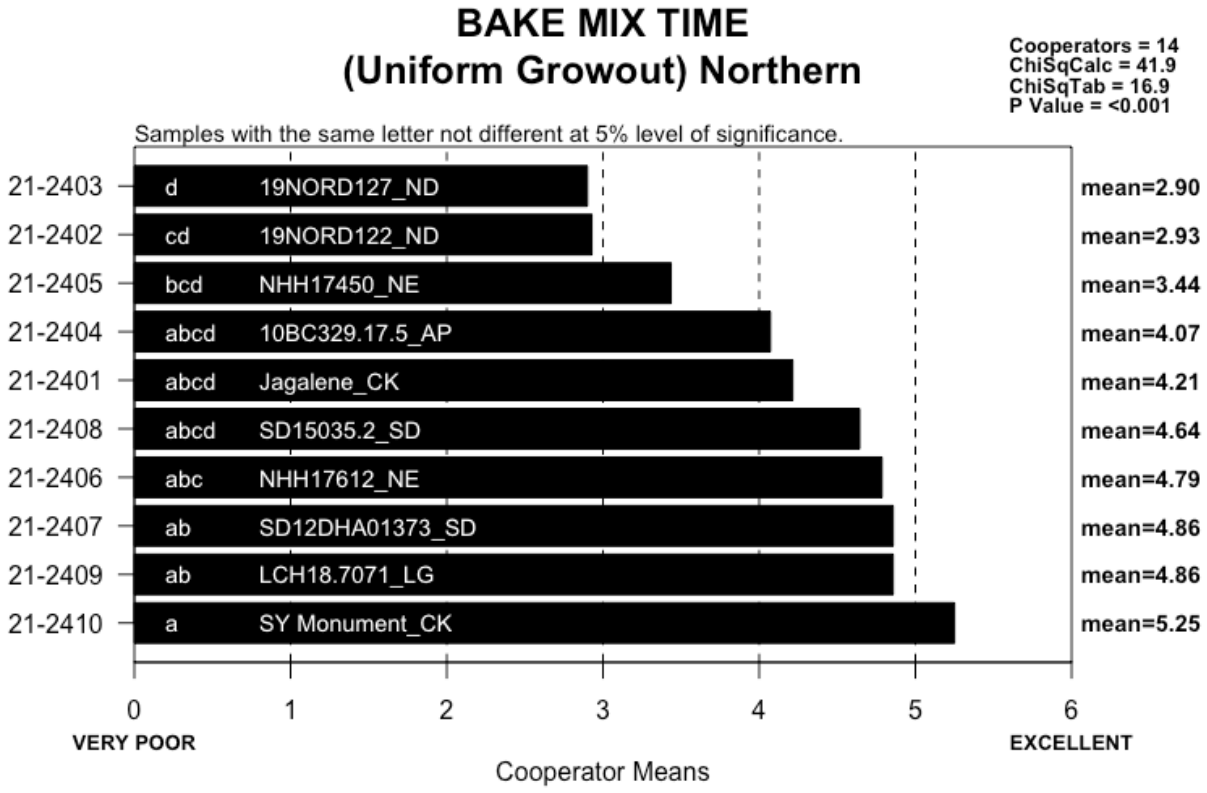

BAKE ABSORPTION
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 25.5
ChiSqTab = 16.9
P Value = 0.002
Samples with the same letter not different at 5% level of significance.
21-2404 b 10BC329.17.5_AP mean=3.69
21-2405 b NHH17450_NE mean=3.97
21-2403 ab 19NORD127_ND mean=4.26
21-2409 ab LCH18.7071_LG mean=4.41
21-2401 ab Jagalene_CK mean=4.51
21-2407 ab SD12DHA01373_SD mean=4.54
21-2406 ab NHH17612_NE mean=4.78
21-2410 ab SY Monument_CK mean=4.79
21-2402 ab 19NORD122_ND mean=4.79
21-2408 a SD15035.2_SD mean=5.29
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

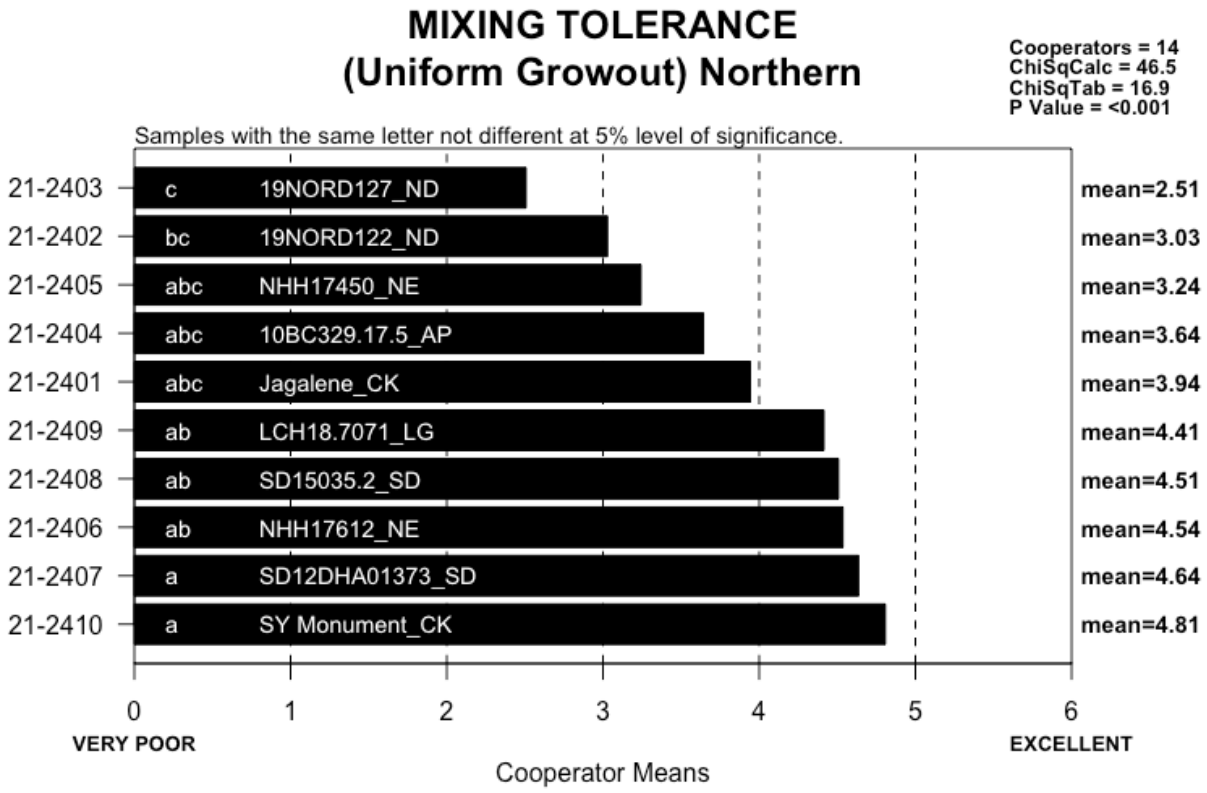
BAKE ABSORPTION, ACTUAL (14% MB)
(Uniform Growout) Northern
Cooperators A – N

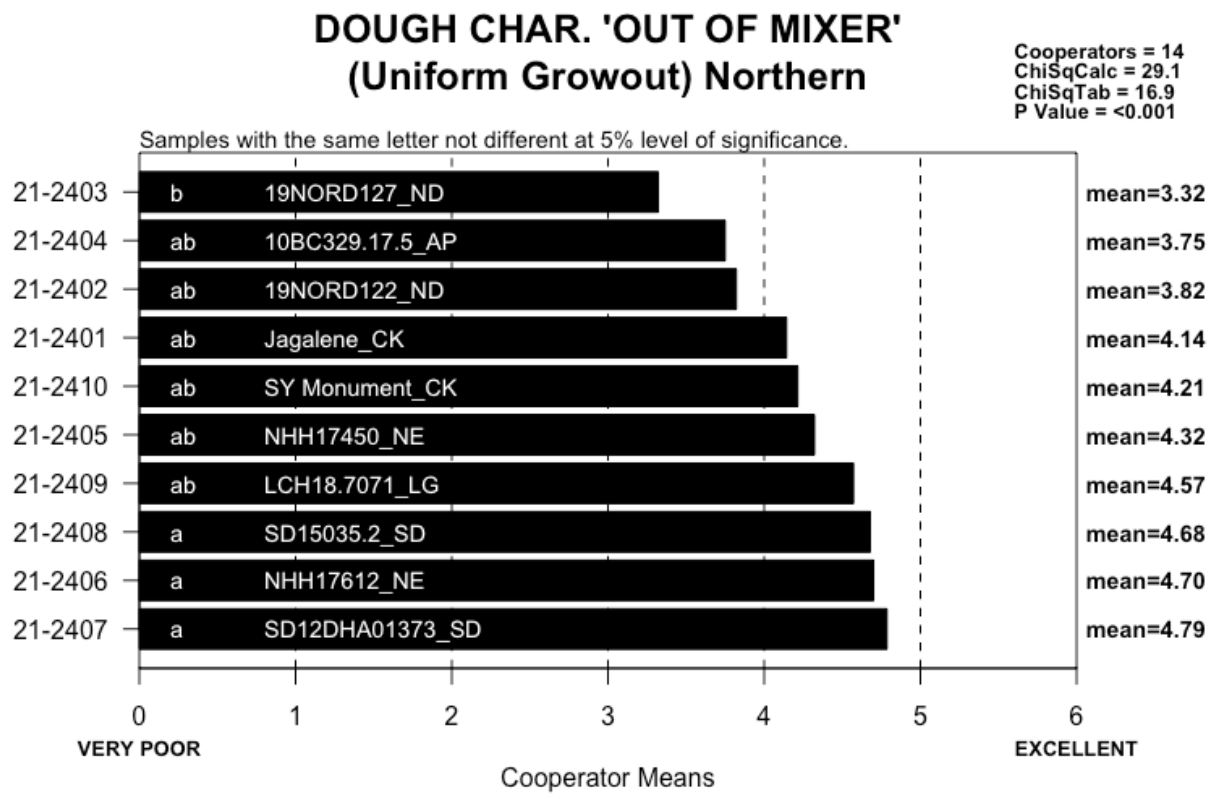
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2401	Jagalene_CK	64	57	65.2	64.1	64.5	64.7	62.8	64.7	63.6	62	62.9	64.7	64.9	67.6
21-2402	19NORD122_ND	65	58	63.9	64.6	65.4	66.3	61.7	66.7	63.0	62	62.2	66.2	64.2	67.1
21-2403	19NORD127_ND	65	58	62.9	64.1	64.4	64.6	59.7	64.7	63.1	62	62.4	64.4	64.4	66.3
21-2404	10BC329-17-5_AP	64	57	63.0	63.1	63.5	63.0	60.8	61.2	61.3	60	60.8	61.1	62.8	66.5
21-2405	NHH17450_NE	64	57	62.6	62.6	64.1	65.4	60.4	64.2	62.5	61	61.7	64.7	63.7	65.2
21-2406	NHH17612_NE	64	57	65.6	62.9	66.9	68.7	62.2	66.3	62.5	61	61.9	66.5	63.9	66.8
21-2407	SD12DHA01373_SD	65	58	65.1	62.6	65.7	65.2	62.0	66.0	62.3	61	61.8	66.0	63.8	67.1
21-2408	SD15035-2_SD	65	58	64.9	64.1	67.4	69.0	62.7	67.7	65.1	64	64.4	67.5	66.4	74.3
21-2409	LCH18-7071_LG	64	57	63.7	62.2	66.2	65.4	61.5	65.8	62.9	62	62.2	65.3	64.2	68.3
21-2410	SY Monument_CK	65	57	65.9	62.5	66.4	68.0	61.7	66.2	64.3	62	62.7	65.7	64.7	68.6

BAKE MIX TIME, ACTUAL
(Uniform Growout) Northern
Cooperators A – N

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2401	Jagalene_CK	5.7	7	4.8	7.9	6.0	5.1	4	5.4	7.3	15	12	4.9	14	4.3
21-2402	19NORD122_ND	3.6	4	3.5	5.0	4.0	3.3	4	3.8	4.0	11	14	3.8	11	3.8
21-2403	19NORD127_ND	4.3	4	3.3	4.6	4.0	4.4	4	3.2	4.0	9	9	3.1	10	3.5
21-2404	10BC329-17-5_AP	6.8	4	4.8	8.5	6.3	5.0	4	4.3	6.5	18	12	6.0	11	4.5
21-2405	NHH17450_NE	4.3	5	3.8	5.1	4.0	4.5	4	3.8	4.3	14	14	3.5	10	4.0
21-2406	NHH17612_NE	6.0	12	5.5	8.6	8.0	5.9	6	5.9	6.8	15	16	5.6	20	6.0
21-2407	SD12DHA01373_SD	5.9	10	5.3	7.8	7.5	6.2	6	5.7	7.0	20	16	5.9	20	5.0
21-2408	SD15035-2_SD	5.7	9	5.0	6.9	7.0	5.5	5	5.1	5.8	20	11	5.4	20	5.0
21-2409	LCH18-7071_LG	6.6	10	6.0	9.2	8.5	6.6	6	6.2	8.3	17	16	6.4	20	6.5
21-2410	SY Monument_CK	8.8	11	7.3	10.3	11.5	8.8	8	8.2	9.5	25	18	7.6	20	7.0

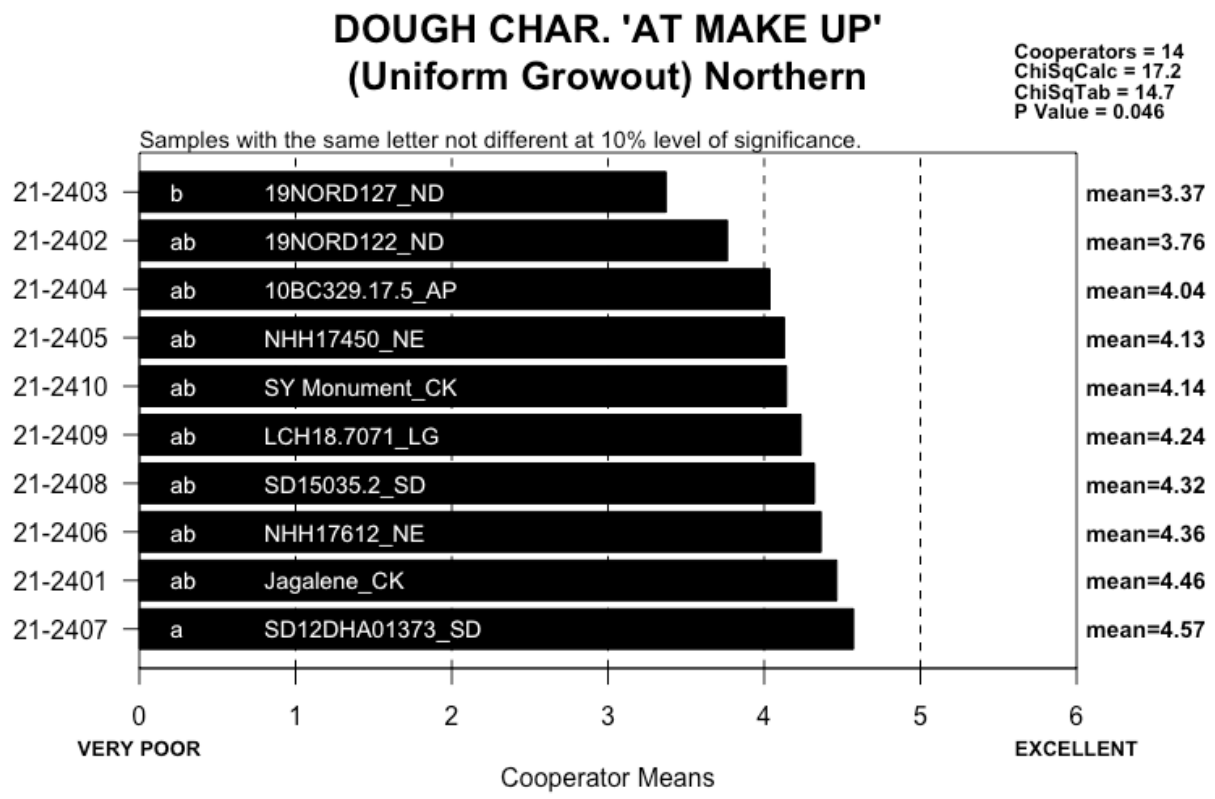

BAKE MIX TIME
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 41.9
ChiSqTab = 16.9
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
21-2403 d 19NORD127_ND mean=2.90
21-2402 cd 19NORD122_ND mean=2.93
21-2405 bcd NHH17450_NE mean=3.44
21-2404 abcd 10BC329.17.5_AP mean=4.07
21-2401 abcd Jagalene_CK mean=4.21
21-2408 abcd SD15035.2_SD mean=4.64
21-2406 abc NHH17612_NE mean=4.79
21-2407 ab SD12DHA01373_SD mean=4.86
21-2409 ab LCH18.7071_LG mean=4.86
21-2410 a SY Monument_CK mean=5.25
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 46.5
ChiSqTab = 16.9
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
21-2403 c 19NORD127_ND mean=2.51
21-2402 bc 19NORD122_ND mean=3.03
21-2405 abc NHH17450_NE mean=3.24
21-2404 abc 10BC329.17.5_AP mean=3.64
21-2401 abc Jagalene_CK mean=3.94
21-2409 ab LCH18.7071_LG mean=4.41
21-2408 ab SD15035.2_SD mean=4.51
21-2406 ab NHH17612_NE mean=4.54
21-2407 a SD12DHA01373_SD mean=4.64
21-2410 a SY Monument_CK mean=4.81
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



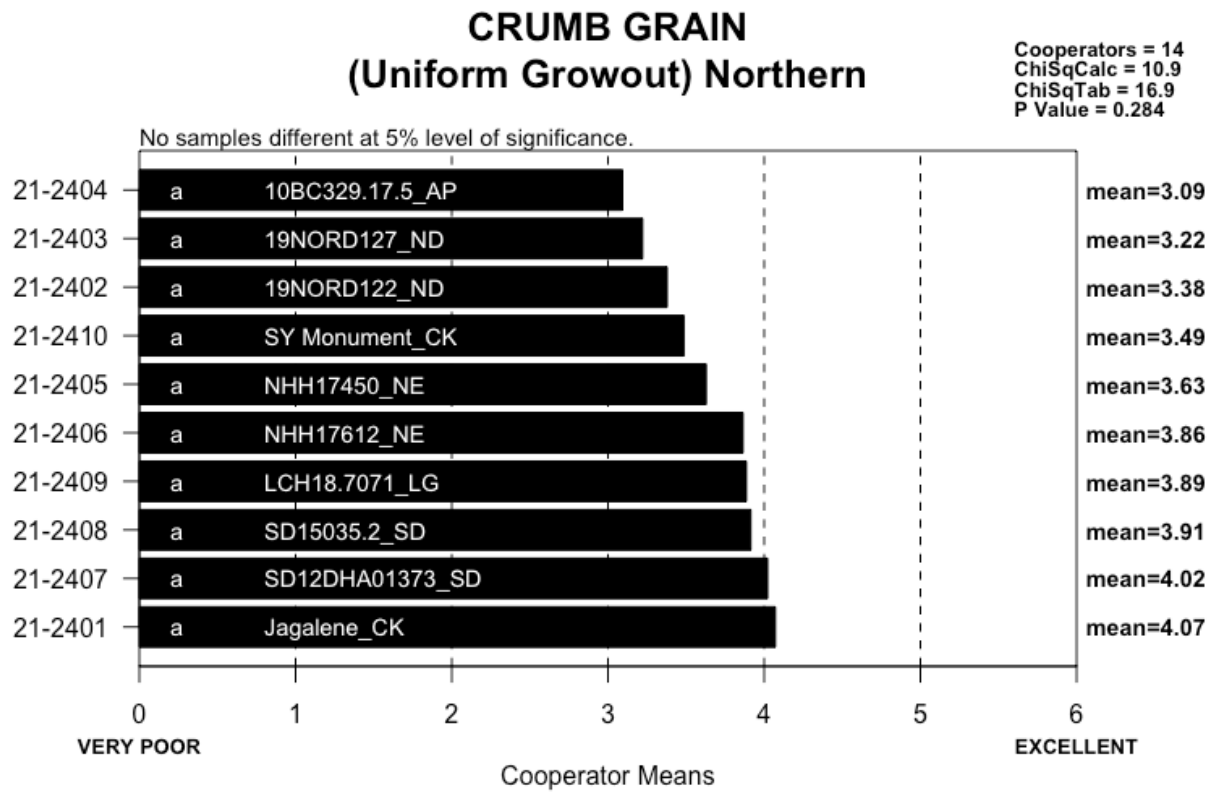
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Uniform Growout) Northern

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
21-2401	Jagalene_CK	2	2	0	10	0
21-2402	19NORD122_ND	4	2	2	5	1
21-2403	19NORD127_ND	5	3	1	5	0
21-2404	10BC329-17-5_AP	3	3	2	5	1
21-2405	NHH17450_NE	1	1	1	10	1
21-2406	NHH17612_NE	1	0	2	7	4
21-2407	SD12DHA01373_SD	0	0	2	8	4
21-2408	SD15035-2_SD	0	1	2	10	1
21-2409	LCH18-7071_LG	1	0	3	8	2
21-2410	SY Monument_CK	3	1	3	6	1



DOUGH CHAR. 'AT MAKE UP', DESCRIBED
(Uniform Growout) Northern

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
21-2401	Jagalene_CK	1	0	0	11	2
21-2402	19NORD122_ND	3	3	2	6	0
21-2403	19NORD127_ND	5	3	1	5	0
21-2404	10BC329-17-5_AP	2	2	1	8	1
21-2405	NHH17450_NE	2	1	1	9	1
21-2406	NHH17612_NE	0	1	2	11	0
21-2407	SD12DHA01373_SD	0	0	1	12	1
21-2408	SD15035-2_SD	4	0	2	6	2
21-2409	LCH18-7071_LG	1	1	2	9	1
21-2410	SY Monument_CK	1	2	3	6	2

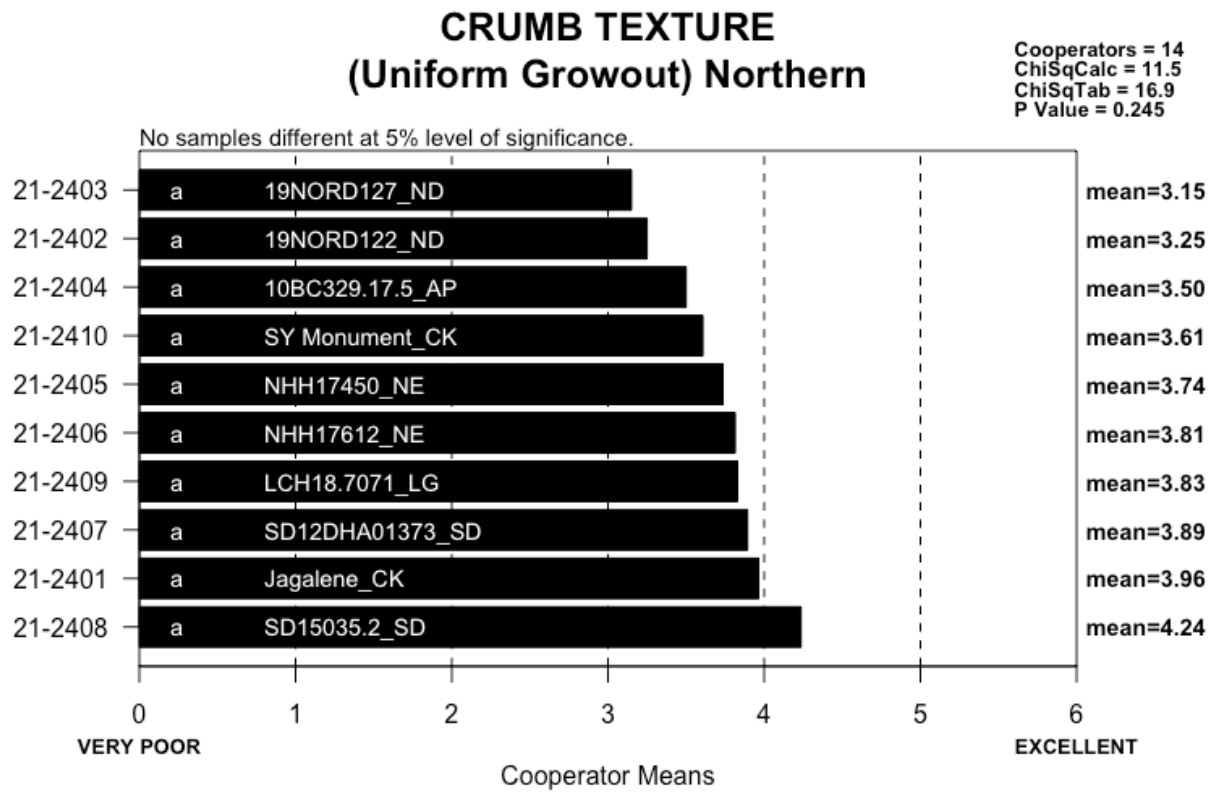


CRUMB GRAIN, DESCRIBED
(Uniform Growout) Northern

IDCODE	ID	Open	Fine	Dense
21-2401	Jagalene_CK	6	7	1
21-2402	19NORD122_ND	10	3	1
21-2403	19NORD127_ND	7	3	4
21-2404	10BC329-17-5_AP	7	4	3
21-2405	NHH17450_NE	9	5	0
21-2406	NHH17612_NE	6	6	2
21-2407	SD12DHA01373_SD	7	5	2
21-2408	SD15035-2_SD	7	7	0
21-2409	LCH18-7071_LG	5	6	3
21-2410	SY Monument_CK	5	6	3

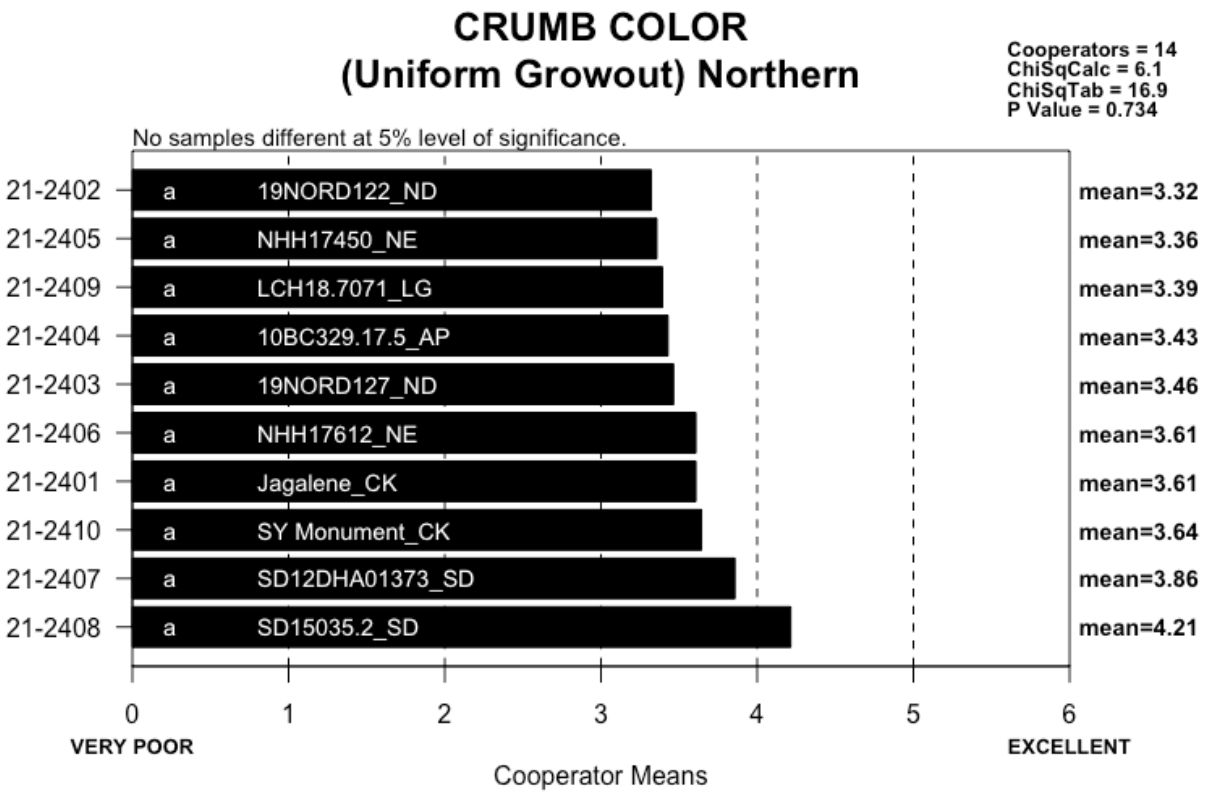
CELL SHAPE, DESCRIBED
(Uniform Growout) Northern

IDCODE	ID	Round	Irregular	Elongated
21-2401	Jagalene_CK	5	3	6
21-2402	19NORD122_ND	4	6	4
21-2403	19NORD127_ND	6	5	3
21-2404	10BC329-17-5_AP	4	3	7
21-2405	NHH17450_NE	3	4	7
21-2406	NHH17612_NE	2	5	7
21-2407	SD12DHA01373_SD	1	6	7
21-2408	SD15035-2_SD	3	3	8
21-2409	LCH18-7071_LG	2	5	7
21-2410	SY Monument_CK	5	4	5



CRUMB TEXTURE, DESCRIBED
(Uniform Growout) Northern

IDCODE	ID	Harsh	Smooth	Silky
21-2401	Jagalene_CK	2	10	2
21-2402	19NORD122_ND	7	6	1
21-2403	19NORD127_ND	8	5	1
21-2404	10BC329-17-5_AP	4	10	0
21-2405	NHH17450_NE	4	8	2
21-2406	NHH17612_NE	2	11	1
21-2407	SD12DHA01373_SD	3	9	2
21-2408	SD15035-2_SD	2	7	5
21-2409	LCH18-7071_LG	4	7	3
21-2410	SY Monument_CK	4	9	1



CRUMB COLOR, DESCRIBED
(Uniform Growout) Northern

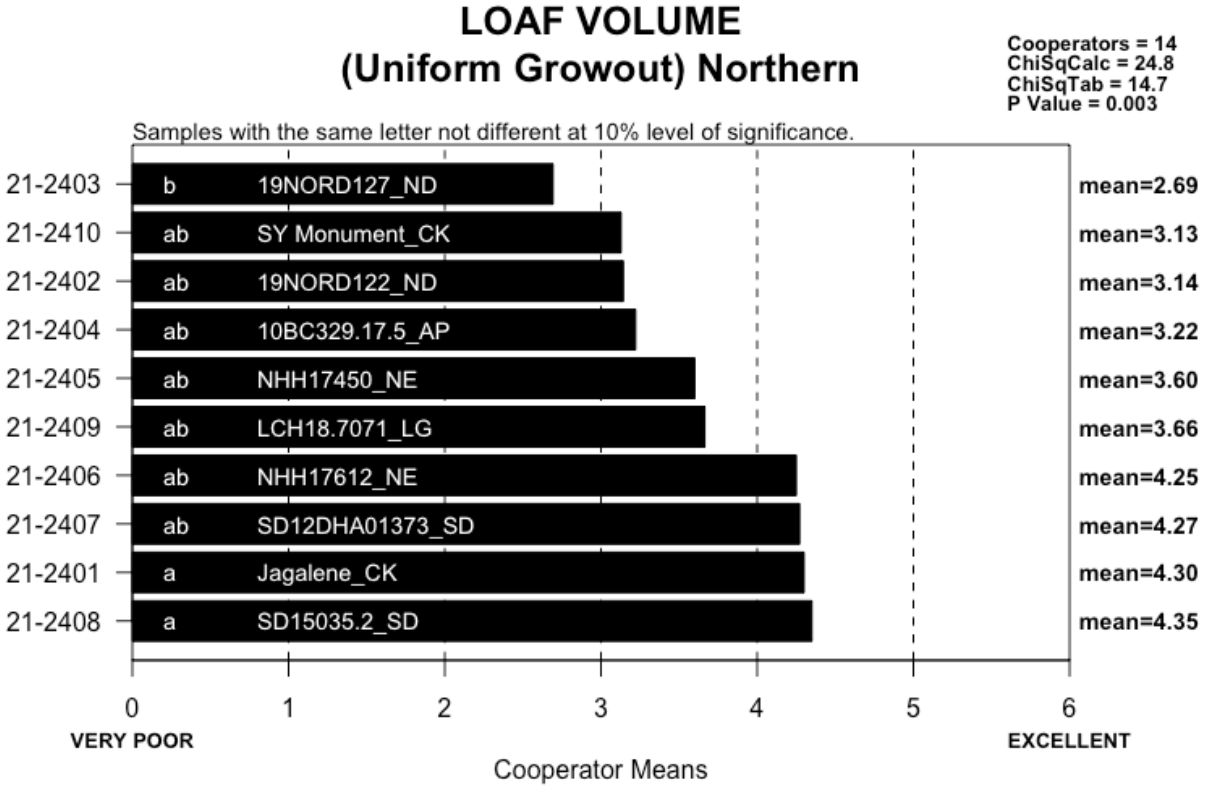
IDCODE	ID	Gray	Dark_Yellow	Yellow	Dull	Creamy	White	Bright_White
21-2401	Jagalene_CK	0	1	2	5	2	3	1
21-2402	19NORD122_ND	1	1	2	2	7	1	0
21-2403	19NORD127_ND	0	0	2	6	6	0	0
21-2404	10BC329-17-5_AP	1	1	1	6	4	1	0
21-2405	NHH17450_NE	0	0	3	5	6	0	0
21-2406	NHH17612_NE	3	0	1	3	4	3	0
21-2407	SD12DHA01373_SD	1	0	2	2	6	2	1
21-2408	SD15035-2_SD	0	0	1	3	5	3	2
21-2409	LCH18-7071_LG	0	1	3	4	3	2	1
21-2410	SY Monument_CK	1	0	1	7	0	4	1

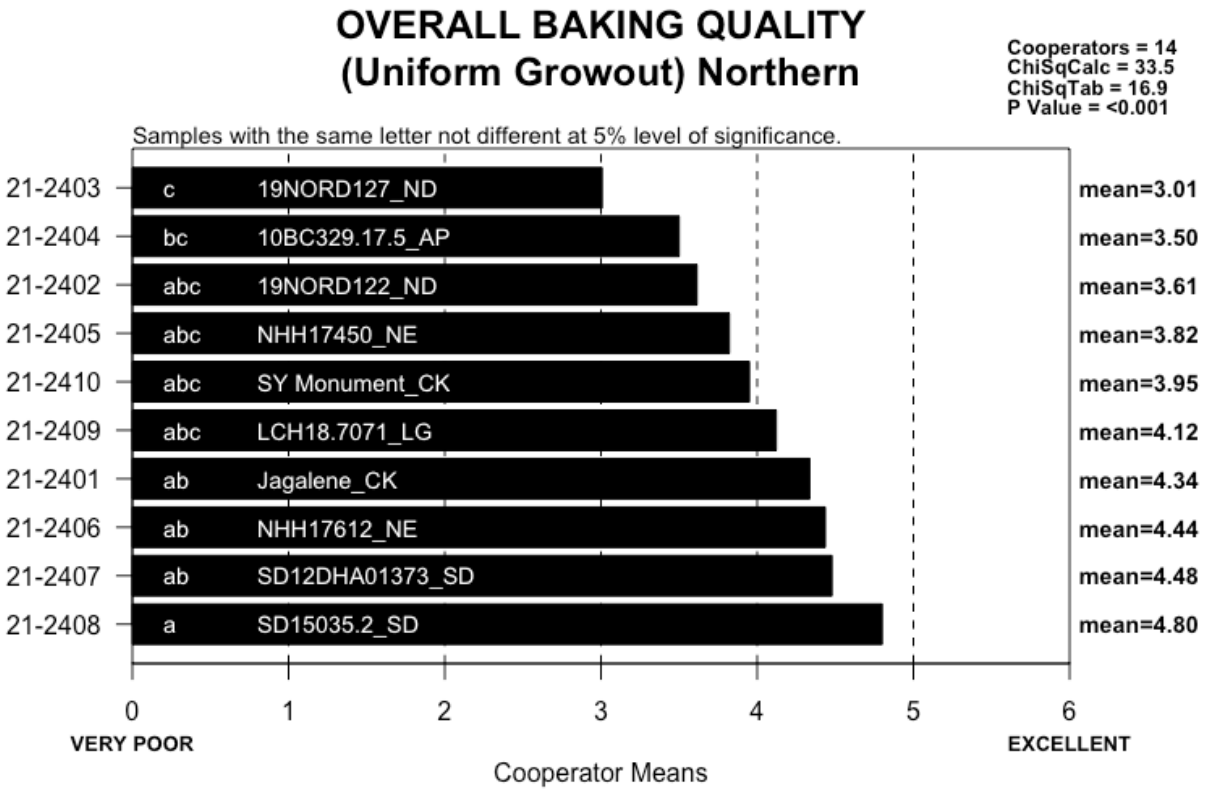
LOAF WEIGHT, ACTUAL
(Uniform Growout) Northern
Cooperators A – N

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2401	Jagalene_CK	145.0	412	142.8	139.1	152.4	246.8	476.9	137.8	143.6	471.5	460.5	146.0	419.3	144.0
21-2402	19NORD122_ND	147.5	411	144.4	142.0	151.4	231.6	481.2	138.8	143.0	467.0	455.5	147.3	413.6	141.9
21-2403	19NORD127_ND	145.8	411	144.3	141.8	149.8	241.5	477.4	139.2	142.9	471.0	464.5	145.5	412.3	144.0
21-2404	10BC329-17-5_AP	145.1	413	139.1	144.6	150.1	244.4	473.5	140.2	141.6	471.5	458.5	143.2	421.1	142.2
21-2405	NHH17450_NE	146.2	412	139.6	140.1	151.4	226.6	478.6	139.5	143.5	469.0	458.5	145.5	418.3	143.9
21-2406	NHH17612_NE	144.4	413	142.0	140.5	152.2	234.3	479.4	137.6	144.4	468.0	462.5	145.4	412.7	141.8
21-2407	SD12DHA01373_SD	146.0	413	141.3	143.0	150.9	248.5	482.3	138.6	143.1	473.5	462.5	146.3	424.3	144.5
21-2408	SD15035-2_SD	146.6	411	141.0	142.5	150.8	227.3	477.0	137.6	144.5	469.0	464.0	148.0	425.9	148.8
21-2409	LCH18-7071_LG	145.6	410	141.2	139.7	148.7	237.2	472.5	137.6	143.3	469.0	459.0	144.6	418.0	143.7
21-2410	SY Monument_CK	144.7	411	142.7	143.7	150.8	244.2	481.1	138.2	144.2	469.5	458.5	144.8	427.1	144.3

LOAF VOLUME, ACTUAL
(Uniform Growout) Northern
Cooperators A – N

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2401	Jagalene_CK	855	2825	1040	868	930	821	2650	864	678	3000	2169	803	2750	770
21-2402	19NORD122_ND	785	2550	880	995	955	837	2388	804	773	2700	1895	853	2300	725
21-2403	19NORD127_ND	700	2650	780	920	925	803	2375	752	761	2675	1901	770	2275	645
21-2404	10BC329-17-5_AP	810	2700	985	910	900	776	2650	828	700	2688	1855	758	2425	735
21-2405	NHH17450_NE	810	2700	945	938	930	829	2538	814	730	2800	1947	813	2400	725
21-2406	NHH17612_NE	885	2750	1075	903	930	846	2588	872	706	3000	2141	778	2500	815
21-2407	SD12DHA01373_SD	825	2800	1025	880	1000	886	2488	874	743	2875	2209	858	2475	800
21-2408	SD15035-2_SD	895	2775	1050	935	935	875	2575	893	735	2825	2263	830	2575	800
21-2409	LCH18-7071_LG	755	2825	980	878	905	801	2600	846	654	2813	2165	768	2575	760
21-2410	SY Monument_CK	860	2650	1050	875	845	761	2600	852	611	2663	2109	743	2475	715


LOAF VOLUME
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 24.8
ChiSqTab = 14.7
P Value = 0.003
Samples with the same letter not different at 10% level of significance.
21-2403 b 19NORD127_ND mean=2.69
21-2410 ab SY Monument_CK mean=3.13
21-2402 ab 19NORD122_ND mean=3.14
21-2404 ab 10BC329.17.5_AP mean=3.22
21-2405 ab NHH17450_NE mean=3.60
21-2409 ab LCH18.7071_LG mean=3.66
21-2406 ab NHH17612_NE mean=4.25
21-2407 ab SD12DHA01373_SD mean=4.27
21-2401 a Jagalene_CK mean=4.30
21-2408 a SD15035.2_SD mean=4.35
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 33.5
ChiSqTab = 16.9
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
21-2403 c 19NORD127_ND mean=3.01
21-2404 bc 10BC329.17.5_AP mean=3.50
21-2402 abc 19NORD122_ND mean=3.61
21-2405 abc NHH17450_NE mean=3.82
21-2410 abc SY Monument_CK mean=3.95
21-2409 abc LCH18.7071_LG mean=4.12
21-2401 ab Jagalene_CK mean=4.34
21-2406 ab NHH17612_NE mean=4.44
21-2407 ab SD12DHA01373_SD mean=4.48
21-2408 a SD15035.2_SD mean=4.80
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) Northern

COOP. 21-2401 Jagalene

A. No comment.
B. Good out of mixer and make up. Nice interior and good volume.
C. Excellent loaf externals. Slightly rough break.
D. High water abs. long MT, slight sticky & strong dough, medium volum, yellow crumb, fine elongate cells, good resilient &smooth texture.
E. Good absorption, avg grain, good volume.
F. No comment.
G. Good absorption, avg grain, dark yellow crumb, excellent volume.
H. No comment.
I. Crumb felt dense and spongy.
J. Excellent volume, good absorption, average mix time and stability.
K. Wild break and shred, open cell structure.
L. No comment.
M. Great volume. Good protein, dough tolerance, and crumb characteristics. Good final product. Recommend.
N. No comment.

COOP. 21-2402 19NORD122_ND

A. No comment.
B. Short mix and lower volume. Soft out of mixer.
C. No comment.
D. High water abs., medium MT, slight sticky & strong dough, very high volume, dark yellow crumb, open round cells, good resilient & slightly harsh texture.
E. Good absorption, sticky dough at make-up, good grain, good volume.
F. No comment.
G. Avg absorption, open grain, low volume.
H. No comment.
I. No comment.
J. Poor volume, good absorption, slightly low mix time and stability.
K. Good overall with only minor flaws.
L. No comment.
M. Higher than avg. protein. Very low volume and mixograph tolerance. Undesirable notes and final product characteristics for bread bake. Do not recommend.
N. No comment.

COOP. 21-2403 19NORD127_ND

A. No comment.
B. Short mix and lower volume, soft out of mixer.
C. No comment.
D. High water abs, medium MT, slight sticky & strong dough, high volume, yellow crumb, open round cells, good resilient & slightly harsh texture.
E. Good absorption, low mixing tolerance, sticky dough at make-up, good grain, good volume.
F. No comment.
G. Low absorption, open grain, low volume.
H. No comment.
I. No comment.
J. Poor volume, good absorption, low mix time and stability.
K. Somewhat dry, dough very sticky and difficult to work with. Short mix time comparatively.
L. No comment.
M. Higher than avg. protein. Very low volume and mixograph tolerance. Undesirable notes and final product characteristics for bread bake. Do not recommend.
N. No comment.

COOP. 21-2404 10BC329-17-5_AP

A. No comment
B. Short mix and lower volume. Soft out of mixer.
C. Slight cap.
D. High water abs, long MT, slight sticky & strong dough, high volume, creamy crumb, fine elongate cells, good resilient & smooth texture.
E. Avg absorption and grain, good volume.
F. No comment.
G. Avg absorption, open grain, dark yellow crumb, excellent volume.
H. No comment.
I. Bright creamy crumb color, crumb felt dense and spongy.
J. Poor volume, average absorption, good mix time and stability.
K. Holes, slightly bulged break and shred, good texture.
L. No comment.
M. Higher than avg. protein. Volume could use improvement and mixograph tolerance is low. Undesirable notes and final product characteristics for bread bake. Do not recommend.
N. No comment.

COOP. 21-2405 NHH17450_NE

A. No comment.
B. Short mix and lower volume. Soft out of mixer.
C. Excellent loaf externals, slightly rough break.
D. Fine water abs, medium MT, slight sticky & strong dough, high volume, yellow crumb, fine elongate cells, good resilient & very smooth texture.
E. Good absorption, grain and volume.
F. No comment.
G. Avg absorption, open grain, good dough out of mixer, avg volume.
H. No comment.
I. No comment.
J. Average volume, good absorption, average mix time, slightly low stability.
K. Good overall with only minor flaws.
L. No comment.
M. Higher than avg protein. Volume could use improvement and mixograph tolerance is low. Undesirable notes and final product characteristics for bread bake. Do not recommend.
N. Weak at makeup, but average loaf volume.

COOP. 21-2406 NHH17612_NE

A. No comment.
B. Excellent mix time and nice interior. Avg loaf volume. Equal to 2401.
C. Cap.
D. High water abs, long MT, slight sticky & strong dough, medium volume, dull crumb, find elongated cells, good resilient & smooth texture.
E. High absorption, long mix time, good dough character, good grain and volume.
F. No comment.
G. Good absorption, avg grain, excellent dough out of mixer, avg volume.
H. No comment.
I. Crumb felt dense and spongy.
J. Excellent volume, good absorption, average mix time and stability.
K. Sponge slightly weak and sticky, but caused no problem with the loaf.
L. No comment.
M. High tolerance dough and higher than avg protein. Good notes all around. Fair volume, but room for improvement. Fair final product. Recommend.
N. No comment.

COOP. 21-2407 SD12DHA01373_SD

A. No comment.
B. Good mix time. Nice interior, good volume, slightly creamy crumb.
C. Excellent loaf externals.
D. Medium water abs, long MT, slight sticky & strong dough, high volume, creamy crumb, find elongate cells, good resilient & smooth texture.
E. High absorption, nice grain, excellent volume.
F. No comment.
G. Good absorption, avg grain, excellent dough out of mixer, good mixing tolerance, low volume.
H. No comment.
I. No comment.
J. Good volume, good absorption, good mix time, average stability.
K. Wild break and shred, only other minor flaws.
L. No comment.
M. Higher than avg. protein, high tolerance dough, good dough notes. Harsh and open crumb. Final product has room for improvement. Recommend.
N. Good crumb texture, color and loaf volume.

COOP. 21-2408 SD15035-2_SD

A. No comment.
B. Good mix time. Nice interior. Good volume. Slightly creamy crumb.
C. Excellent loaf externals.
D. High water abs. long MT, slight sticky & strong dough, high volume, yellow crumb, fine elongate cells. Good resilient & very smooth texture.
E. High absorption, excellent gran, good volume.
F. No comment.
G. Good absorption, avg grain and volume.
H. No comment.
I. Nice dough characteristics, crumb felt dense and spongy.
J. Average volume, excellent absorption, very good mix time, average stability.
K. Excellent texture and color, elongated cells, slightly bulged break and shred.
L. No comment.
M. Higher than avg. protein. High tolerance dough. Overall, good final product. Recommend.
N. Good crumb texture and color.

COOP. **21-2409** **LCH18-7071_LG**

A. No comment.
B. Good mix time. Nice interior. good volume. Slightly creamy crumb.
C. Slight cap, rough break.
D. Medium water abs, long MT, slight sticky & strong dough, high volume, yellow crumb, fine elongate cells, good resilient & smooth texture.
E. High absorption, long mix time, avg grain, dark yellow crumb, good volume.
F. No comment.
G. Avg absorption and grain, good volume.
H. No comment.
I. Poor crumb color.
J. Average volume, good absorption, good mix time, average stability.
K. Excellent texture and color, elongated cells.
L. No comment.
M. Fair protein, high tolerance dough, overall good final product. Recommend.
N. No comment.

COOP. **21-2410** **SY Monument**

A. No comment.
B. Good mix but lower loaf volume. Nice interior.
C. Slight cap
D. Medium water abs, Long MT, slight sticky & strong dough, medium volume, dull crumb, fine elongate cells, good resilient & smooth texture.
E. High absorption, very long mix time, tough dough at make-up, avg grain, low volume.
F. No comment.
G. Avg absorption and grain, good mixing tolerance, good volume.
H. No comment.
I. No comment.
J. Poor volume, good absorption, excellent mix time, very good stability.
K. Excellent color and texture, a few large, elongated holes.
L. No comment.
M. Fair protein. High tolerance dough. High stability and mix time could be contributing to the lack of volume. Fair final product. Recommend.
N. Long mixer decent, decent loaf volume.

Notes: **B, G, J, K and M** conducted sponge and dough bake tests

MICRO-QUALITY ANALYSIS

Sample No	Comp.ID.	Micro_ID	Locations	Cultivars	Breeding Programs
1	B1	01	ND	Jagalene	Check
2	B2	02	ND	19NORD122	NDSU
3	B3	03	ND	19NORD127	NDSU
4	B4	04	ND	10BC329-17-5	AgriPro(Syngenta)
5	B5	05	ND	NHH17450	UNL
6	B6	06	ND	NHH17612	UNL
7	B7	07	ND	SD12DHA01373	SDSU
8	B8	08	ND	SD15035-2	SDSU
9	B9	09	ND	LCH18-7071	Limagrain
10	B10	10	ND	SY Monument	Check
11	B1	01	SD	Jagalene	Check
12	B2	02	SD	19NORD122	NDSU
13	B3	03	SD	19NORD127	NDSU
14	B4	04	SD	10BC329-17-5	AgriPro(Syngenta)
15	B5	05	SD	NHH17450	UNL
16	B6	06	SD	NHH17612	UNL
17	B7	07	SD	SD12DHA01373	SDSU
18	B8	08	SD	SD15035-2	SDSU
19	B9	09	SD	LCH18-7071	Limagrain
20	B10	10	SD	SY Monument	Check
21	B1	01	NE	Jagalene	Check
22	B2	02	NE	19NORD122	NDSU
23	B3	03	NE	19NORD127	NDSU
24	B4	04	NE	10BC329-17-5	AgriPro(Syngenta)
25	B5	05	NE	NHH17450	UNL
26	B6	06	NE	NHH17612	UNL
27	B7	07	NE	SD12DHA01373	SDSU
28	B8	08	NE	SD15035-2	SDSU
29	B9	09	NE	LCH18-7071	Limagrain
30	B10	10	NE	SY Monument	Check

1. LOCATIONS AND ENTRIES

A. There are 3 locations:

Nebraska = NE;

North Dakota = ND;

South Dakota = SD.

B. There are 10 entries grown in each of locations:

Jagalene (Check) = 01

19NORD122 (NDSU) = 02

19NORD127 (NDSU) = 03

10BC329-17-5 (AgriPro) = 04

NHH17450 (UNL) = 05

NHH17612 (UNL) = 06

SD12DHA01373 (SDSU) = 07

SD15035-2 (SDSU) = 08

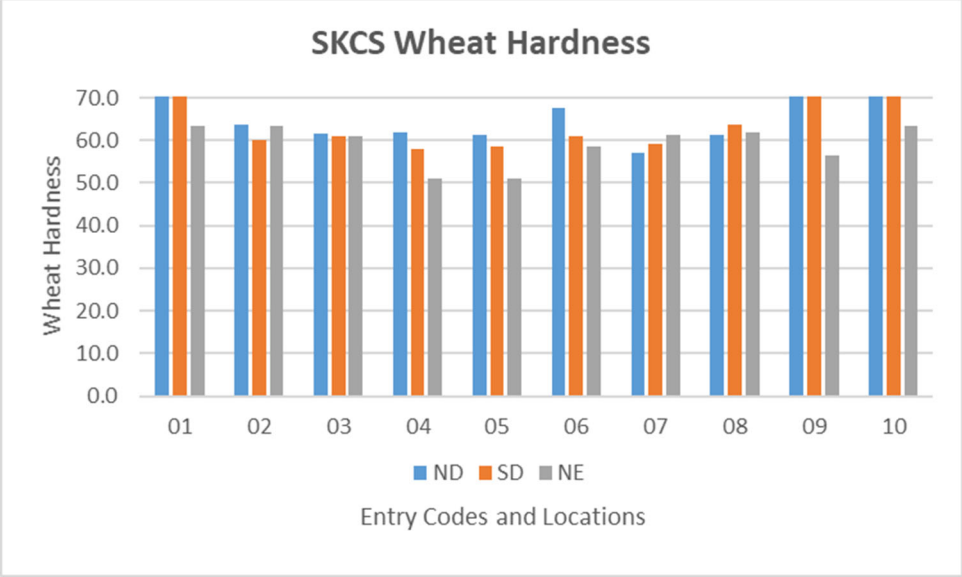
LCH18-7071 (Limagrain) = 09

SY Monument (Check) = 10

2. SKCS SINGLE KERNEL INFORMATION

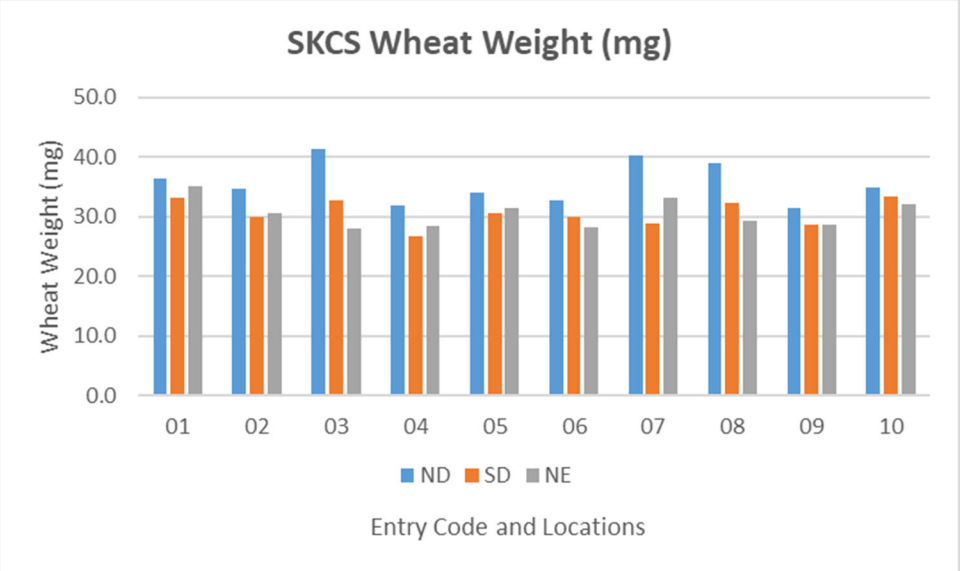
A. Kernel Hardness

SKCS Wheat Kernel Hardness					
	LOCATIONS				
Entry Codes	ND	SD	NE	Avg	Std
01	81.9	72.0	63.3	72.4	9.31
02	63.6	60.1	63.5	62.4	1.99
03	61.6	61.1	61.1	61.3	0.29
04	61.8	58.1	51.1	57.0	5.43
05	61.3	58.6	51.0	57.0	5.34
06	67.5	60.9	58.7	62.4	4.58
07	57	59.2	61.2	59.1	2.10
08	61.4	63.7	61.9	62.3	1.21
09	76.3	70.3	56.6	67.7	10.10
10	85.2	72.0	63.5	73.6	10.93
Avg.	67.8	63.6	59.2		
Std	9.81	5.64	4.81		



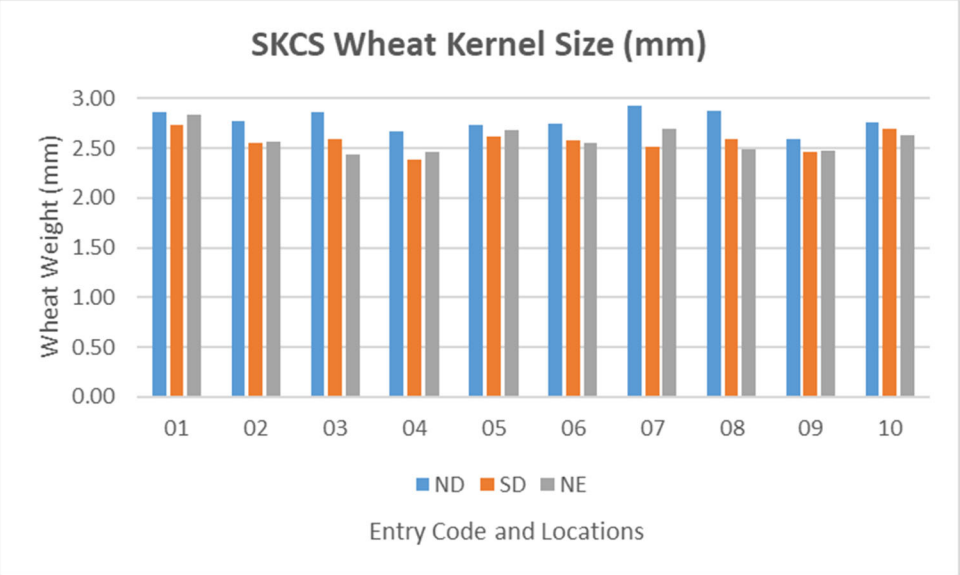
B. Kernel Weight (mg)

SKCS Wheat Kernel Weight (mg)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	36.4	33.3	35.1	34.9	1.56
02	34.6	29.9	30.6	31.7	2.54
03	41.3	32.7	28.1	34.0	6.70
04	31.9	26.8	28.4	29.0	2.61
05	34.1	30.6	31.5	32.1	1.82
06	32.7	29.9	28.3	30.3	2.23
07	40.4	28.8	33.3	34.2	5.85
08	38.9	32.3	29.4	33.5	4.87
09	31.5	28.6	28.7	29.6	1.65
10	35.0	33.4	32.2	33.5	1.40
Avg.	35.7	30.6	30.6		
Std	3.49	2.24	2.41		



C. Kernel Size

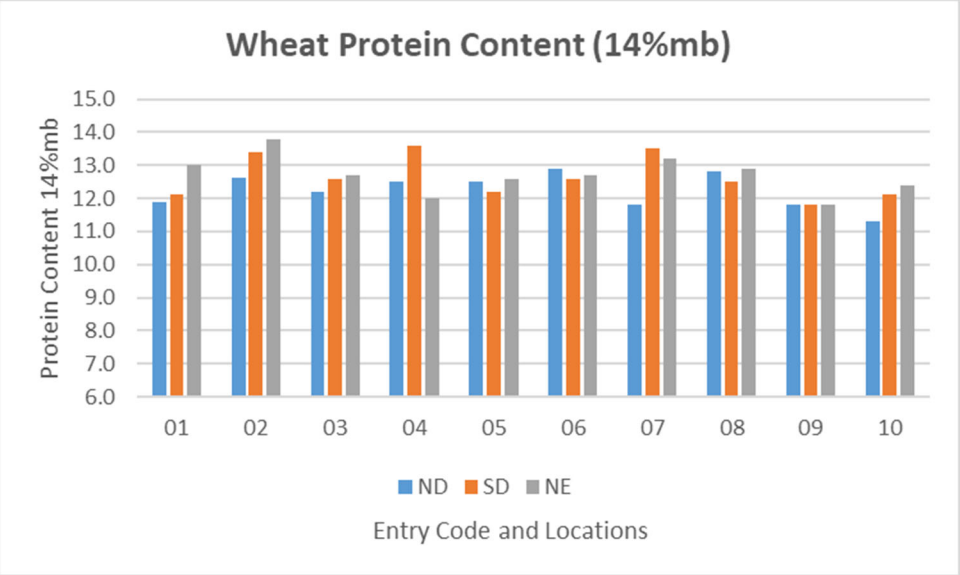
SKCS Wheat Kernel Size (mm)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	2.86	2.73	2.84	2.81	0.07
02	2.77	2.55	2.56	2.63	0.12
03	2.86	2.59	2.44	2.63	0.21
04	2.67	2.38	2.46	2.50	0.15
05	2.73	2.62	2.68	2.68	0.06
06	2.75	2.58	2.55	2.63	0.11
07	2.93	2.51	2.69	2.71	0.21
08	2.88	2.59	2.49	2.65	0.20
09	2.59	2.46	2.47	2.51	0.07
10	2.76	2.69	2.63	2.69	0.07
Avg.	2.78	2.57	2.58		
Std	0.10	0.10	0.13		



3. PROTEN CONTENT

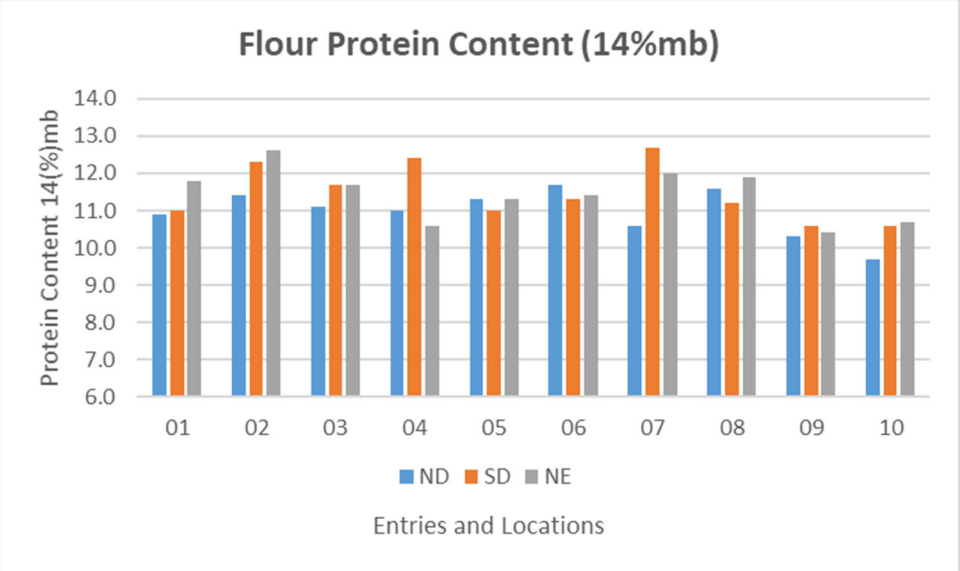
A. Wheat Protein

Wheat Protein Content (14%mb)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	11.9	12.1	13.0	12.3	0.59
02	12.6	13.4	13.8	13.3	0.60
03	12.2	12.6	12.7	12.5	0.26
04	12.5	13.6	12.0	12.7	0.82
05	12.5	12.2	12.6	12.4	0.21
06	12.9	12.6	12.7	12.7	0.15
07	11.8	13.5	13.2	12.8	0.91
08	12.8	12.5	12.9	12.7	0.21
09	11.8	11.8	11.8	11.8	0.00
10	11.3	12.1	12.4	11.9	0.57
Avg.	12.2	12.6	12.7		
Std	0.5	0.6	0.6		



B. Flour Protein

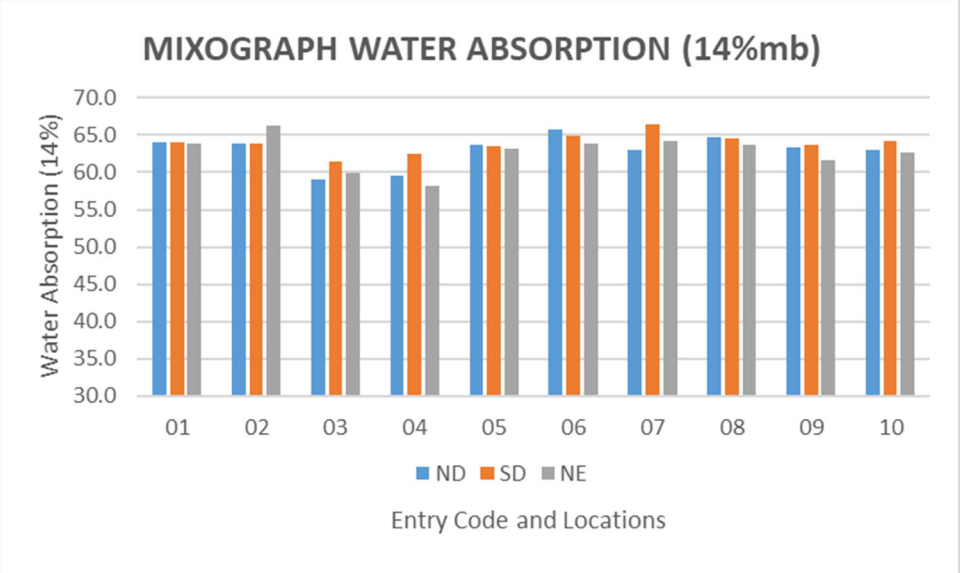
Flour Protein Content (14%)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	10.9	11.0	11.8	11.2	0.49
02	11.4	12.3	12.6	12.1	0.62
03	11.1	11.7	11.7	11.5	0.35
04	11.0	12.4	10.6	11.3	0.95
05	11.3	11.0	11.3	11.2	0.17
06	11.7	11.3	11.4	11.5	0.21
07	10.6	12.7	12.0	11.8	1.07
08	11.6	11.2	11.9	11.6	0.35
09	10.3	10.6	10.4	10.4	0.15
10	9.7	10.6	10.7	10.3	0.55
Avg.	11.0	11.5	11.4		
Std	0.62	0.76	0.70		



4. MIXOGRAPH TEST RESULTS

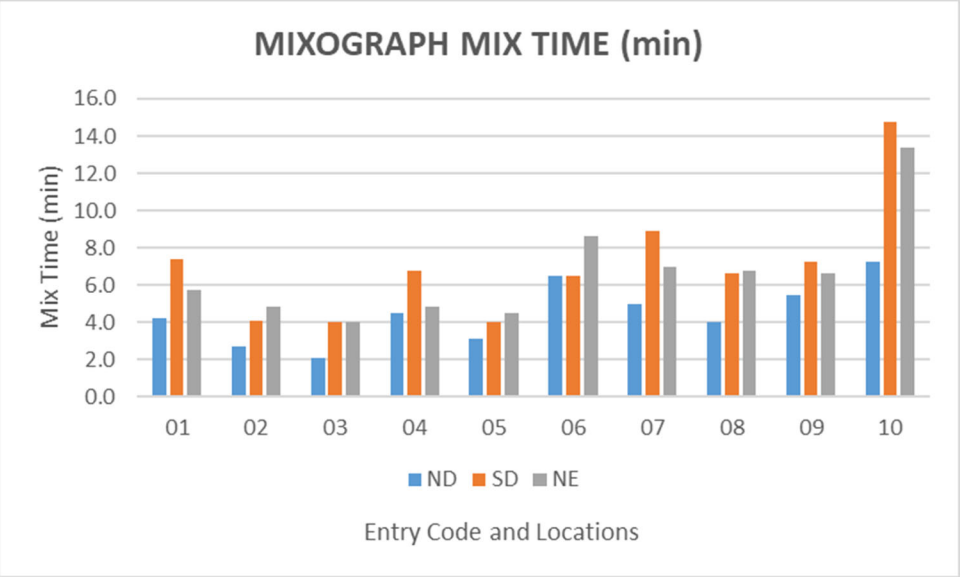
A. Mixograph Water Absorption

Mixograph Water Absorption (14%mb)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	64.1	64.0	63.9	64.0	0.11
02	63.8	63.8	66.3	64.7	1.46
03	59.0	61.5	59.9	60.1	1.26
04	59.6	62.5	58.2	60.1	2.17
05	63.7	63.5	63.2	63.4	0.28
06	65.7	64.8	63.8	64.8	0.94
07	63.0	66.4	64.1	64.5	1.71
08	64.7	64.6	63.8	64.4	0.54
09	63.3	63.7	61.6	62.9	1.09
10	63.0	64.2	62.7	63.3	0.80
Avg.	63.0	63.9	62.8		
Std	2.12	1.32	2.32		



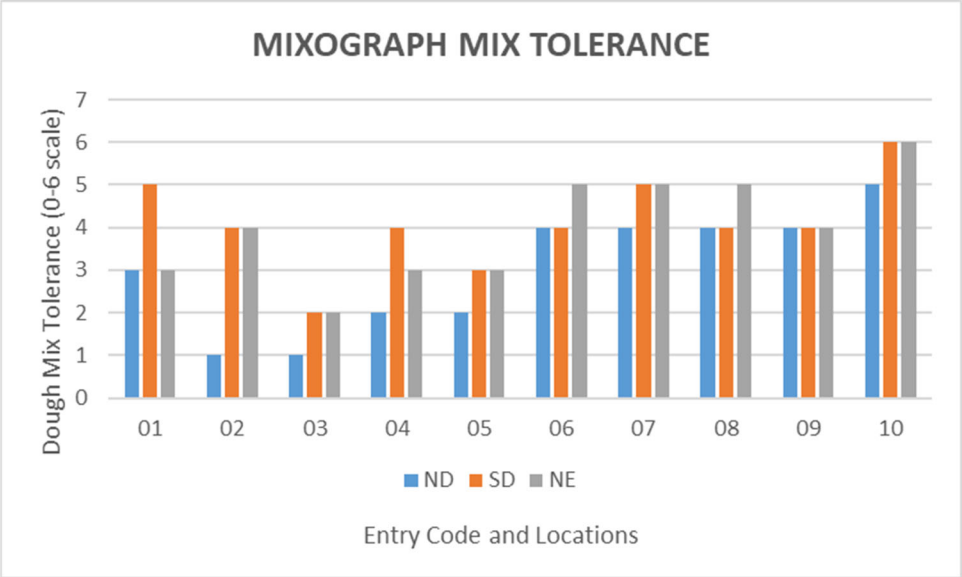
B. Mixograph Mix Time

Mixograph Mix Time (min)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	4.3	7.4	5.8	5.8	1.57
02	2.8	4.1	4.9	3.9	1.08
03	2.1	4.0	4.0	3.4	1.08
04	4.5	6.8	4.9	5.4	1.20
05	3.1	4.0	4.5	3.9	0.69
06	6.5	6.5	8.6	7.2	1.23
07	5.0	8.9	7.0	7.0	1.94
08	4.0	6.6	6.8	5.8	1.55
09	5.5	7.3	6.6	6.5	0.89
10	7.3	14.8	13.4	11.8	3.99
Avg.	4.5	7.0	6.6		
Std	1.62	3.17	2.75		



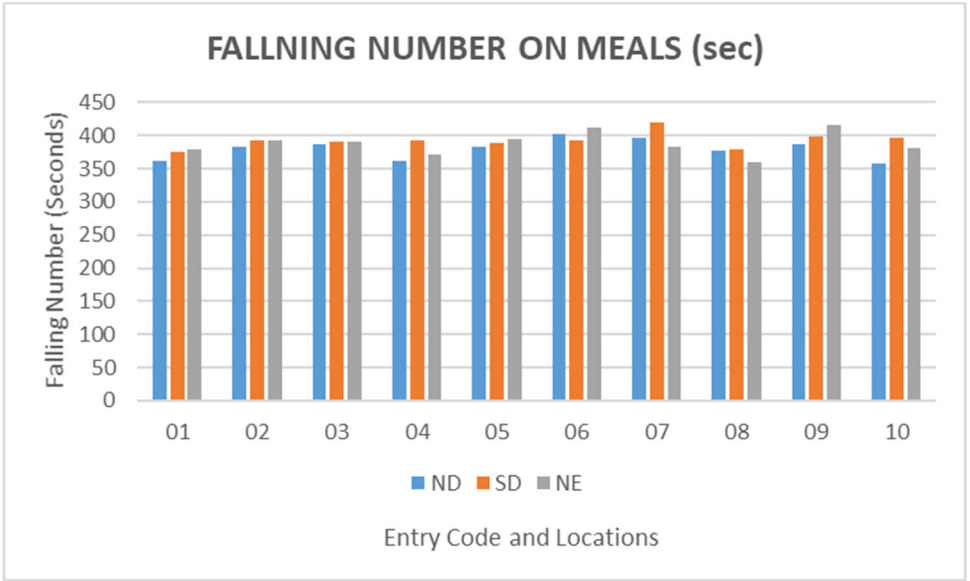
C. Mixograph Mix Tolerance

Mixograph Mix Tolerance					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	3	5	3	3.7	1.15
02	1	4	4	3.0	1.73
03	1	2	2	1.7	0.58
04	2	4	3	3.0	1.00
05	2	3	3	2.7	0.58
06	4	4	5	4.3	0.58
07	4	5	5	4.7	0.58
08	4	4	5	4.3	0.58
09	4	4	4	4.0	0.00
10	5	6	6	5.7	0.58
Avg.	3.0	4.1	4.0		
Std	1.41	1.10	1.25		



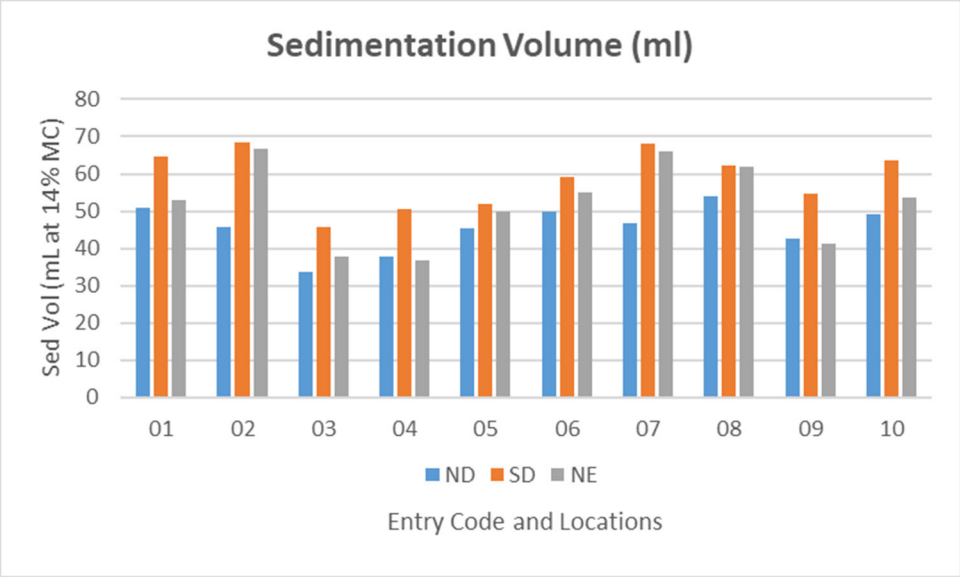
5. FALLING NUMBER TEST

Falling Number on Meals (sec)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	362	376	379	372	9
02	383	392	392	389	5
03	386	391	390	389	3
04	361	392	372	375	16
05	383	388	395	389	6
06	402	393	411	402	9
07	397	420	382	400	19
08	378	379	360	372	11
09	387	398	415	400	14
10	357	396	381	378	20
Avg.	380	393	388		
Std	15	12	17		



6. SEDIMENTATION TEST

Sedimentation Volume (ml)					
	LOCATIONS				
Entry Code	ND	SD	NE	Avg	Std
01	50.8	64.8	52.9	56.2	7.55
02	45.8	68.3	66.7	60.3	12.55
03	33.8	45.8	37.7	39.1	6.12
04	37.8	50.5	36.9	41.7	7.61
05	45.4	52.0	49.9	49.1	3.37
06	49.9	59.1	54.9	54.6	4.61
07	46.7	68.0	66.1	60.3	11.79
08	53.9	62.1	61.8	59.3	4.65
09	42.6	54.7	41.1	46.1	7.46
10	49.1	63.7	53.7	55.5	7.46
Avg.	45.6	58.9	52.2		
Std	6.12	7.79	10.95		



SOUTHERN GROWOUT

21-2411	Jagalene_CK
21-2412	LCH17-4196_LG
21-2413	SY Monument_CK
21-2414	OK15MAS8-29_OK
21-2415	AP Roadrunner_AP
21-2416	OK15DMAS6-8_OK
21-2417	CO13007-F6R_CO
21-2418	CO16D1487_CO
21-2419	TX15M8024_TX
21-2420	XE4101_WB
21-2421	WB4401_WB

CK=Check; LG=Limagrain; OK=Oklahoma; AP=Agripro(Syngenta); CO=Colorado; TX=Texas; WB=Westbred(Bayer).

OK15MAS8-29=OK15MASBx7ARS8-29; OK15DMAS6-8=OK15MASBx7ARS6-8.

Description of Test Plots and Breeder Entries

Southern Growout (OK, CO, TX, LG, KS, WB, and AP)

OKLAHOMA by Brett Carver

The North Central Agronomy Research Station at Lahoma (12 miles west of Enid) provided the Oklahoma site for the southern uniform WQC growout. Grain production was largely influenced by stripe rust, followed by leaf rust, both present at moderately severe levels. Test weight (mean of 58 lb/bu) reflected this disease pressure. Unlike the experimentals, the Jagalene check was protected with a fungicide, producing a test weight of 63.5 lb/bu. Mean wheat protein concentration in the growout was 11.5%. Harvest occurred relatively late (June 24, 2021) due to multiple precipitation events in June. No visible sign of pre-harvest sprouting was present. Mean falling number in this nursery was 425 sec.

OK15MASBx7 ARS 8-29 (abridged here as OK15MAS8-29)

This Gallagher-backcross derivative (Gallagher*3/Snowmass) was developed with the express intent to introgress the gene encoding Bx7oe from Snowmass while removing the T1RS·1BL translocation from Gallagher. A sib line to this one, OK15MASBx7 ARS 8-20, was evaluated in the 2020 WQC program.

In comparisons of 19 sib lines (including this line) versus the recurrent parent Gallagher, mixograph tolerance rating increased from 4 to 5, mixogram band width at 2 min past the peak increased from 13 to 19 mm, mixogram stability index decreased from 5.2 to 1.6 (flatter curve), and mixograph peak time increased from 6 to 12 min.

OK15MASBx7 ARS 8-29, along with OK15MASBx7 ARS 8-20, likely will be released in 2022 to provide an alternative strengthening component in flour blends that otherwise depend on hard red spring wheat, vital wheat gluten, and/or dough conditioners. OK15MASBx7 ARS 8-29 has agronomic characteristics similar to Gallagher, but with 5-6% higher grain yield across Oklahoma since 2018.

OK15DMASBx7 ARS 6-8 (abridged here as OK15DMAS6-8)

Similar to OK15MASBx7 ARS 8-29, this doubled haploid line was produced from a backcrossing project involving OK10130 as the recurrent parent (OK10130*3/Snowmass). OK10130 has the pedigree,
OK02204 (=KS93U206/Jagger sib)/OK02604 (=KS92WGRC15/Tonkawa//Ponderosa).

OK15DMASBx7 ARS 6-8 has provided the best combination of yield performance (10-11% above Gallagher since 2018) and dough strength, with slightly lower farinograph stability at just under one hour compared with OK15MASBx7 ARS 8-29. OK15DMASBx7 ARS 6-8, however, lacks resistance to Hessian fly, acid soils, and barley yellow dwarf.

OK15DMASBx7 ARS 6-8 likely will be released in 2022 to provide an alternative strengthening component in flour blends utilized in pan bread, noodles, and frozen dough. It is further distinguished from OK15MASBx7 ARS 8-29 by its more balanced dough characteristics, softer kernel texture consistent with its *Pina-D1* (allele *a*)and *Pinb-D1* (allele *b*) genotype, and its higher test weight of about 1.5 lbs.

TEXAS by Amir Ibrahim and Jackie Rudd

Texas A&M AgriLife Research Test Plots

Greenville, TX. Located north-east of Dallas. Abandoned due to severe sprouting damage.

Bushland, TX. Located in the Texas Panhandle west of Amarillo. Samples were harvested in June 2021 from strips planted adjacent to our intensively managed irrigated yield trials. Plots were fertilized for a yield goal of 100 bu/a and the average yield of the nearby SRPN was 88 bu/a. The crop was irrigated with a linear at regular intervals from early March to early May. Crop development was normal for the Texas Panhandle and there were no uncommon abiotic or biotic stresses.

Texas A&M AgriLife Research Entries
TX15M8024

TX15M8024 was released by Texas A&M AgriLife in 2021. This hard red winter wheat experimental was selected from the TAM Wheat Improvement Program in College Station from the cross 'TAM 203' (PI 655960)/'Duster' (PI 644016). It is resistant to leaf, stripe, and stem rusts. It is resistant to Hessian fly but susceptible to greenbug. It will provide a good compliment to other hard red winter wheat cultivars for wheat producers across the state, particularly in Texas Rolling Plains, Blacklands, South and Central Texas and under irrigated conditions in Texas High plains and similar adaptation zones.

COLORADO by Esten Mason

Growing Location & Conditions

The Wheat Quality Council samples from Colorado originated from strip increases grown under irrigated conditions at the Agricultural Research, Development and Education Center. The field with the strip increases, including adjacent breeding and extension trials, was fertilized with a pre-plant application of 70 lbs N (applied as 46-0-0). The planting date was September 24, 2020 and the harvest date was July 20, 2021. The trial was planted into moisture with excellent stands and good fall growth. No diseases noted in mid-June. Irrigation started around June 3rd due to a wet spring with a total of 5" applied in June, none applied in July. Radar estimates showed the trial received 9.6" of precipitation and 3518 growing degree-days (GDD) (base 32°F) from Jan. 1st through July 20th, which was 0.3" above and 200 GDD below the 10-year averages, respectively.

CO13007-F6R

CO13007-F6R is a hard red winter wheat (HRW) breeding line developed at Colorado State University. CO13007-F6R is derived from a cross between a Kansas State University breeding line, KS05HW122-5, and Byrd. Byrd was tested in the 2010 WQC sample set under experimental number CO06424 and has shown good milling and bread baking quality characteristics, including particularly strong dough mixing properties, high loaf volume, and good crumb grain scores. Over several years of testing, CO13007-F6R has shown excellent milling, large loaf volume and strong mixing properties.

CO16D1487

CO16D1487 is a HRW breeding line developed at Colorado State University. CO16D1487 is derived from a cross between the CSU breeding line CO11D346 and the hard white winter wheat variety ‘Antero’. Over several years of testing, CO16D1487 has shown above average milling and baking qualities with acceptable dough mixing strength. It has also shown high yield potential and test weight, and good straw strength, particularly under irrigated conditions.

LIMAGRAIN by Marla Barnett

Growing Location & Conditions

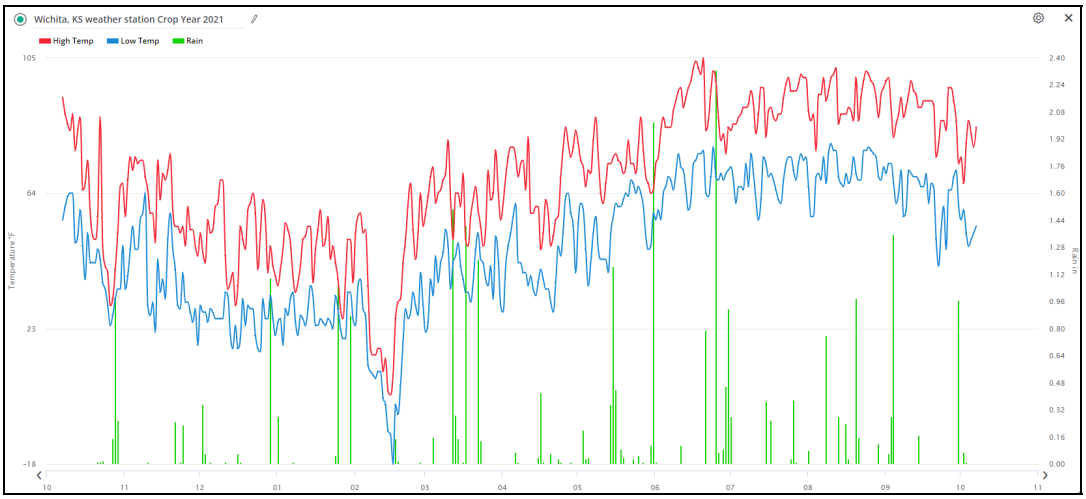
The hard winter Wheat Quality Council samples from Limagrain Cereal Seeds originated from strip increases grown in Wichita, KS located in south central Kansas. The WQC strips were planted on October 7th, 2020 into good soil moisture with good fall stands and decent growth. The field received 120 lbs actual N on March 4th, 2021 at Feekes growth stage 4. No fungicide was applied, and severe stripe rust pressure influenced yields. The mean grain yield of the 11 entries was 59.3 bushels/acre with the lowest yielding entry averaging 51.9 bushels/acre and the highest yielding entry averaging 71.8 bushels/acre (Table 1).

Table 1. Grain yield, test weight, and grain moisture from eleven winter wheat experimental entries and checks grown in Wichita, KS 2021, Limagrain Cereal Seeds.

	Grain Yield (bu/ac)	Test Weight (lbs/bu)	Grain Moisture (%)
Jagalene	51.9	61.9	9.7
CO13007-F6R	71.8	63.8	9.6
CO16D1487	67.1	64.2	9.4
LCH17-4196	59.4	63.8	9.6
OK15MASBx7ARS6-8	59.5	62.1	9.7
OK15MASBx7ARS6-29	58.1	62.6	9.5
SYMonument	55.6	60.5	9.4
APRoadrunner	54.8	62.3	9.7
XE4101	56.4	60.7	9.5
TX15M8024	55.8	62.5	9.6
WB4401	61.8	63.1	10
Mean	59.3	62.5	9.6

Temperatures ranged from -18°F on February 16th, 2021 to 104°F on June 16th, 2021 during the growth season at the location. (Graph 1). No winterkill or winter injury was noted on this winter wheat material; however adjacent Brazilian material did show severe stunting and chlorosis following 14 days below freezing (32°F) during February 2021. The field received 16.23 inches of rainfall (not counting snowfall) from planting (October 7th, 2020) through harvest (June 17th, 2021).

Graph 1. Daily high temperature, daily low temperature, and daily total rainfall from the field location of the 2021 Wheat Quality Council grow out strips at Wichita, KS 2021, Limagrain Cereal Seeds.



Description of Breeder Entries – Limagrain Cereal Seeds

LCH17-4196

LCH17-4196 is a medium maturing hard-red winter wheat with very good yield stability. The pedigree of LCH17-4196 is LCSMint / VA12HRW-27. The pedigree of VA12HRW-27 is TAM303 / KS940786-6-11-2. Excellent yield potential and drought tolerance along with resistance to soil-borne mosaic virus make this medium maturing line very attractive to growers across the Central Plains including the high plains and central corridor regions. LCH17-4196 has a well-rounded disease package. It is moderately resistant to leaf rust, stripe rust, and fusarium head blight, while being resistant to stem rust yet susceptible to Hessian fly. The tillering ability of LCH17-4196 is high; fall ground cover and grazing potential is very good. A medium-tall wheat with excellent winter hardiness and an intermediate growth rate to first hollow stem, LCH17-4196 has better straw strength in high yielding environments than its parent LCS Mint.

This line was tested in the 2020 Southern Regional Performance Nursery. Milling and baking quality data from LCS show acceptable overall quality with most desirable milling attributes and acceptable baking and dough properties.

LCH18-7071

LCH18-7071 is a late maturing hard-red winter wheat with two genes of tolerance to Quizalofop-P-ethyl group 1 ACCase inhibiting herbicides. The pedigree of LCH18-7071 is LCSChrome / ACC7-38. Very high tillering combined with a slow growth rate in the appearance of the first hollow stem makes LCH18-7071 a very attractive line throughout Kansas and Oklahoma where growers want to graze wheat while also controlling winter annual grassy weeds like rye, downy brome, and cheat. LCH18-7071 is susceptible to stem rust and stripe rust while being resistant to leaf rust and soil-borne mosaic virus. The tillering ability of LCH18-7071 is very high; winter hardiness is excellent. A medium-tall, long coleoptile wheat, LCH18-7071 is an excellent grazing option and the latest maturing CoAXium line currently available.

Milling and baking quality data from LCS show acceptable overall quality with acceptable baking qualities and desirable dough and milling properties. The line was ultimately released as LCS Steel AX under the CoAXium wheat production system.

KANSAS MANHATTAN by Allan Fritz

The WQC growouts at Colby, KS were planted on September 26, 2020 on the Western Kansas Agricultural Research Center experiment field. Twenty-eight pounds actual N was applied at planting via diammonium phosphate. Fifty pounds of N were applied pre-plant and 60 pounds were applied as top dress at green-up. The plots emerged in a uniform stand. We generally had excellent growing conditions during in the Spring and early Summer of 2021. The plots did experience significant lodging as the result of excellent growth and a strong thunderstorm at mid grainfill.

SYNGENTA by Josh Coltrain

Northern uniform growout increase strips were planted on 10/9/20 at our location in Junction City, KS. The strips had very good fall stand establishment. All increases had 80lbs of 11-52-0 applied with the planter with 70lbs of N applied prior to planting. An additional 70lbs of N and 20lbs of Sulfur was top dressed in the spring prior to jointing. All strips were sprayed with a 13.7oz rate of Trivapro at flag leaf to ensure good quality seed. Unfortunately, due to an extremely wide variance on maturities, the earliest group were harvested on 6/22/21 but the later group were not at an acceptable grain moisture level. Prior to the later group drying down, nearly one inch of precipitation fell between 6/24/21 and 6/26/21. As such, the later plots were abandoned since uniformity was no longer possible and no samples were submitted.

10BC329-17-5

AP Bigfoot (10BC329-17-5) was developed from the cross TAM112/CO04393//SY Wolf made in the fall of 2009 in Junction City, KS. It was tested and evaluated under the experimental designation 10BC329-17-5. TAM112 is a PVP variety developed by Texas A&M University from the cross U1254-7-9-2-1/TXGH10440 and released in 2006. CO04393 is an experimental line from Colorado State University with pedigree Stanton/CO950043. SY Wolf is a PVP variety developed by Syngenta Crop Protection AG from the cross of W99-331/97x0906-8 and released in 2007.

AP Bigfoot is a hard red winter wheat broadly adapted to the Central and Western High Plains. The line is short with moderately early maturity and very good test weight. AP Bigfoot has shown very good straw strength and aluminum tolerance. It's fungal disease package is similar to but slightly better than SY Wolf. AP Bigfoot is quite tolerant to leaf rust, and moderately tolerant of stripe rust. It has intermediate tolerance of Wheat Streak Mosaic Virus and Soilborne Mosaic Virus. Milling and baking data compiled over multiple locations in multiple years indicates very good milling and acceptable baking properties with excellent flour yield and protein.

AP Roadrunner

AP Roadrunner was developed from the cross Jackpot/Duster made in the fall of 2008 in Vernon, TX. It was tested and evaluated under the experimental designation AP14T21619. Jackpot is a PVP variety developed by Syngenta Seeds, Inc. from the cross W98-232/KS96WGRC38 and released in 2009. Duster is a PVP variety developed by Oklahoma Agricultural Experiment Station from the cross of W0405D/NE78488/W7469C/TX81V6187 and released in 2007.

AP Roadrunner is a hard red winter wheat broadly adapted to the Central and Western High Plains. The line is medium tall with moderately late maturity. AP Roadrunner has shown excellent aluminum tolerance. It's fungal disease package is very good with excellent tolerance to leaf rust, and stripe rust, though it is susceptible to stem rust. It has intermediate tolerance of Wheat Streak Mosaic Virus but is tolerant of Soilborne Mosaic Virus. Milling and baking data compiled over multiple locations in multiple years indicates excellent milling and baking properties which rival SY Monument in mixing tolerance and loaf volume.

BAYER (Westbred) by Adam Bray

The Bayer/WestBred hard red winter WQC Uniform Growout was abandoned due to extreme drought conditions in Floydada, Texas.

WB4401

WB4401 is a hard red winter wheat, with medium maturity, good straw strength, and average test weight. It has good winterhardiness and is well adapted to the central and southern plains region. It has a strong disease package with very good Powdery Mildew and Stripe Rust resistance, as well as good FHB, Soil-borne Mosaic Virus, and leaf rust resistance. It is moderately resistant to Hessian Fly, and moderately susceptible to Wheat Streak Mosaic Virus. Additionally, it has very good aluminum tolerance for low pH soils. Internal quality testing indicates below average protein, but good to very good functionality. WB4401 was released in 2020, targeting broad acres across the central and southern plains.

XE4101 (WB4422)

XE4101 is a hard red winter wheat, with medium maturity, excellent straw strength, very good protein content, and high test weight. It has good winter hardiness and is well adapted to the central and southern plains. It has strong resistance to Leaf Rust and Soil-borne Wheat Mosaic Virus. It is moderately resistant to FHB and Powdery Mildew, moderate susceptibility Wheat Streak Mosaic Virus, and is susceptible to Stripe Rust. Internal quality testing indicates acceptable mixing and baking qualities for hard red winter wheat class. XE4101 is a new release that will be marketed as WB4422 targeting broad acres across the central and southern plains.

Southern Growout: 2021 (Small-Scale) Samples

Test entry number	21-2411	21-2412	21-2413	21-2414
Sample identification	**Jagalene_CK**	**LCH17-4196_LG**	**SY Monument_CK**	***OK15MAS8-29_OK**
Wheat Data				
GIPSA classification	1 HRW	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	63.1	61.7	60.7	61.7
Hectoliter weight (kg/hl)	82.9	81.1	79.8	81.1
1000 kernel weight (gm)	33.6	30.5	28.3	32.1
Wheat kernel size (Rotap)				
Over 7 wire (%)	79.4	62.1	74.4	74.0
Over 9 wire (%)	20.4	36.9	25.1	25.7
Through 9 wire (%)	0.2	1.0	0.5	0.3
Single kernel (skcs)[a]				
Hardness (avg /s.d)	75.1/16.9	74.4/18.9	66.0/18.5	63.4/17.5
Weight (mg) (avg/s.d)	33.6/9.5	30.5/10.2	28.3/10.1	32.1/11.3
Diameter (mm)(avg/s.d)	2.79/0.38	2.61/0.45	2.46/0.37	2.59/0.40
Moisture (%) (avg/s.d)	11.5/0.6	13.2/0.4	13.3/0.3	12.7/0.4
SKCS distribution	01-04-12-83-01	01-05-15-79-01	04-10-19-67-01	04-13-24-59-01
Classification	Hard	Hard	Hard	Hard
Wheat protein (12% mb)	12.5	11.7	12.1	11.8
Wheat ash (12% mb)	1.38	1.51	1.48	1.50
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	78.5	76.3	76.1	74.8
Quadrumat Sr. Mill	67.5	67.8	67.5	64.6
Flour moisture (%)	13.7	13.8	13.6	14.3
Flour protein (14% mb)	11.4	10.5	10.9	10.9
Flour ash (14% mb)	0.54	0.49	0.48	0.47
Rapid Visco-Analyser				
Peak time (min)	6.2	6.2	6.1	6.3
Peak viscosity (RVU)	190.7	216.5	210.2	200.0
Breakdown (RVU)	71.9	80.5	76.6	65.2
Final viscosity at 13 min (RVU)	222.3	246.1	247.5	240.0
Minolta color meter				
L*	90.09	91.21	91.36	91.64
a*	-1.14	-1.55	-1.45	-1.67
b*	9.22	9.20	8.81	9.30
PPO	0.439	0.518	0.266	0.198
Falling number (sec)	390	376	399	405
Damaged Starch				
(AI%)	99.0	98.6	98.7	99.0
(AACC76-31)	8.8	8.4	8.6	8.8

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

*OK15MAS8-29_OK=OK15MASBx7ARS8-29

Southern Growout: 2021 (Small-Scale) Samples (continued)

Test entry number	21-2415	21-2416	21-2417	21-2418
Sample identification	**AP Roadrunner_AP**	***OK15DMAS6-8_OK**	**CO13007-F6R_CO**	**CO16D1487_CO**
Wheat Data				
GIPSA classification	1 HRW	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	61.0	62.2	62.6	61.8
Hectoliter weight (kg/hl)	80.2	81.8	82.3	81.3
1000 kernel weight (gm)	33.3	28.8	31.4	27.8
Wheat kernel size (Rotap)				
Over 7 wire (%)	65.6	72.6	77.9	70.6
Over 9 wire (%)	34.0	26.9	21.7	28.8
Through 9 wire (%)	0.4	0.5	0.4	0.6
Single kernel (skcs)[a]				
Hardness (avg /s.d)	61.0/16.3	62.9/14.9	57.3/16.6	57.3/15.8
Weight (mg) (avg/s.d)	33.3/11.3	28.8/9.5	31.4/9.6	27.8/9.8
Diameter (mm)(avg/s.d)	2.69/0.40	2.59/0.37	2.67/0.37	2.46/0.39
Moisture (%) (avg/s.d)	12.9/0.3	12.7/0.4	12.8/0.4	13.1/0.4
SKCS distribution	04-14-31-51-01	03-12-24-61-01	06-19-32-43-01	06-17-32-45-01
Classification	Hard	Hard	Hard	Hard
Wheat protein (12% mb)	12.0	12.6	11.8	11.8
Wheat ash (12% mb)	1.58	1.46	1.44	1.49
Milling and Flour Quality Data				
Flour yield (%, str. grade)				
Miag Multomat Mill	75.9	75.9	76.8	76.6
Quadrumat Sr. Mill	67.7	67.2	68.5	68.9
Flour moisture (%)	14.0	13.9	13.9	13.6
Flour protein (14% mb)	10.9	11.4	10.8	10.5
Flour ash (14% mb)	0.51	0.46	0.49	0.48
Rapid Visco-Analyser				
Peak time (min)	6.3	6.1	6.2	6.3
Peak viscosity (RVU)	192.1	215.8	229.4	237.7
Breakdown (RVU)	67.7	87.9	100.8	95.8
Final viscosity at 13 min (RVU)	228.2	227.6	217.2	243.1
Minolta color meter				
L*	90.79	91.35	91.23	91.34
a*	-1.41	-1.31	-1.37	-1.20
b*	9.77	8.57	8.92	8.15
PPO	0.492	0.440	0.439	0.478
Falling number (sec)	364	357	385	404
Damaged Starch				
(AI%)	99.0	98.8	98.5	98.3
(AACC76-31)	8.8	8.6	8.3	8.2

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

*OK15DMAS6-8_OK = OK15MASBx7ARS6-8

Southern Growout: 2021 (Small-Scale) Samples (continued)

Test entry number	21-2419	21-2420	21-2421
Sample identification	**TX15M8024_TX**	**XE4101_WB**	**WB4401_WB**
Wheat Data			
GIPSA classification	1 HRW	1 HRW	1 HRW
Test weight (lb/bu)	61.0	60.7	61.3
Hectoliter weight (kg/hl)	80.2	79.8	80.6
1000 kernel weight (gm)	30.9	31.8	34.6
Wheat kernel size (Rotap)			
Over 7 wire (%)	68.8	64.2	71.0
Over 9 wire (%)	31.0	35.1	28.6
Through 9 wire (%)	0.2	0.7	0.4
Single kernel (skcs)[a]			
Hardness (avg /s.d)	62.5/18.2	64.0/14.9	71.5/17.7
Weight (mg) (avg/s.d)	30.9/10.8	31.8/10.5	34.6/11.2
Diameter (mm)(avg/s.d)	2.56/0.40	2.62/0.37	2.78/0.40
Moisture (%) (avg/s.d)	13.1/0.4	13.0/0.5	13.1/0.4
SKCS distribution	07-13-22-58-01	04-06-27-63-01	03-06-15-76-01
Classification	Hard	Hard	Hard
Wheat protein (12% mb)	12.8	13.4	11.8
Wheat ash (12% mb)	1.52	1.55	1.52
Milling and Flour Quality Data			
Flour yield (%, str. grade)			
Miag Multomat Mill	76.8	76.5	75.2
Quadrumat Sr. Mill	66.3	65.5	62.3
Flour moisture (%)	13.8	13.2	12.8
Flour protein (14% mb)	11.5	12.3	10.8
Flour ash (14% mb)	0.53	0.57	0.63
Rapid Visco-Analyser			
Peak time (min)	6.3	5.7	6.2
Peak viscosity (RVU)	210.2	130.7	176.7
Breakdown (RVU)	73.0	74.9	70.3
Final viscosity at 13 min (RVU)	242.3	119.8	197.8
Minolta color meter			
L*	90.55	90.34	91.34
a*	-1.20	-1.06	-1.38
b*	9.12	8.86	10.04
PPO	0.492	0.223	0.411
Falling number (sec)	403	303	357
Damaged Starch			
(AI%)	98.2	98.8	98.8
(AACC76-31)	8.1	8.6	8.6

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

Southern Growout: Physical Dough Tests and Gluten Analysis 2021 (Small-Scale) Samples

Test Entry Number	21-2411	21-2412	21-2413	21-2414
Sample Identification	Jagalene_OK	LCH17-4196_LG	SY Monument_CK	*OK15MAS8-29_OK
MIXOGRAPH				
Flour Abs (% as-is)	69.8	65.1	67.9	68.2
Flour Abs (14% mb)	69.5	64.9	67.7	68.7
Mix Time (min)	4.6	4.5	8.4	10.8
Mix tolerance (0-6)	4	4	6	6
FARINOGRAPH				
Flour Abs (% as-is)	68.1	64.3	66.1	69.7
Flour Abs (14% mb)	67.7	64.1	65.9	70.2
Peak time (min)	6.0	6.7	9.4	40.6
Mix stability (min)	12.7	12.4	17.2	54.5
Mix Tolerance Index (FU)	14	20	15	0
Breakdown time (min)	14.3	13.7	18.4	57.6
ALVEOGRAPH				
P(mm): Tenacity	191	140	181	174
L(mm): Extensibility	52	41	36	190
G(mm): Swelling index	16.0	14.2	13.3	30.6
W(10^{-4} J): strength (curve area)	298	232	294	790
P/L: curve configuration ratio	3.67	3.41	5.03	0.92
Ie(P_{200}/P): elasticity index	18.5	41.6	0.0	38.9
EXTENSIGRAPH				
Resist (BU at 45/90/135 min)	403/590/568	335/455/516	598/996/1013	799/1405/1404
Extensibility (mm at 45/90/135 min)	131/127/121	136/144/129	128/116/98	129/96/92
Energy (cm^2 at 45/90/135 min)	89/125/111	79/121/112	130/172/129	175/179/154
Resist $_{max}$ (BU at 45/90/135min)	518/802/736	435/665/682	814/1254/1123	1116/1638/1493
Ratio (at 45/90/135 min)	3.1/4.6/4.7	2.5/3.2/4.0	4.7/8.6/10.3	6.2/14.6/15.3
PROTEIN ANALYSIS				
HMW-GS Composition	1,2*, 17+18, 5+10	2*, 7+8, 5+10	2*, 7+9, 5+10	2*, 7^{oe}+8, 5+10
TPP/TMP	0.83	0.78	0.82	0.85
SEDIMENTATION TEST				
Volume (ml)	57.8	48.9	62.9	61.8

*OK15MAS8-29_OK= OK15MASBx7ARS8-29

Southern Growout: Physical Dough Tests and Gluten Analysis 2021 (Small-Scale) Samples (continued)

Test Entry Number	21-2415	21-2416	21-2417	21-2418
Sample Identification	AP Roadrunner_AP	*OK15DMAS6-8_OK	CO13007-F6R_CO	CO16D1487_CO
MIXOGRAPH				
Flour Abs (% as-is)	66.8	69.1	67.0	67.9
Flour Abs (14% mb)	66.8	69.0	66.8	67.7
Mix Time (min)	4.6	6.8	4.8	5.0
Mix tolerance (0-6)	5	6	5	5
FARINOGRAPH				
Flour Abs (% as-is)	68.6	68.8	68.7	67.0
Flour Abs (14% mb)	68.6	68.7	68.5	66.8
Peak time (min)	7.2	9.3	7.7	7.8
Mix stability (min)	11.6	26.5	11.2	19.7
Mix Tolerance Index (FU)	24	17	29	12
Breakdown time (min)	13.1	28.0	13.0	21.1
ALVEOGRAPH				
P(mm): Tenacity	178	203	195	170
L(mm): Extensibility	61	42	30	40
G(mm): Swelling index	17.3	14.4	12.2	14.0
W(10^{-4} J): strength (curve area)	331	378	261	290
P/L: curve configuration ratio	2.92	4.83	6.50	4.25
Ie(P_{200}/P): elasticity index	32.8	57.9	0.0	47.8
EXTENSIGRAPH				
Resist (BU at 45/90/135 min)	388/559/592	477/871/1011	509/675/700	431/595/650
Extensibility (mm at 45/90/135 min)	140/130/123	130/117/97	132/115/111	128/118/115
Energy (cm^2 at 45/90/135 min)	93/124/119	103/153/124	116/126/121	91/111/115
Resist $_{max}$ (BU at 45/90/135min)	502/783/777	634/1120/1116	706/933/929	533/770/826
Ratio (at 45/90/135 min)	2.8/4.3/4.8	3.7/7.5/10.4	3.9/5.9/6.3	3.4/5.1/5.6
PROTEIN ANALYSIS				
HMW-GS Composition	1, 7+8, 5+10	2*, 7^{oe}+8, 5+10	2*, 7+8, 5+10	1, 7+8, 5+10
TPP/TMP	0.94	0.85	0.94	0.86
SEDIMENTATION TEST				
Volume (ml)	51.5	61.4	53.9	49.4

*OK15DMAS6-8_OK = OK15MASBx7ARS6-8

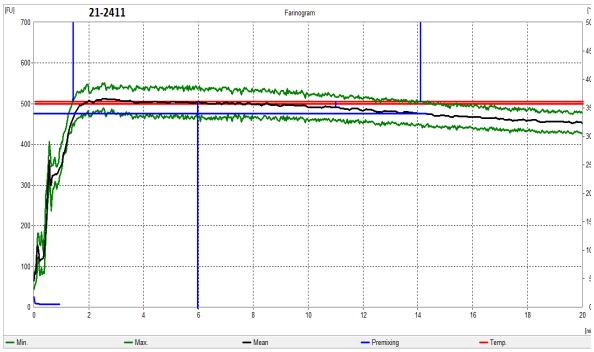
Southern Growout: Physical Dough Tests and Gluten Analysis 2021 (Small-Scale) Samples (continued)

Test Entry Number	21-2419	21-2420	21-2421
Sample Identification	TX15M8024_TX	XE4101_WB	WB4401_WB
MIXOGRAPH			
Flour Abs (% as-is)	69.7	73.4	73.8
Flour Abs (14% mb)	69.5	72.5	72.6
Mix Time (min)	4.9	4.1	5.9
Mix tolerance (0-6)	5	3	2
FARINOGRAPH			
Flour Abs (% as-is)	69.3	71.8	72.4
Flour Abs (14% mb)	69.2	71.0	71.2
Peak time (min)	6.5	6.0	6.4
Mix stability (min)	12.8	8.3	10.1
Mix Tolerance Index (FU)	20	32	28
Breakdown time (min)	13.1	10.1	12.7
ALVEOGRAPH			
P(mm): Tenacity	188	170	176
L(mm): Extensibility	37	49	27
G(mm): Swelling index	13.5	15.5	11.5
W(10^{-4} J): strength (curve area)	300	318	217
P/L: curve configuration ratio	5.08	3.47	6.52
Ie(P_{200}/P): elasticity index	0.0	45.2	0.0
EXTENSIGRAPH			
Resist (BU at 45/90/135 min)	424/572/584	325/504/553	469/685/759
Extensibility (mm at 45/90/135 min)	129/132/117	138/122/117	119/102/108
Energy (cm^2 at 45/90/135 min)	92/130/111	74/97/91	88/100/115
Resist $_{max}$ (BU at 45/90/135min)	552/793/812	405/634/653	551/775/858
Ratio (at 45/90/135 min)	3.3/4.3/5.0	2.4/4.1/4.6	4.0/6.7/7.0
PROTEIN ANALYSIS			
HMW-GS Composition	1, 17+18,7, 5+10	1, 17+18,7, 5+10	2*, 7+8, 5+10
TPP/TMP	0.76	0.67	1.03
SEDIMENTATION TEST			
Volume (ml)	53.9	50.5	53.4

Physical Dough Tests – Farino and Mixo

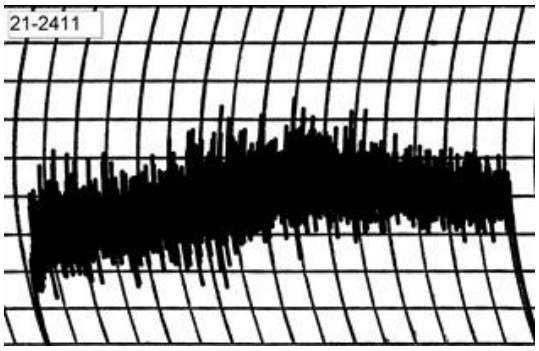
2021 (Small Scale) Samples – Southern Growout

Farinograms



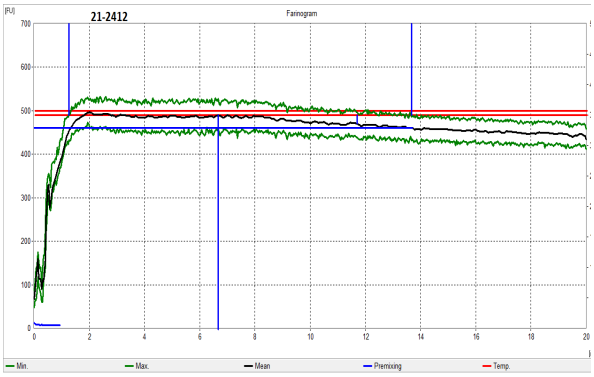
Water abs = 67.7%, Peak time = 6.0 min,
Mix stab = 12.7 min, MTI = 14 FU

Mixograms

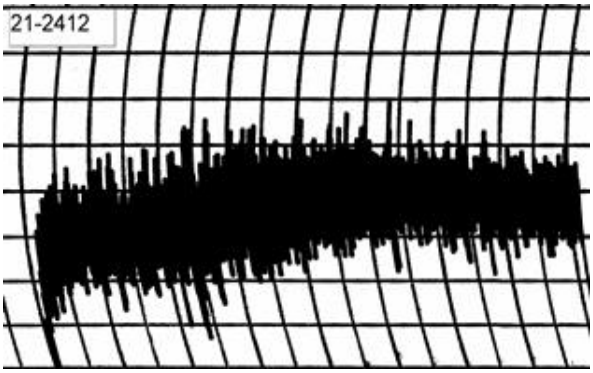


Water abs = 69.5%
Mix time = 4.6 min

21-2411, Jagalene_CK



Water abs = 64.1%, Peak time = 6.7 min,
Mix stab = 12.4 min, MTI = 20 FU



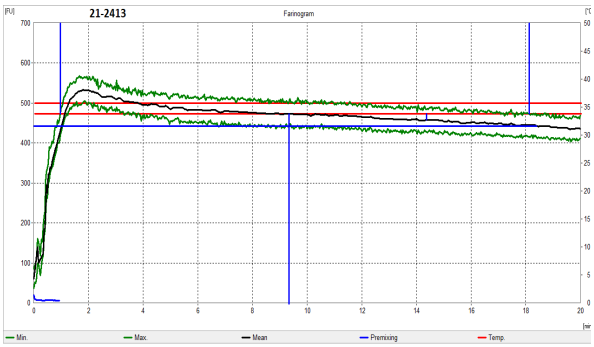
Water abs = 64.9%
Mix time = 4.5 min

21-2412, LCH17-4196_LG

Physical Dough Tests – Farino and Mixo

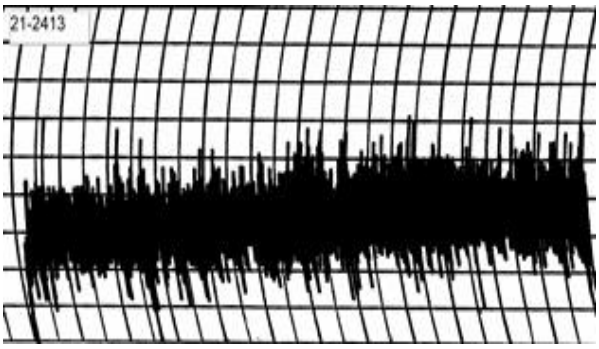
2021 (Small Scale) Samples – Southern Growout

Farinograms



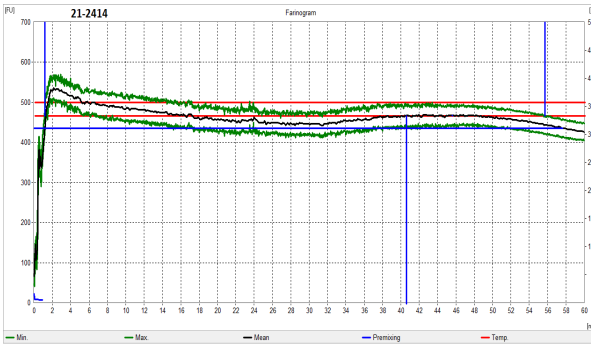
Water abs = 65.9%, Peak time = 9.4 min,
Mix stab = 17.2 min, MTI = 15 FU

Mixograms

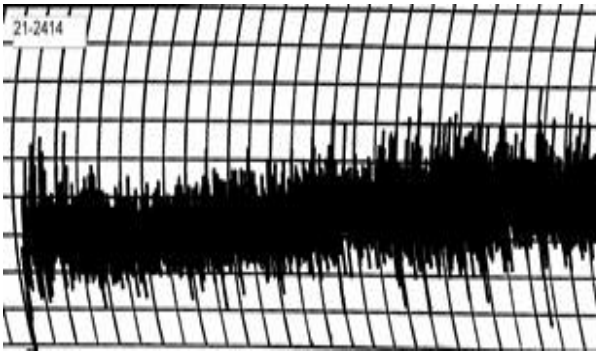


Water abs = 67.7%
Mix time = 8.4 min

21-2413, SY Monument_CK



Water abs = 70.2%, Peak time = 40.6 min,
Mix stab = 54.5 min, MTI = 0 FU



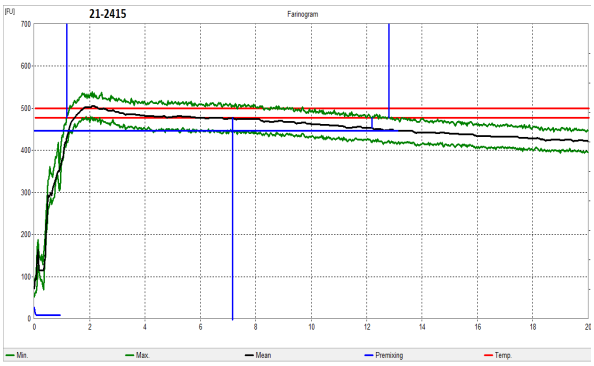
Water abs = 68.7%
Mix time = 10.8 min

21-2414, OK15MAS8-29_OK

Physical Dough Tests - Farino and Mixo

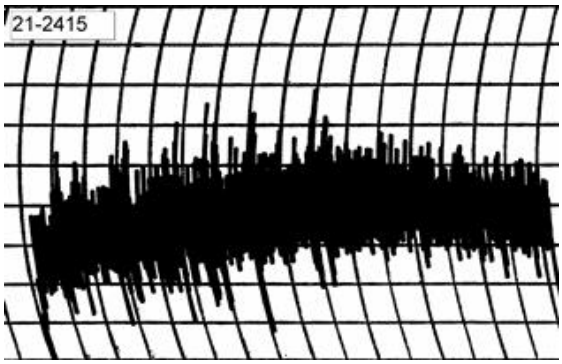
2021 (Small Scale) Samples – Southern Growout

Farinograms



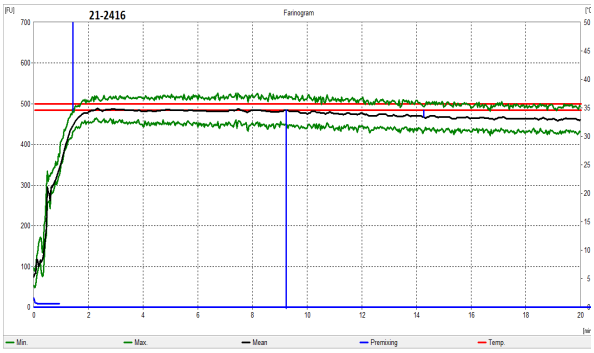
Water abs = 68.6%, Peak time = 7.2 min,
Mix stab = 11.6 min, MTI = 24 FU

Mixograms

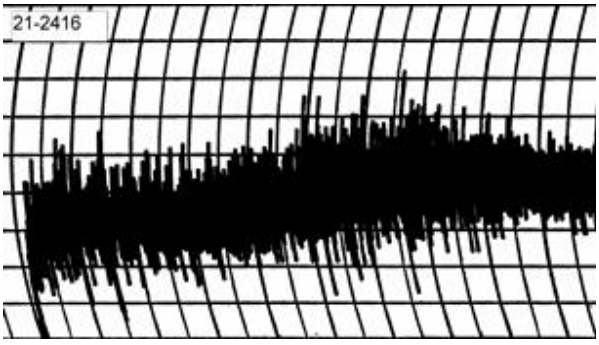


Water abs = 66.8%
Mix time = 4.6 min

21-2415, AP Roadrunner_AP



Water abs = 68.7%, Peak time = 9.3 min,
Mix stab = 26.5 min, MTI = 17 FU



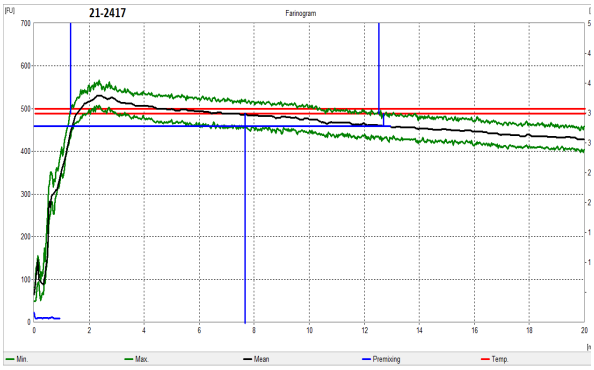
Water abs = 69.0%
Mix time = 6.8 min

21-2416, OK15DMAS6-8_OK

Physical Dough Tests- Farino and Mixo

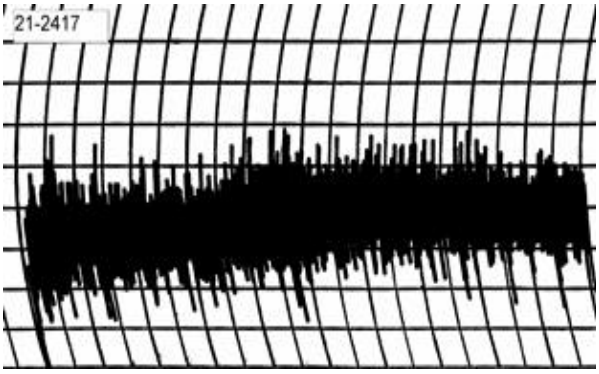
2021 (Small Scale) Samples – Southern Growout

Farinograms



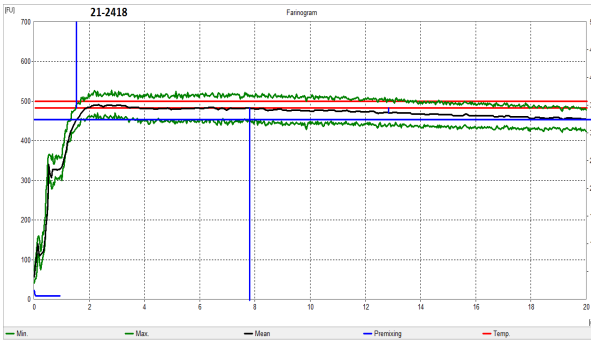
Water abs = 68.5%, Peak time = 7.7 min,
Mix stab = 11.2 min, MTI = 29 FU

Mixograms

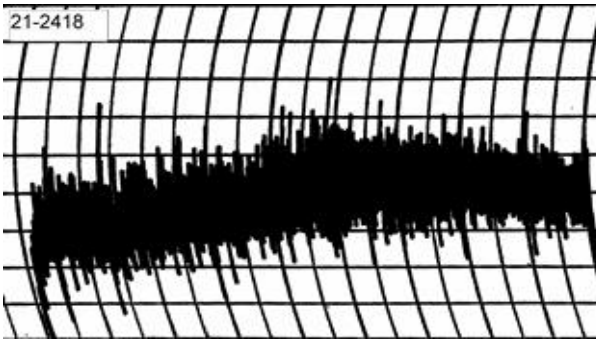


Water abs = 66.8%
Mix time = 4.8 min

21-2417, CO13007-F6R_CO



Water abs = 66.8%, Peak time = 7.8 min,
Mix stab = 19.7 min, MTI = 12 FU



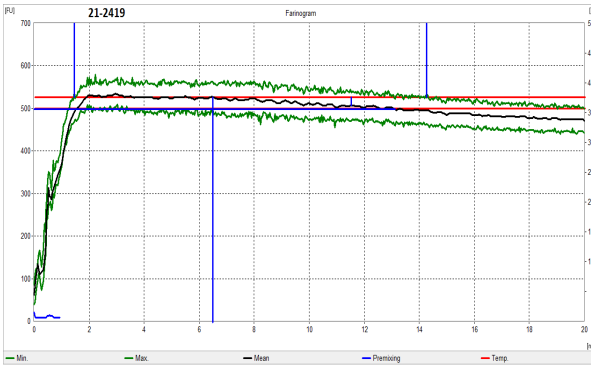
Water abs = 67.7%
Mix time = 5.0 min

21-2418, CO16D1487_CO

Physical Dough Tests- Farino and Mixo

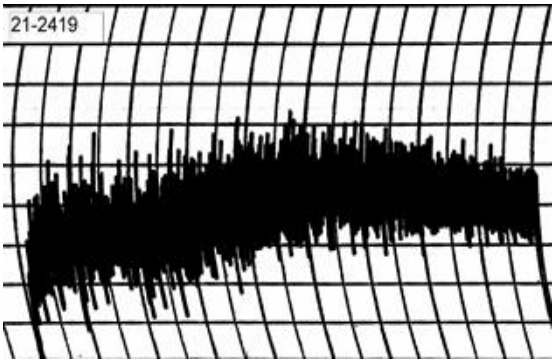
2021 (Small Scale) Samples – Southern Growout

Farinograms



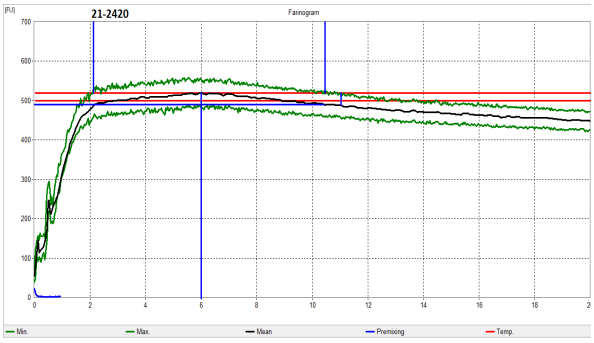
Water abs = 69.2%, Peak time = 6.5 min,
Mix stab = 12.8 min, MTI = 20 FU

Mixograms

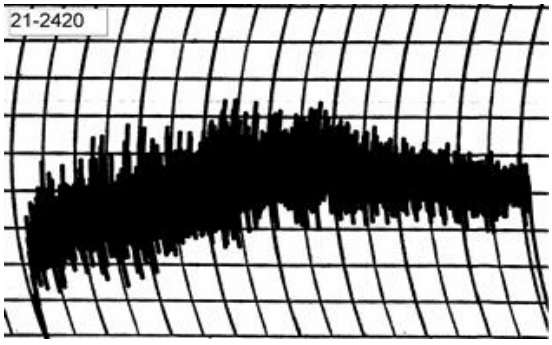


Water abs = 69.5%
Mix time = 4.9 min

21-2419, TX15M8024_TX



Water abs = 71.0%, Peak time = 6.0 min,
Mix stab = 8.3 min, MTI = 32 FU



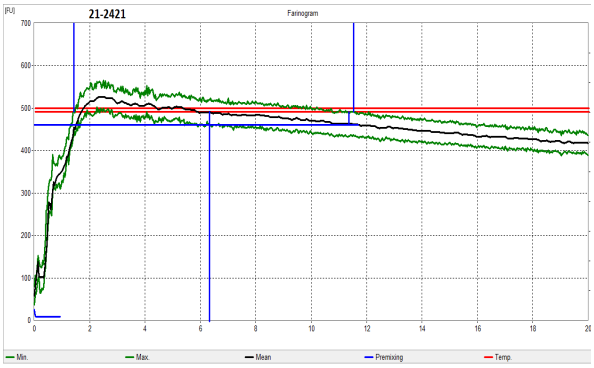
Water abs = 72.5%
Mix time = 4.1 min

21-2420, XE4101_WB

Physical Dough Tests- Farino and Mixo

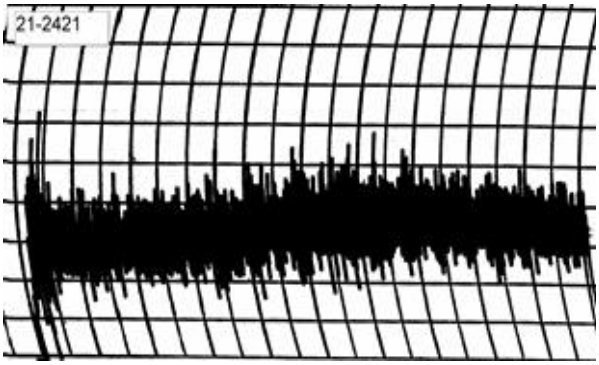
2021 (Small Scale) Samples – Southern Growout

Farinograms



Water abs = 71.2%, Peak time = 6.4 min,
Mix stab = 10.1 min, MTI = 28 FU

Mixograms

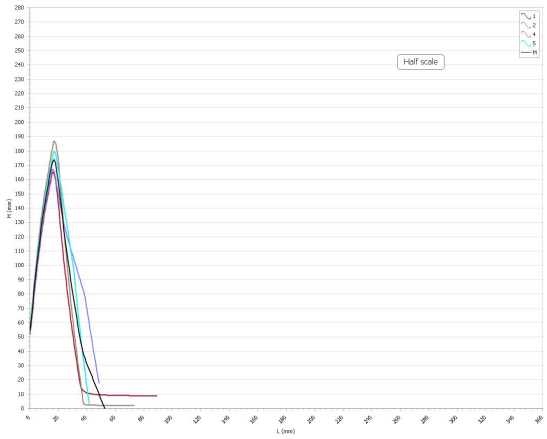


Water abs = 72.6%
Mix time = 5.9 min

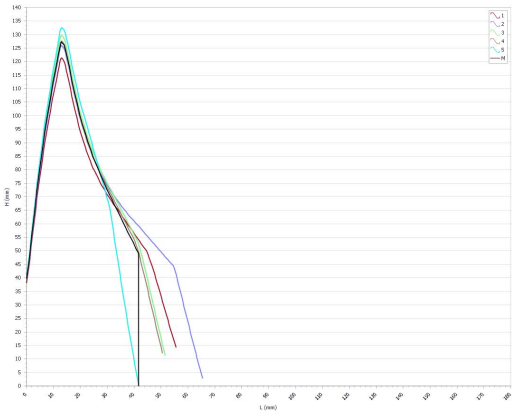
21-2421, WB4401_WB

Physical Dough Tests - Alveograms

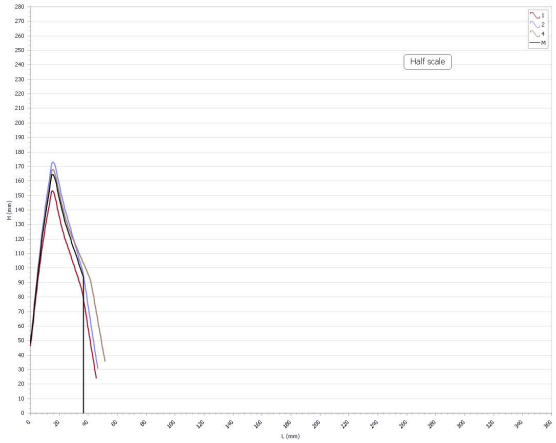
2021 (Small Scale) Samples – Southern Growout



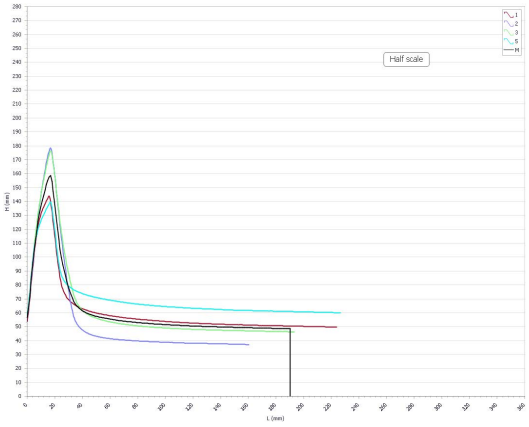
21-2411, Jagalene_CK
P(mm H_20) = 191, L(mm) = 52, W(10E^{-4} J) = 298



21-2412, LCH17-4196_LG
P(mm H_20) = 140, L(mm) = 41, W(10E^{-4} J) = 232



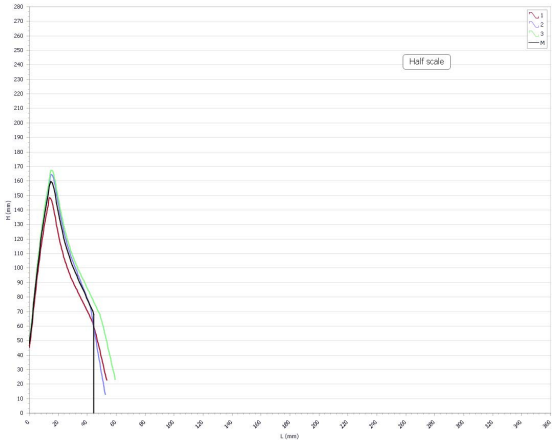
21-2413, SY Monument_CK
P(mm H_20) = 181, L(mm) = 36, W(10E^{-4} J) = 294



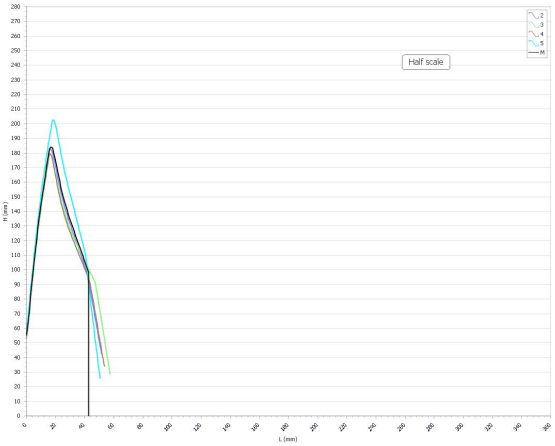
21-2414, OK15MAS8-29_OK
P(mm H_20) = 174, L(mm) = 190, W(10E^{-4} J) = 790

Physical Dough Tests - Alveograms

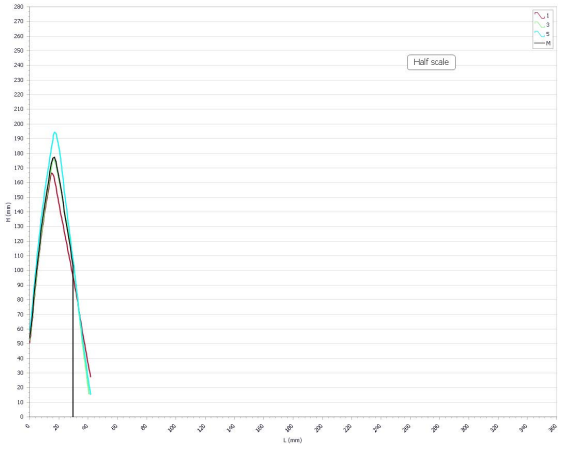
2021 (Small Scale) Samples – Southern Growout



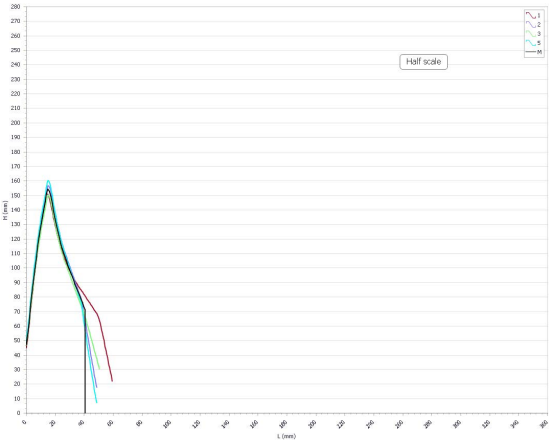
21-2415, AP Roadrunner_AP
P(mm H_20) = 178, L(mm) = 61, W($10E^{-4}$ J) = 332



21-2416, OK15DMAS6-8_OK
P(mm H_20) = 203, L(mm) = 42, W($10E^{-4}$ J) = 378



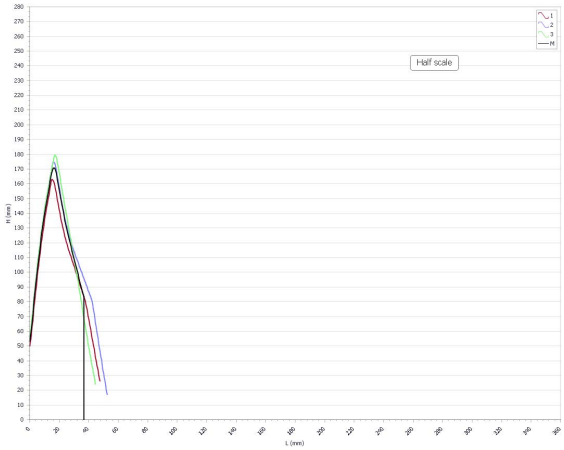
21-2417, CO13007-F6R_CO
P(mm H_20) = 195, L(mm) = 30, W($10E^{-4}$ J) = 261



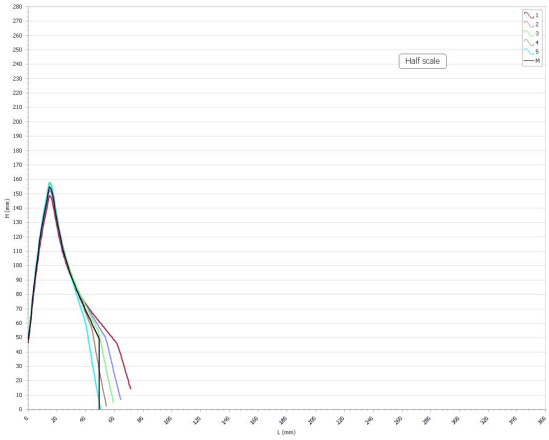
21-2418, CO16D1487_CO
P(mm H_20) = 170, L(mm) = 40, W($10E^{-4}$ J) = 290

Physical Dough Tests - Alveograms

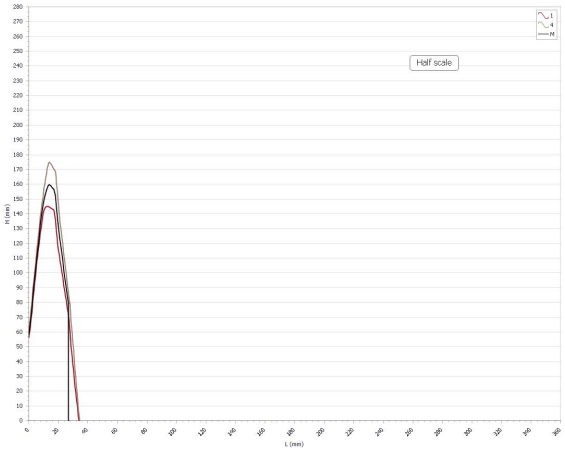
2020 (Small Scale) Samples – Southern Growout



21-2419, TX15M88024_TX
P(mm H_20) = 188, L(mm) = 37, W($10E^{-4}$ J) = 300



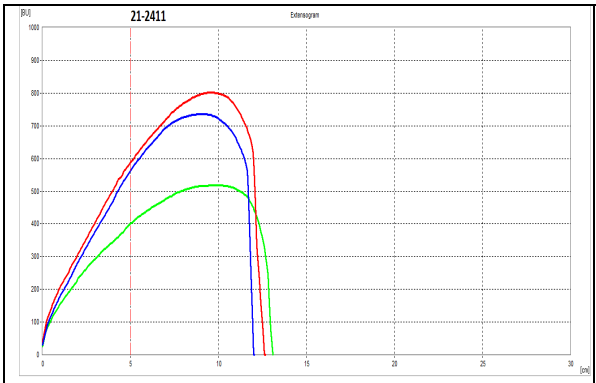
21-2420, XE4101_WB
P(mm H_20) = 170, L(mm) = 49, W($10E^{-4}$ J) = 318



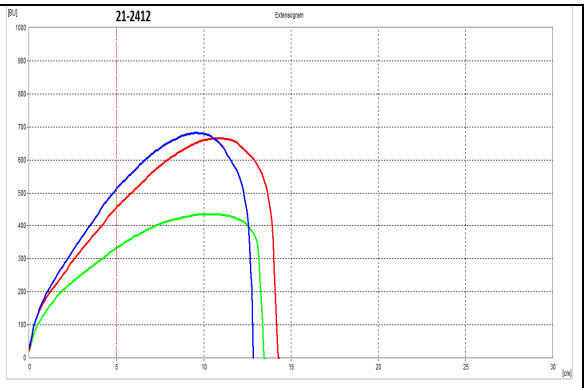
21-2421, WB4401_WB
P(mm H_20) 176, L(mm) = 27, W($10E^{-4}$ J) = 217

Physical Dough Tests - Extensigrams

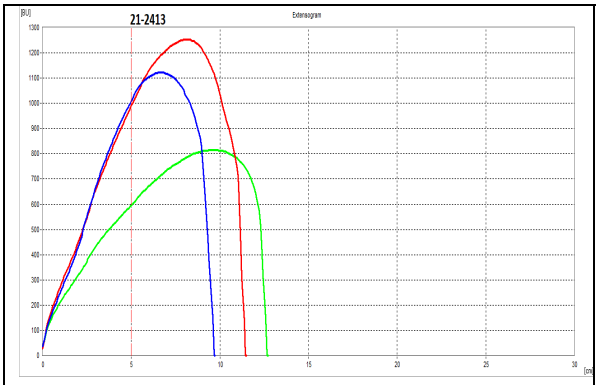
2021 (Small Scale) Samples – Southern Growout



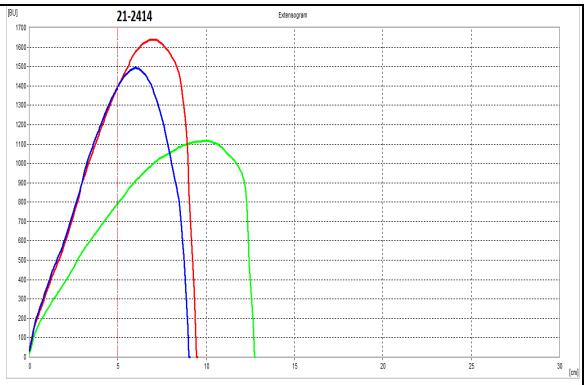
21-2411, Jagalene_CK
R (BU) =590, E (mm) = 127, W (cm^2) = 125
Rmax (BU) = 802, Ratio = 4.6 at 90 min



21-2412, LCH17-4196_LG
R (BU) = 455, E (mm) = 144, W (cm^2) = 121
Rmax (BU) = 665, Ratio = 3.2 at 90 min



21-2413, SY Monument_CK
R (BU) =996, E (mm) = 116, W (cm^2) = 172
Rmax (BU) = 1254, Ratio = 8.6 at 90 min

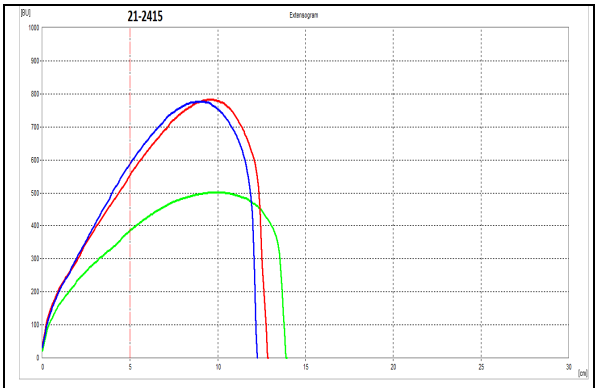


21-2414, OK15MAS8-29_OK
R (BU) = 1405, E (mm) = 96, W (cm^2) = 179
Rmax (BU) = 1638, Ratio = 14.6 at 90 min

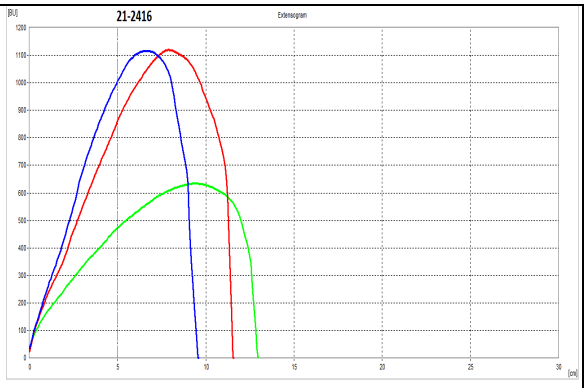
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigrams

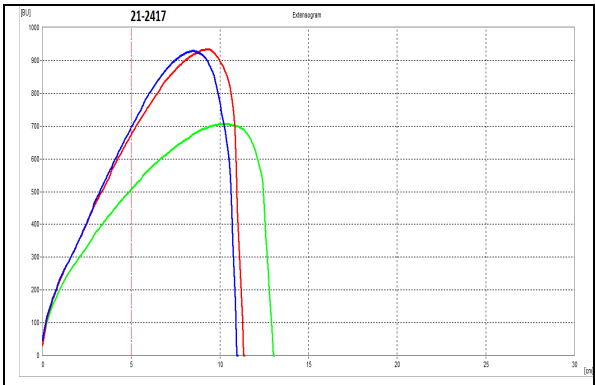
2021 (Small Scale) Samples – Southern Growout



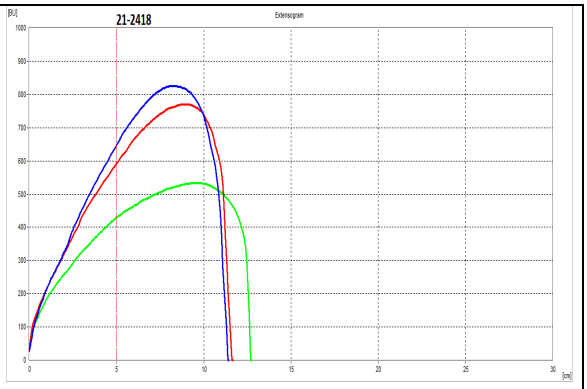
21-2415, AP Roadrunner_AP
R (BU) = 559, E (mm) = 130, W (cm^2) = 124
Rmax (BU) = 783, Ratio = 4.3 at 90 min



21-2416, OK15DMAS6-8_OK
R (BU) = 871, E (mm) = 117, W (cm^2) = 153
Rmax (BU) = 1120, Ratio = 7.5 at 90 min



21-2417, CO13007-F6R_CO
R (BU) = 675, E (mm) = 115, W (cm^2) = 126
Rmax (BU) = 933, Ratio = 5.9 at 90 min

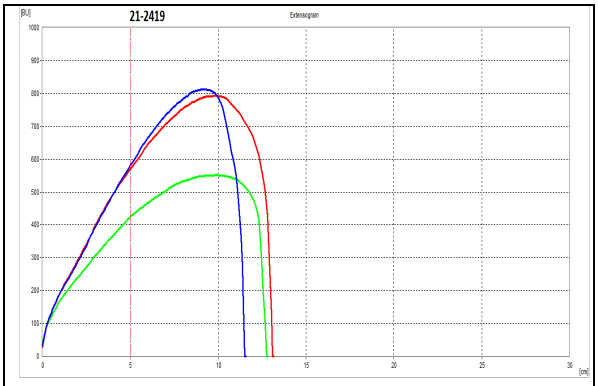


21-2418, CO16D1487_CO
R (BU) = 595, E (mm) = 118, W (cm^2) = 111
Rmax (BU) = 770, Ratio = 5.1 at 90 min

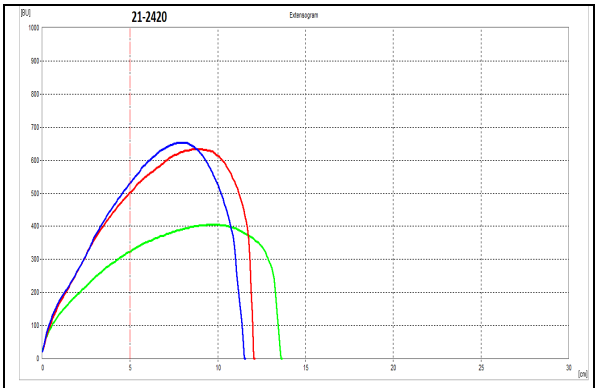
Notes: R (BU) = Resistance; E (mm) = Extensibility; W (cm^2) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

Physical Dough Tests - Extensigrams

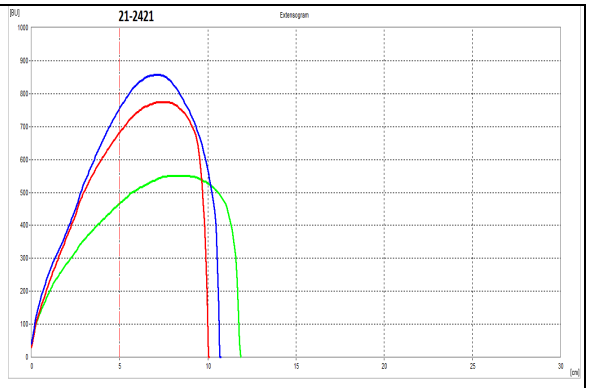
2021 (Small Scale) Samples – Southern Growout



21-2419, TX15M8024_TX
R (BU) =572, E (mm) = 132, W (cm^2) = 130
Rmax (BU) = 793, Ratio = 4.3 at 90 min



21-2420, XE4101_WB
R (BU) = 504, E (mm) = 122, W (cm^2) = 97
Rmax (BU) = 634, Ratio = 4.1 at 90 min

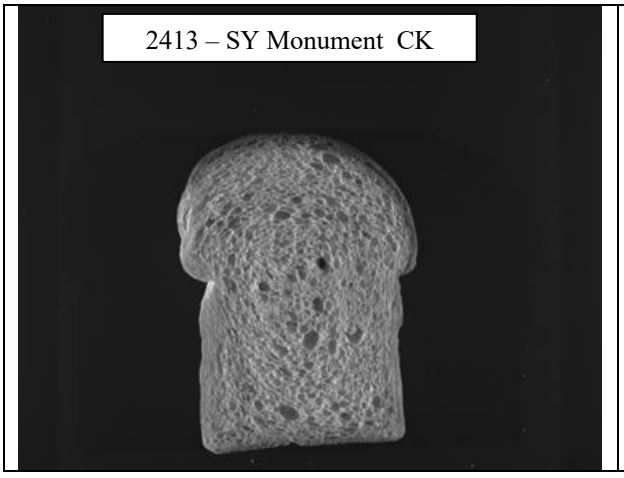


21-2421, WB4401_WB
R (BU) = 685, E (mm) = 102, W (cm^2) = 100
Rmax (BU) = 775, Ratio = 6.7 at 90 min

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

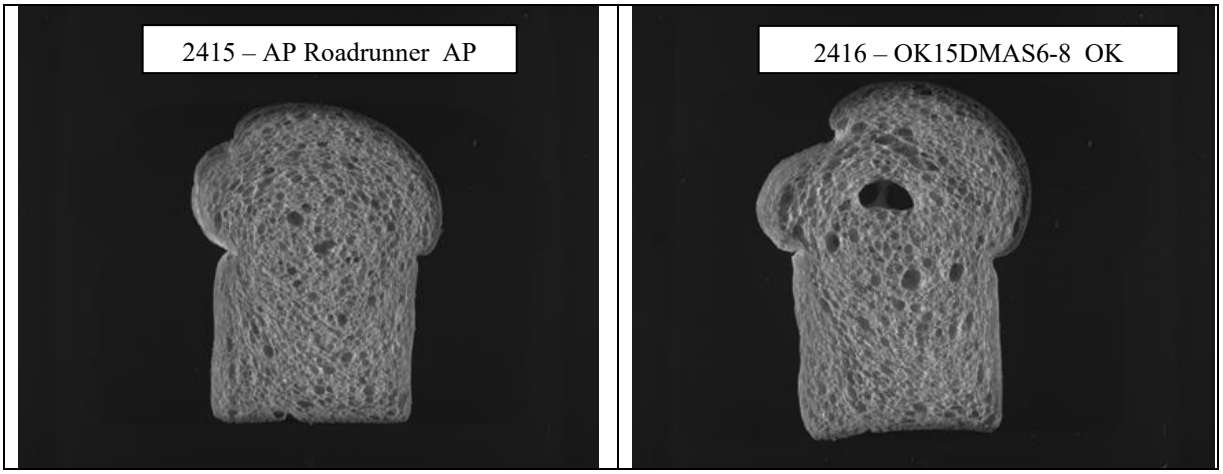
Southern Growout: C-Cell Bread Images and Analysis
2021 (Small-Scale) Samples

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	6722	105	3690	0.435	2.180	3.728	1.785	-4.85
2412	6759	114	4107	0.420	1.980	1.608	1.785	-6.38

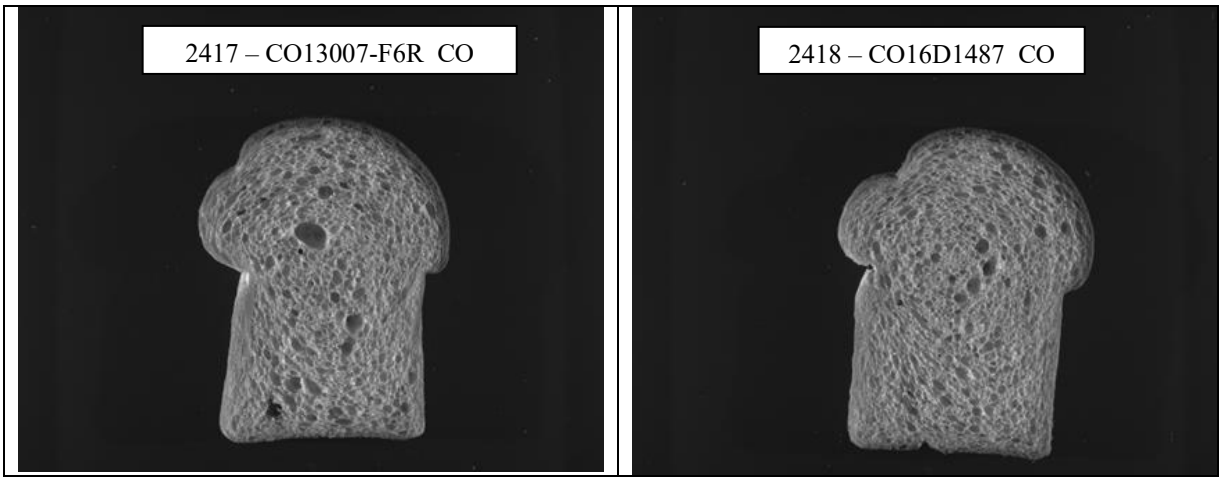


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2413	6083	111	3560	0.420	1.955	2.393	1.785	-3.75
2414	6093	113	3600	0.423	1.955	2.440	1.805	-6.15

Southern Growout: C-Cell Bread Images and Analysis
2021 (Small-Scale) Samples

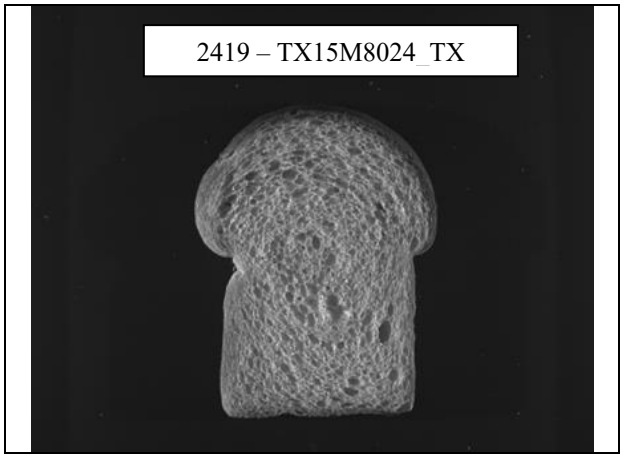


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2415	6381	107	3661	0.433	2.015	3.473	1.765	-5.30
2416	7029	108	3736	0.435	2.235	4.483	1.780	-5.13

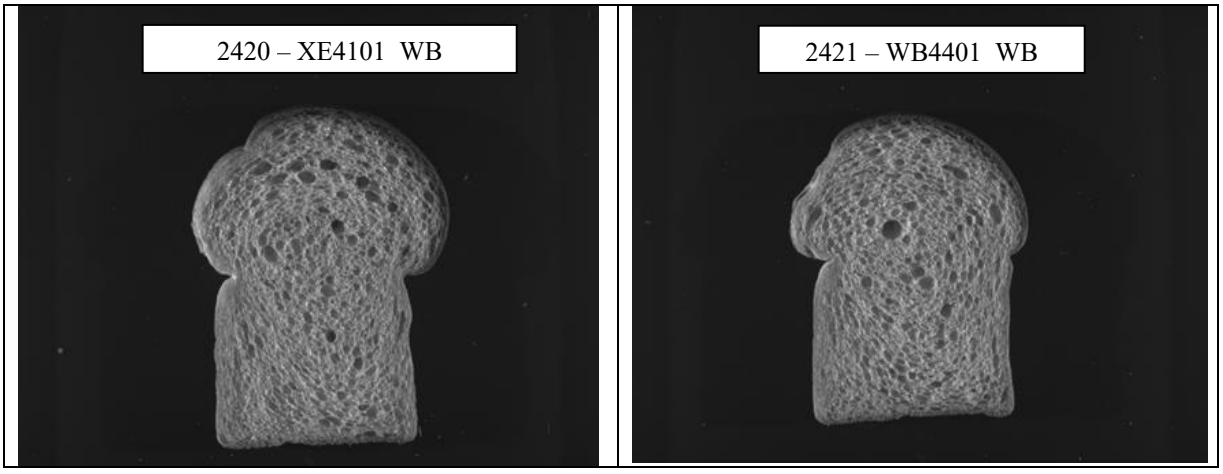


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2417	6230	112	3389	0.433	2.140	3.758	1.798	-5.90
2418	6223	113	3500	0.433	2.018	2.500	1.773	-7.03

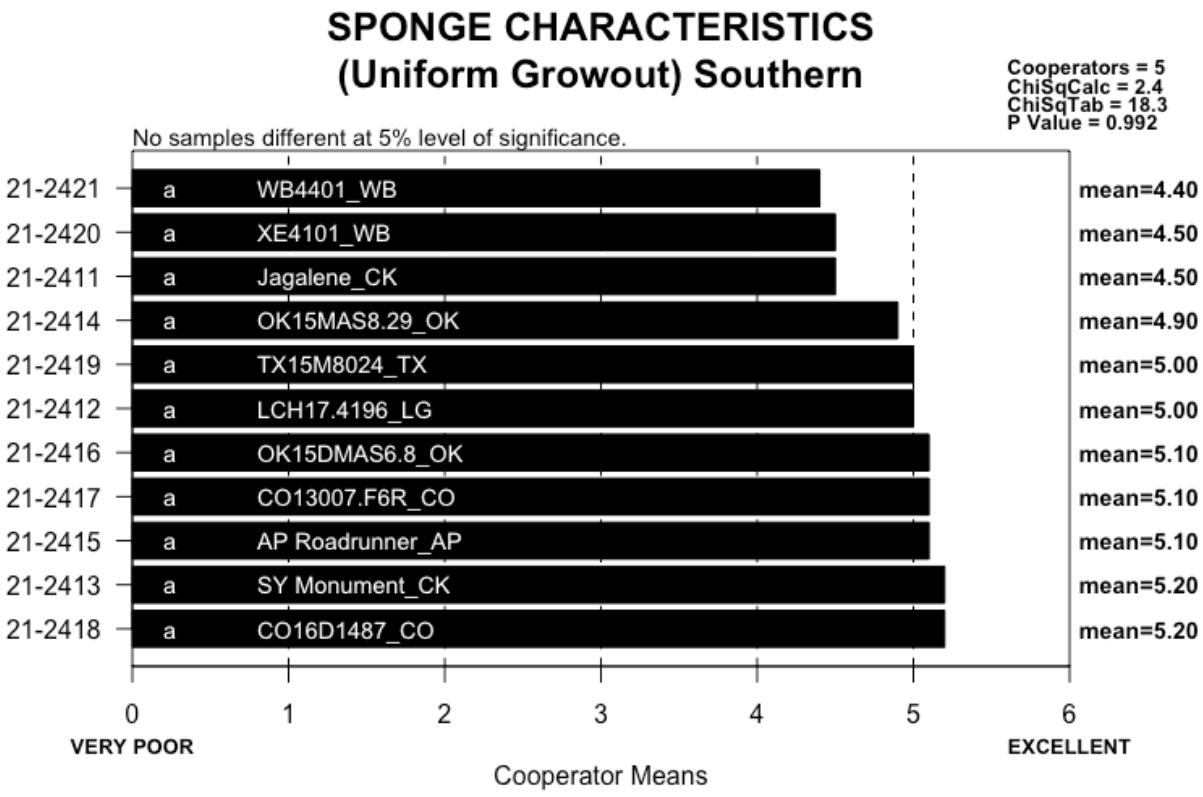
Southern Growout: C-Cell Bread Images and Analysis
2021 (Small-Scale) Samples

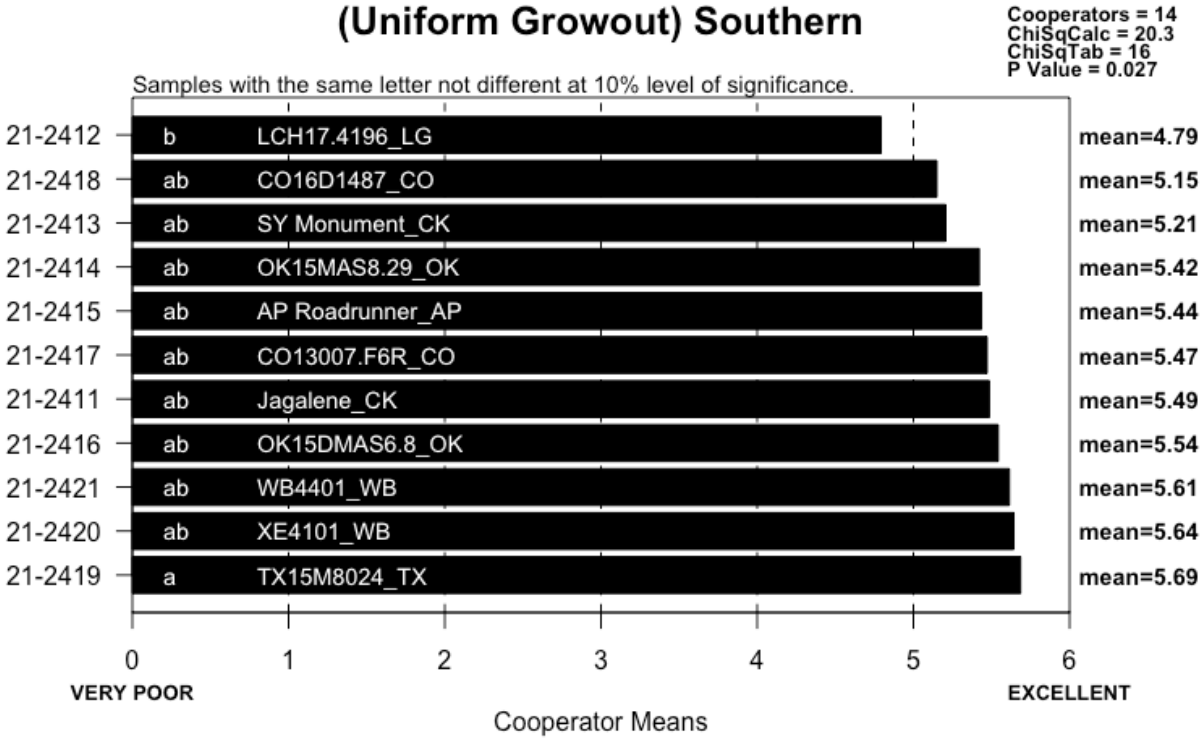


Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2419	6330	111	3445	0.433	2.088	2.893	1.808	-5.50



Entry #	Slice Area (mm^2)	Slice Brightness	Number Cells	Wall Thick (mm)	Cell Diameter (mm)	Non-uniformity	Avg. Cell Elongation	Cell Angle to Vertical (^{0})
2420	6689	106	3543	0.440	2.223	1.875	1.743	-4.15
2421	6003	108	3281	0.438	2.005	4.703	1.818	-3.83


SPONGE CHARACTERISTICS
(Uniform Growout) Southern
Cooperators = 5
ChiSqCalc = 2.4
ChiSqTab = 18.3
P Value = 0.992
No samples different at 5% level of significance.
21-2421 a WB4401_WB mean=4.40
21-2420 a XE4101_WB mean=4.50
21-2411 a Jagalene_CK mean=4.50
21-2414 a OK15MAS8.29_OK mean=4.90
21-2419 a TX15M8024_TX mean=5.00
21-2412 a LCH17.4196_LG mean=5.00
21-2416 a OK15DMAS6.8_OK mean=5.10
21-2417 a CO13007.F6R_CO mean=5.10
21-2415 a AP Roadrunner_AP mean=5.10
21-2413 a SY Monument_CK mean=5.20
21-2418 a CO16D1487_CO mean=5.20
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

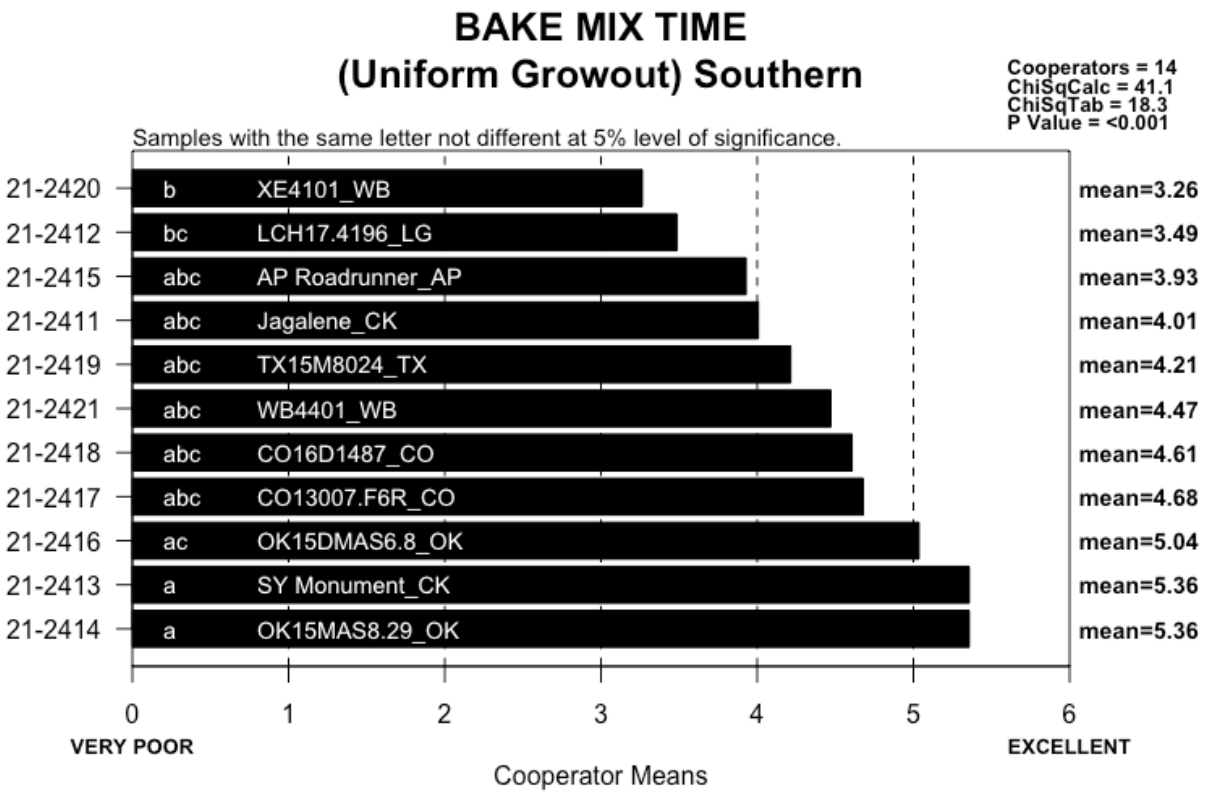

BAKE ABSORPTION
(Uniform Growout) Southern
Cooperators = 14
ChiSqCalc = 20.3
ChiSqTab = 16
P Value = 0.027
Samples with the same letter not different at 10% level of significance.
21-2412 b LCH17.4196_LG mean=4.79
21-2418 ab CO16D1487_CO mean=5.15
21-2413 ab SY Monument_CK mean=5.21
21-2414 ab OK15MAS8.29_OK mean=5.42
21-2415 ab AP Roadrunner_AP mean=5.44
21-2417 ab CO13007.F6R_CO mean=5.47
21-2411 ab Jagalene_CK mean=5.49
21-2416 ab OK15DMAS6.8_OK mean=5.54
21-2421 ab WB4401_WB mean=5.61
21-2420 ab XE4101_WB mean=5.64
21-2419 a TX15M8024_TX mean=5.69
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

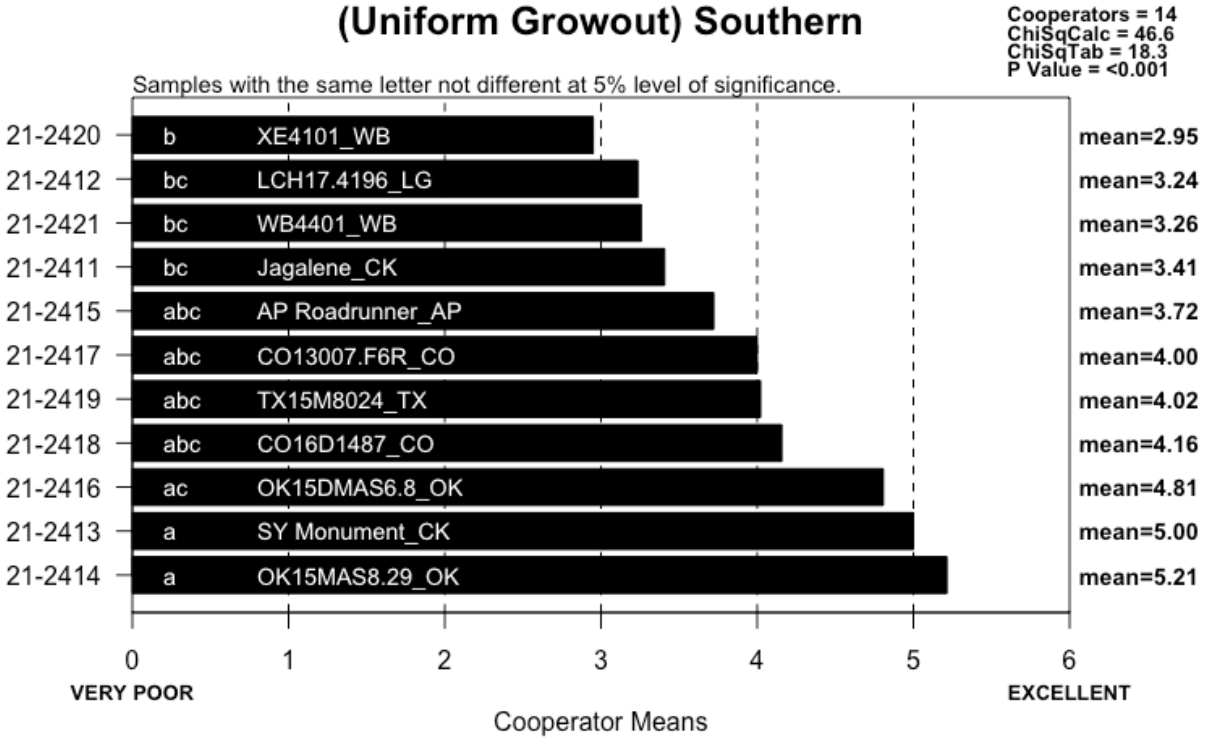
BAKE ABSORPTION, ACTUAL (14% MB)
(Uniform Growout) Southern
Cooperators A – N

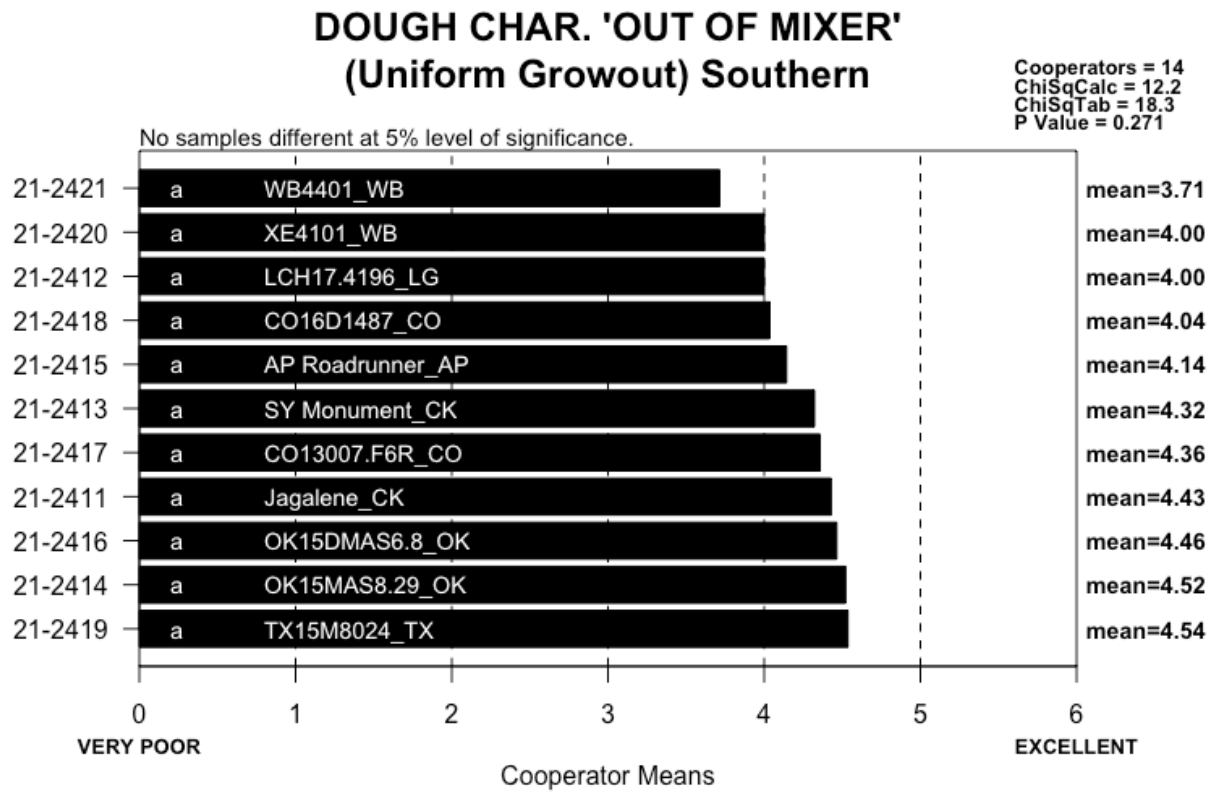
IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2411	Jagalene_CK	65	57	64.9	64.3	68.4	70.2	63.7	69.7	68.9	65	67.7	69.5	69.7	73.6
21-2412	LCH17-4196_LG	64	56	65.1	63.1	64.5	67.2	62.8	65.1	65.1	64	64.1	64.9	66.1	69.7
21-2413	SY Monument_CK	65	57	66.0	63.9	68.5	66.5	62.8	68.1	66.9	65	65.9	67.7	67.9	71.5
21-2414	OK15MAS8-29_OK	65	57	67.9	62.4	70.2	71.9	65.5	68.2	71.0	65	70.2	68.7	72.2	73.7
21-2415	AP Roadrunner_AP	65	57	66.3	63.1	66.7	70.9	64.0	67.0	69.3	65	68.6	66.8	70.6	72.9
21-2416	OK15DMAS6-8_OK	66	57	65.1	64.1	68.6	71.3	63.9	69.1	68.7	65	68.7	69.0	70.7	74.2
21-2417	CO13007-F6R_CO	65	57	67.2	63.1	68.5	71.1	64.8	67.1	68.5	65	68.5	66.8	70.5	72.1
21-2418	CO16D1487_CO	64	56	63.2	63.1	67.5	67.7	62.8	67.7	67.3	65	66.8	67.7	68.8	71.5
21-2419	TX15M8024_TX	66	57	67.0	64.1	70.5	72.0	64.8	69.6	69.6	65	69.2	69.5	71.2	74.7
21-2420	XE4101_WB	65	58	66.3	65.4	72.8	68.5	64.1	73.2	71.0	65	71.0	72.5	73.0	77.8
21-2421	WB4401_WB	65	57	66.0	64.1	70.5	70.8	63.8	78.9	71.5	65	71.2	72.6	73.2	76.6

BAKE MIX TIME, ACTUAL
(Uniform Growout) Southern Cooperators A – N

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2411	Jagalene_CK	4.6	7	4.5	5.1	5.3	4.5	5	4.5	6.0	15	10	4.6	12	5.5
21-2412	LCH17-4196_LG	3.9	6	4.0	5.8	5.0	4.6	4	4.4	4.8	8	12	4.5	12	4.5
21-2413	SY Monument_CK	6.0	15	7.3	11.0	11.5	9.0	10	8.2	9.8	24	16	8.5	20	4.5
21-2414	OK15MAS8-29_OK	10.3	15	10.0	17.2	15.0	10.3	18	10.8	13.8	40	14	11.7	20	4.0
21-2415	AP Roadrunner_AP	3.5	5	4.0	5.0	6.5	3.7	6	4.5	5.8	14	10	4.9	15	5.0
21-2416	OK15DMAS6-8_OK	6.2	9	5.5	8.0	8.8	6.4	8	6.6	8.0	27	10	7.0	18	5.0
21-2417	CO13007-F6R_CO	5.9	8	5.3	7.3	8.3	5.9	7	5.7	8.0	14	12	5.8	18	5.0
21-2418	CO16D1487_CO	4.8	7	4.8	6.5	6.6	6.4	8	5.4	6.0	17	10	5.0	15	5.0
21-2419	TX15M8024_TX	4.4	7	4.8	7.2	6.0	3.0	6	5.0	5.5	15	12	4.9	14	4.5
21-2420	XE4101_WB	3.4	5	3.5	4.2	4.5	4.7	4	4.0	4.3	10	10	4.1	13	6.5
21-2421	WB4401_WB	5.3	10	5.3	5.6	8.3	6.6	5	6.6	7.8	13	8	6.9	14	6.0

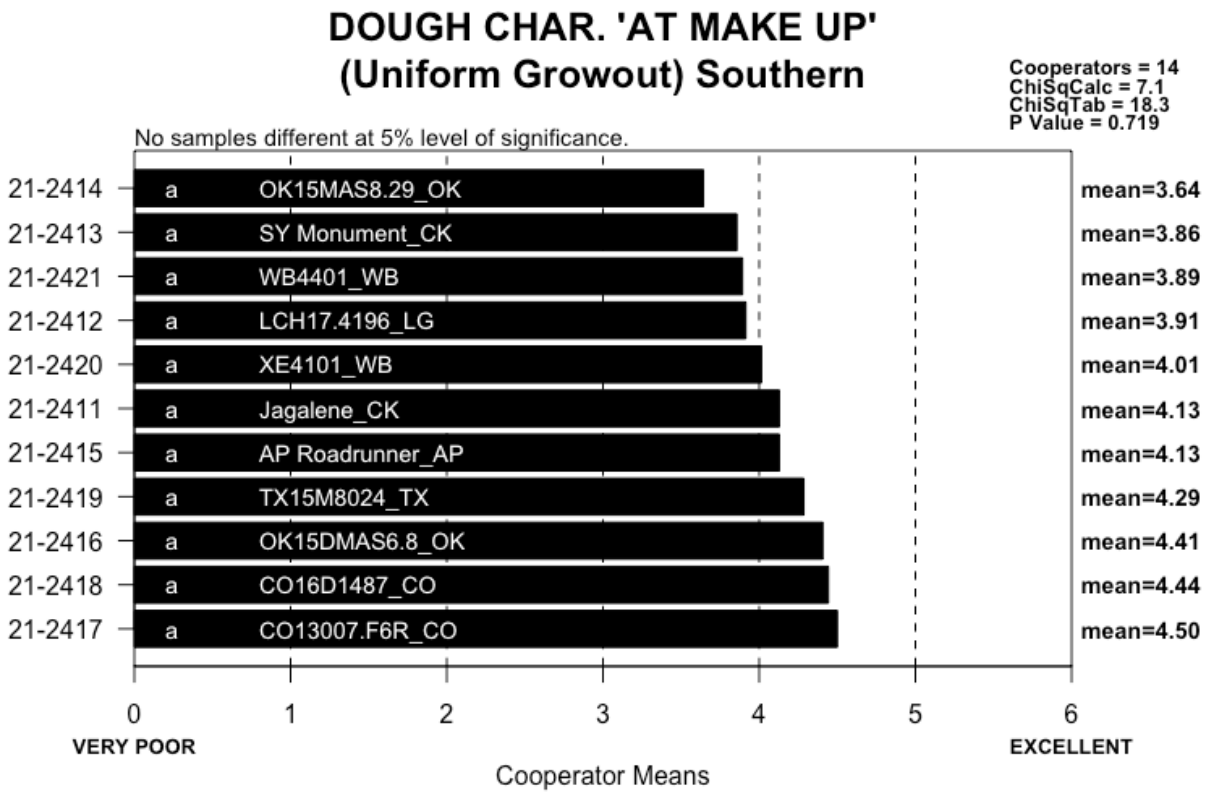

BAKE MIX TIME
(Uniform Growout) Southern
Cooperators = 14
ChiSqCalc = 41.1
ChiSqTab = 18.3
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
21-2420 b XE4101_WB mean=3.26
21-2412 bc LCH17.4196_LG mean=3.49
21-2415 abc AP Roadrunner_AP mean=3.93
21-2411 abc Jagalene_CK mean=4.01
21-2419 abc TX15M8024_TX mean=4.21
21-2421 abc WB4401_WB mean=4.47
21-2418 abc CO16D1487_CO mean=4.61
21-2417 abc CO13007.F6R_CO mean=4.68
21-2416 ac OK15DMAS6.8_OK mean=5.04
21-2413 a SY Monument_CK mean=5.36
21-2414 a OK15MAS8.29_OK mean=5.36
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Uniform Growout) Southern
Cooperators = 14
ChiSqCalc = 46.6
ChiSqTab = 18.3
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
21-2420 b XE4101_WB mean=2.95
21-2412 bc LCH17.4196_LG mean=3.24
21-2421 bc WB4401_WB mean=3.26
21-2411 bc Jagalene_CK mean=3.41
21-2415 abc AP Roadrunner_AP mean=3.72
21-2417 abc CO13007.F6R_CO mean=4.00
21-2419 abc TX15M8024_TX mean=4.02
21-2418 abc CO16D1487_CO mean=4.16
21-2416 ac OK15DMAS6.8_OK mean=4.81
21-2413 a SY Monument_CK mean=5.00
21-2414 a OK15MAS8.29_OK mean=5.21
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



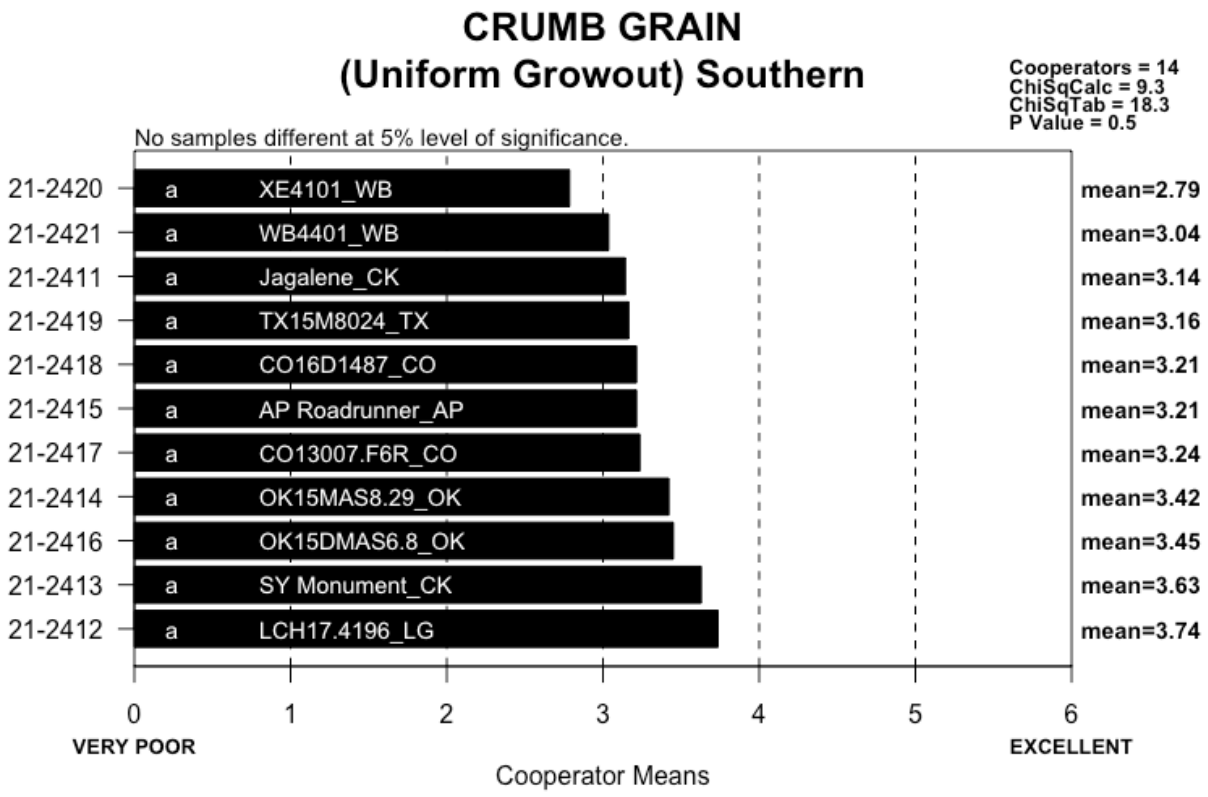
DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Uniform Growout) Southern

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
21-2411	Jagalene_CK	4	1	0	8	1
21-2412	LCH17-4196_LG	2	2	2	8	0
21-2413	SY Monument_CK	2	1	3	7	1
21-2414	OK15MAS8-29_OK	2	1	3	7	1
21-2415	AP Roadrunner_AP	3	2	1	7	1
21-2416	OK15DMAS6-8_OK	0	3	2	9	0
21-2417	CO13007-F6R_CO	2	1	3	8	0
21-2418	CO16D1487_CO	5	0	2	6	1
21-2419	TX15M8024_TX	2	1	2	8	1
21-2420	XE4101_WB	4	3	2	5	0
21-2421	WB4401_WB	2	2	5	5	0



DOUGH CHAR. 'AT MAKE UP', DESCRIBED
(Uniform Growout) Southern

IDCODE	ID	Sticky	Wet	Tough	Good	Excellent
21-2411	Jagalene_CK	1	1	2	8	2
21-2412	LCH17-4196_LG	2	1	1	9	1
21-2413	SY Monument_CK	1	1	7	5	0
21-2414	OK15MAS8-29_OK	1	1	9	3	0
21-2415	AP Roadrunner_AP	4	1	1	8	0
21-2416	OK15DMAS6-8_OK	2	0	3	7	2
21-2417	CO13007-F6R_CO	2	1	1	10	0
21-2418	CO16D1487_CO	1	0	2	8	3
21-2419	TX15M8024_TX	1	1	2	8	2
21-2420	XE4101_WB	1	1	2	9	1
21-2421	WB4401_WB	1	1	4	7	1

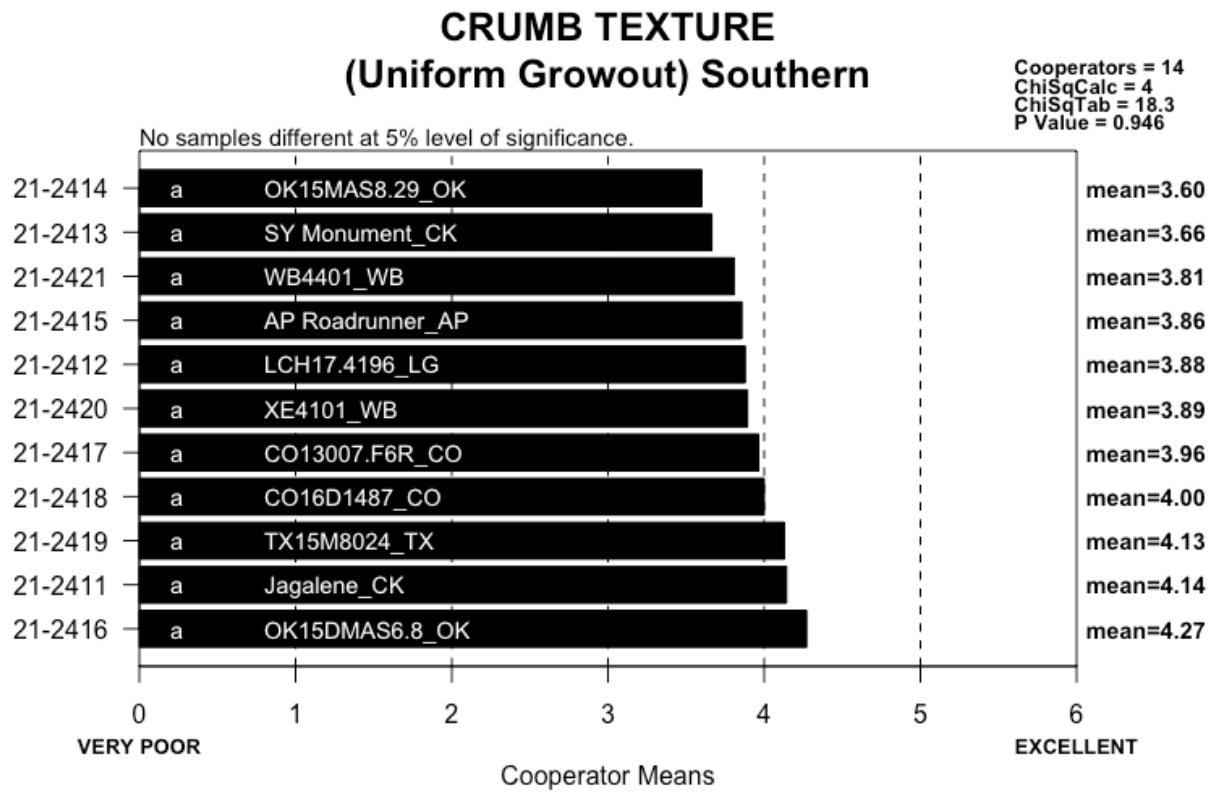


CRUMB GRAIN, DESCRIBED
(Uniform Growout) Southern

IDCODE	ID	Open	Fine	Dense
21-2411	Jagalene_CK	9	3	2
21-2412	LCH17-4196_LG	5	6	3
21-2413	SY Monument_CK	6	4	4
21-2414	OK15MAS8-29_OK	7	3	4
21-2415	AP Roadrunner_AP	9	3	2
21-2416	OK15DMAS6-8_OK	9	4	1
21-2417	CO13007-F6R_CO	9	3	2
21-2418	CO16D1487_CO	8	5	1
21-2419	TX15M8024_TX	8	5	1
21-2420	XE4101_WB	9	3	2
21-2421	WB4401_WB	9	4	1

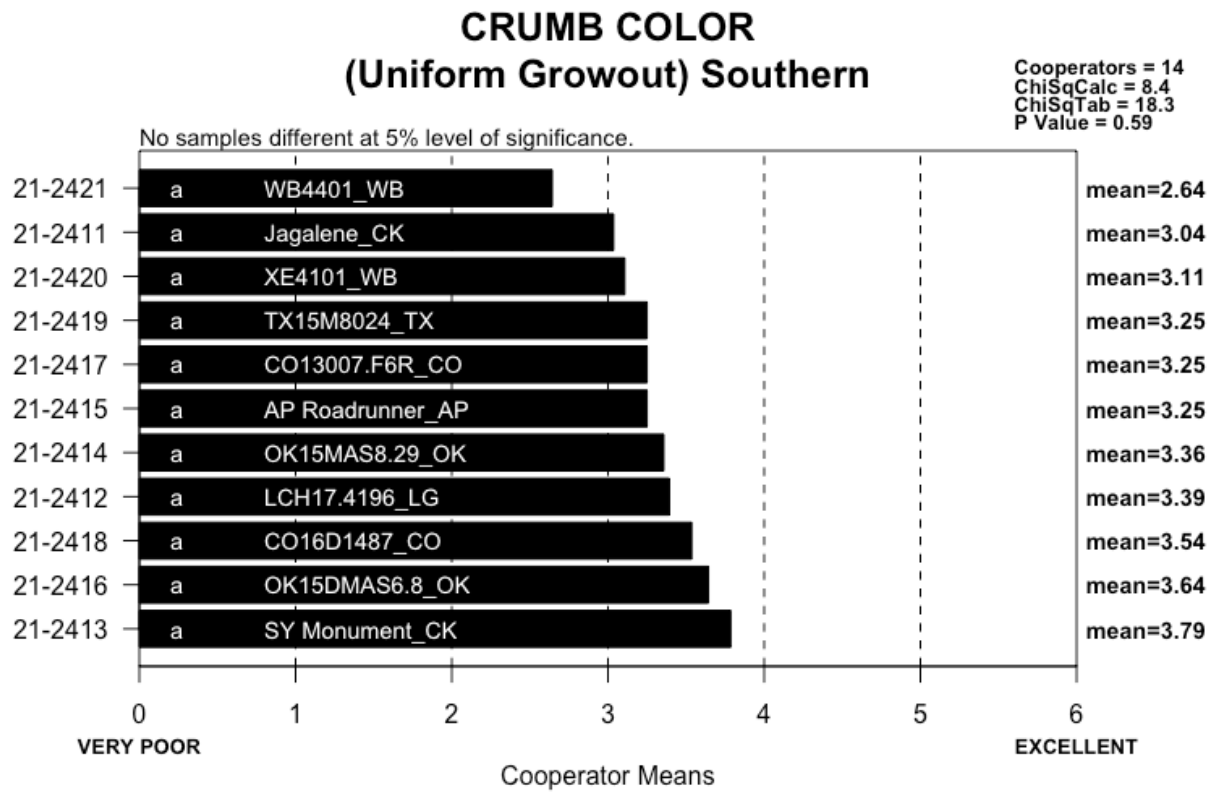
CELL SHAPE, DESCRIBED
(Uniform Growout) Southern

IDCODE	ID	Round	Irregular	Elongated
21-2411	Jagalene_CK	8	3	3
21-2412	LCH17-4196_LG	4	5	5
21-2413	SY Monument_CK	6	3	5
21-2414	OK15MAS8-29_OK	6	3	5
21-2415	AP Roadrunner_AP	6	6	2
21-2416	OK15DMAS6-8_OK	5	5	4
21-2417	CO13007-F6R_CO	8	3	3
21-2418	CO16D1487_CO	7	4	3
21-2419	TX15M8024_TX	4	6	4
21-2420	XE4101_WB	6	7	1
21-2421	WB4401_WB	4	6	4



CRUMB TEXTURE, DESCRIBED
(Uniform Growout) Southern

IDCODE	ID	Harsh	Smooth	Silky
21-2411	Jagalene_CK	2	9	3
21-2412	LCH17-4196_LG	3	9	2
21-2413	SY Monument_CK	3	10	1
21-2414	OK15MAS8-29_OK	4	9	1
21-2415	AP Roadrunner_AP	3	9	2
21-2416	OK15DMAS6-8_OK	2	9	3
21-2417	CO13007-F6R_CO	3	9	2
21-2418	CO16D1487_CO	3	8	3
21-2419	TX15M8024_TX	4	6	4
21-2420	XE4101_WB	5	6	3
21-2421	WB4401_WB	5	6	3



CRUMB COLOR, DESCRIBED
(Uniform Growout) Southern

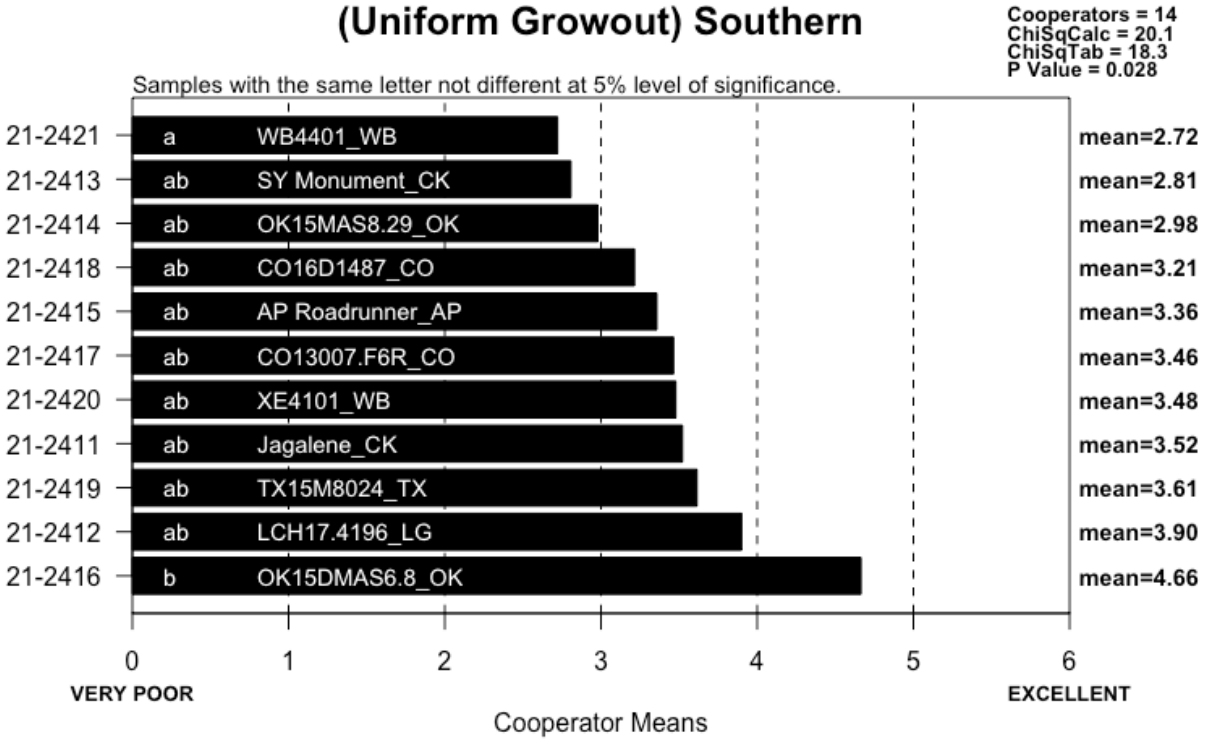
IDCODE	ID	Gray	Dark_Yellow	Yellow	Dull	Creamy	White	Bright_White
21-2411	Jagalene_CK	1	1	4	2	5	0	1
21-2412	LCH17-4196_LG	0	1	4	2	4	2	1
21-2413	SY Monument_CK	0	1	3	2	3	4	1
21-2414	OK15MAS8-29_OK	0	2	2	3	4	3	0
21-2415	AP Roadrunner_AP	0	1	2	6	3	2	0
21-2416	OK15DMAS6-8_OK	0	0	4	3	2	5	0
21-2417	CO13007-F6R_CO	0	1	4	2	6	1	0
21-2418	CO16D1487_CO	0	0	3	3	6	2	0
21-2419	TX15M8024_TX	0	1	2	5	5	1	0
21-2420	XE4101_WB	2	0	3	4	4	1	0
21-2421	WB4401_WB	2	3	2	2	4	1	0

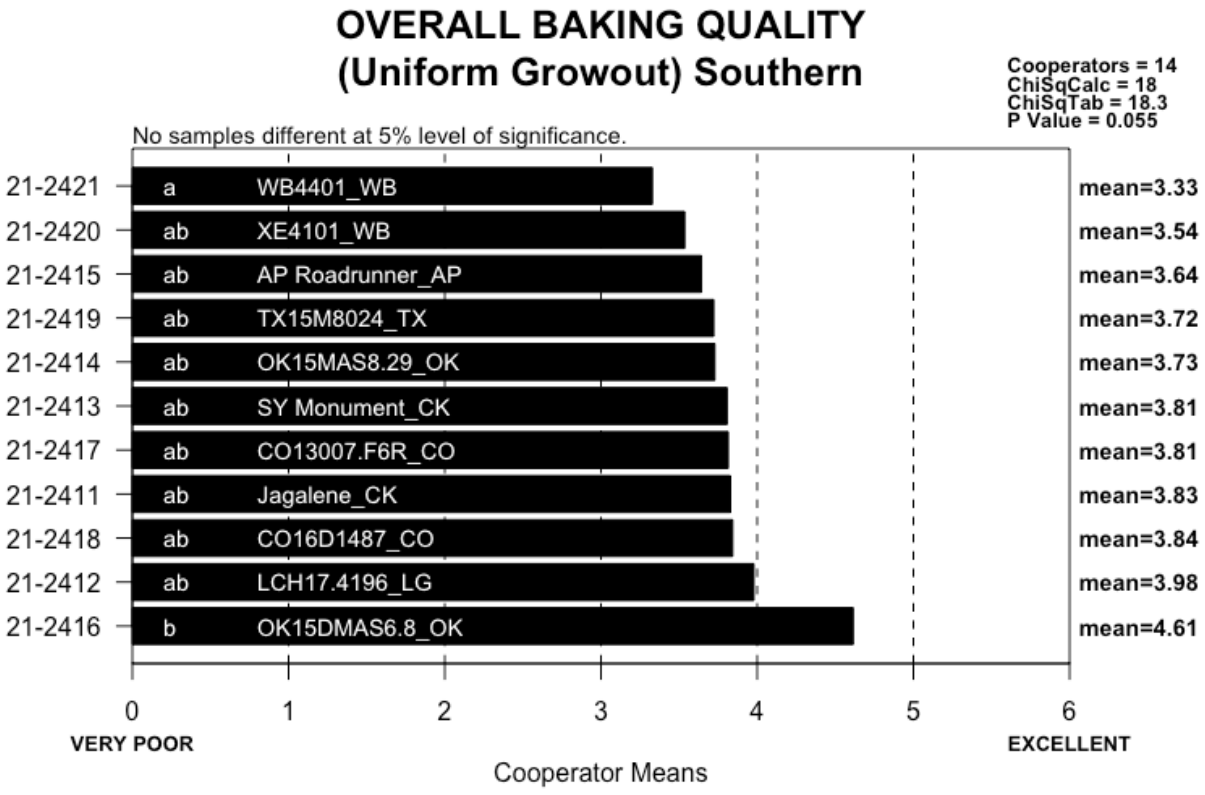
LOAF WEIGHT, ACTUAL
(Uniform Growout) Southern
Cooperators A – N

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2411	Jagalene_CK	147.0	411	142.9	144.2	151.7	241.1	478.1	136.4	149.7	476.0	457.0	149.0	425.1	147.2
21-2412	LCH17-4196_LG	147.8	414	141.8	142.1	150.6	242.6	480.2	139.2	144.9	469.5	454.5	145.6	415.7	143.8
21-2413	SY Monument_CK	147.7	413	141.3	142.1	154.6	251.6	483.2	139.1	144.9	469.0	463.5	146.1	427.5	146.0
21-2414	OK15MAS8-29_OK	144.5	412	143.6	142.9	154.7	258.5	479.0	137.0	149.6	473.0	450.0	147.7	424.4	149.4
21-2415	AP Roadrunner_AP	148.0	412	142.7	144.1	153.7	234.1	480.9	138.8	147.8	467.0	453.5	147.9	417.2	153.2
21-2416	OK15DMAS6-8_OK	147.7	412	139.7	142.2	151.1	232.7	473.7	135.8	144.5	467.0	443.0	146.8	424.2	154.3
21-2417	CO13007-F6R_CO	147.0	411	142.2	141.2	154.4	246.5	479.0	138.9	149.7	468.0	448.0	147.0	420.9	150.2
21-2418	CO16D1487_CO	148.4	410	141.5	147.0	153.8	230.4	475.2	138.0	148.3	468.0	460.5	147.1	420.1	149.7
21-2419	TX15M8024_TX	149.6	410	144.0	143.9	154.4	248.5	477.4	137.4	145.7	467.0	471.0	147.5	425.8	147.8
21-2420	XE4101_WB	148.3	411	144.3	143.2	156.7	234.5	469.9	138.2	147.0	467.0	448.0	149.0	424.8	149.6
21-2421	WB4401_WB	149.6	412	143.5	140.8	154.6	234.5	473.1	136.3	148.7	465.0	448.5	148.9	422.2	148.7

LOAF VOLUME, ACTUAL
(Uniform Growout) Southern
Cooperators A – N

IDCODE	ID	A	B	C	D	E	F	G	H	I	J	K	L	M	N
21-2411	Jagalene_CK	805	2700	980	880	935	843	2550	816	677	2706	2066	775	2650	720
21-2412	LCH17-4196_LG	720	2800	975	913	910	810	2500	816	728	2927	2183	828	2675	700
21-2413	SY Monument_CK	775	2750	1020	831	870	772	2350	781	638	2751	1989	778	2575	585
21-2414	OK15MAS8-29_OK	785	2750	975	815	860	765	2600	820	594	2839	2188	723	2525	510
21-2415	AP Roadrunner_AP	765	2825	890	850	860	851	2525	764	666	2809	2170	750	2575	735
21-2416	OK15DMAS6-8_OK	910	2750	1145	930	1040	910	2663	948	781	2780	2246	858	2700	685
21-2417	CO13007-F6R_CO	785	2800	1020	853	890	833	2525	781	609	2751	2130	810	2600	740
21-2418	CO16D1487_CO	755	2675	955	945	880	796	2575	772	689	2809	2048	753	2600	690
21-2419	TX15M8024_TX	740	2725	995	910	905	857	2525	794	709	2780	2280	803	2550	710
21-2420	XE4101_WB	755	2625	950	973	980	813	2563	768	809	2721	2263	830	2400	750
21-2421	WB4401_WB	695	2700	890	755	805	813	2413	712	678	2751	2244	725	2575	645


LOAF VOLUME
(Uniform Growout) Southern
Cooperators = 14
ChiSqCalc = 20.1
ChiSqTab = 18.3
P Value = 0.028
Samples with the same letter not different at 5% level of significance.
21-2421 a WB4401_WB mean=2.72
21-2413 ab SY Monument_CK mean=2.81
21-2414 ab OK15MAS8.29_OK mean=2.98
21-2418 ab CO16D1487_CO mean=3.21
21-2415 ab AP Roadrunner_AP mean=3.36
21-2417 ab CO13007.F6R_CO mean=3.46
21-2420 ab XE4101_WB mean=3.48
21-2411 ab Jagalene_CK mean=3.52
21-2419 ab TX15M8024_TX mean=3.61
21-2412 ab LCH17.4196_LG mean=3.90
21-2416 b OK15DMAS6.8_OK mean=4.66
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Uniform Growout) Southern
Cooperators = 14
ChiSqCalc = 18
ChiSqTab = 18.3
P Value = 0.055
No samples different at 5% level of significance.
21-2421 a WB4401_WB mean=3.33
21-2420 ab XE4101_WB mean=3.54
21-2415 ab AP Roadrunner_AP mean=3.64
21-2419 ab TX15M8024_TX mean=3.72
21-2414 ab OK15MAS8.29_OK mean=3.73
21-2413 ab SY Monument_CK mean=3.81
21-2417 ab CO13007.F6R_CO mean=3.81
21-2411 ab Jagalene_CK mean=3.83
21-2418 ab CO16D1487_CO mean=3.84
21-2412 ab LCH17.4196_LG mean=3.98
21-2416 b OK15DMAS6.8_OK mean=4.61
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

COOPERATOR'S COMMENTS
(Small Scale) BASF

COOP. 21-2411 Jagalene_CK

A. No comment.
B. Good out of mixer and make up. Average volume slightly open grain.
C. Rough break.\
D. High water abs. medium MT, slight sticky & strong dough, high volume, yellow crumb, open elongate cells, good resilient & smooth texture.
E. High absorption, open grain, dark yellow crumb, good volume.
F. No comment.
G. Good absorption, open grain, avg volume.
H. No comment.
I. Poor crumb color, considering the crumb grain, the texture exceeded expectations- smooth and soft.
J. Poor volume, excellent absorption, average mix time, slightly low stability.
K. Dough very sticky and difficult to work with, good color and texture, some irregular cells.
L. No comment.
M. Higher than avg protein and high abs. could be contributing to the wet dough notes. Good final product, recommend.
N. No comment.

COOP. 21-2412 LCH17-4196_LG

A. No comment.
B. Shorter mix, but good out of mixer. Better volume than 2411 slightly open grain.
C. Cap, rough break.
D. High water abs, medium MT, slight sticky & strong dough, high volume, yellow crumb, fine elongate cells, good resilient & smooth texture.
E. Good absorption, good dough character, avg grain, good volume.
F. No comment.
G. Good absorption, avg grain, dark yellow crumb, avg volume.
H. No comment.
I. Low protein, poor crumb color.
J. Excellent volume, excellent absorption, low mix time, slightly low stability.
K. Very good all around, some elongated cells.
L. No comment.
M. Good volume and avg protein. During handling there were wet/sticky dough notes. Good final product. Recommend.
N. No comment.

COOP. 21-2413 SY Monument_CK

A. No comment.
B. Strong dough out of mixer and make up. Long mix, average volume.
C. Excellent loaf externals.
D. High water abs. very long MT, slight sticky & Strong dough, fair volume, creamy crumb, fine elongate cells, good resilient & smooth texture.
E. High absorption, very long mix time, tough dough at make-up, open grain, dark yellow crumb, avg volume.
F. No comment.
G. Long mix time, good absorption, strong mixing tolerance, tough dough at make-up, avg grain, low volume.
H. No comment.
I. Poor crumb color.
J. Low volume, excellent absorption, excellent mix time, above average stability.
K. Large holes, somewhat wet dough, very good texture and color.
L. No comment.
M. Fair protein. High tolerance dough and high abs. volume has room for improvement. Fair final product. Recommend.
N. Poor loaf volume and poor dense crumb.

COOP. 21-2414 OK15MAS8-29_OK

A. No comment.
B. Strong dough out of mixer and make up, long mix, average volume.
C. Long time to pick up, tough dough, nice loaf externals.
D. High water abs. very long MT, strong dough, fair volume, creamy crumb, fine elongate cells, good resilient & smooth texture.
E. Very high absorption, very long mix time, tough dough at make-up, open grain, dark yellow crumb, avg volume.
F. No comment.
G. Very long mix time, high absorption, strong mixing tolerance, open grain, dark yellow crumb, good volume.
H. No comment.
I. Undesirable mix time, poor end-product.
J. Average volume, excellent absorption, excellent mix time, excellent stability.
K. Irregular loaf shape, blistered crust, very good on other characteristics.
L. No comment.
M. Fair protein and high abs. very high stability and high dough tolerance could be contributing negatively to final product. Recommend.
N. High absorption and stability but very poor baking characteristics.

COOP. 21-2415 AP Roadrunne_AP

A. No comment.
B. Short mix but good dough. Good volume but more open grain.
C. Cap.
D. High water abs. medium MT, slight sticky & strong dough, medium volume, dull crumb, fine elongate cells, good resilient & smooth texture.
E. High absorption, sticky dough at make-up, open grain, dark yellow crumb, avg volume.
F. No comment.
G. High absorption, avg grain and volume.
H. No comment.
I. Poor crumb color.
J. Average volume, excellent absorption, excellent mix time, excellent stability.
K. Large holes, very good texture, decent overall shape.
L. No comment.
M. Fair protein, high absorption, could be contributing to the wet dough notes and lack of volume. Fair final product. Recommend.
N. No comment.

COOP. 21-2416 OK15DMAS6-8_OK

A. No comment.
B. Good out of mixer and make up. Average volume, open grain, creamy interior.
C. Cap.
D. High water abs. long MT, slight sticky & strong dough, high volume, yellow crumb, fine elongate cells, good resilient & smooth texture.
E. High absorption, long mix time, avg grain, excellent volume.
F. No comment.
G. Good absorption, good mixing tolerance, avg grain, excellent volume.
H. No comment.
I. Nice dough characteristics.
J. Low volume, excellent absorption, average mix time, slightly low stability.
K. Many elongated holes, excellent texture, building on break and shred.
L. No comment.
M. Higher than average protein and stability. High abs. could be contributing to the wet/sticky dough notes. Good final product. Recommend.
N. No comment.

COOP. 21-2417 CO13007-F6R_CO

A. No comment.
B. Good out of mixer and make-up. Average volume, open grain, creamy interior.
C. White dough, slight cap.
D. High water abs, Long MT, slight sticky & strong dough, medium volume, yellow crumb, open elongate cells, good resilient & smooth texture.
E. High absorption, long mix time, open grain, dark yellow crumb, avg volume.
F. No comment.
G. High absorption, good mixing tolerance, open grain, avg volume.
H. No comment.
I. Good dough characteristics but poor end-product, no break-and-shred and poor crumb color.
J. Low volume, excellent absorption, above average mix time, good stability.
K. Many holes, irregular shape, decent texture.
L. No comment.
M. Fair protein. Fair dough notes and fair final product. Recommend.
N. Good crumb but poor color.

COOP. 21-2418 CO16D1487_CO

A. No comment.
B. Good out of mixer and make-up. Lower volume, slightly squatty loaf and more open grain.
C. Dry, cap, rough break.
D. High water abs. Long MT, slight sticky & strong dough, high volume, yellow crumb, open elongate cells, good resilient & smooth texture.
E. High absorption, sticky dough off mixer, open grain, avg volume.
F. No comment.
G. Good absorption, good mixing tolerance, avg grain and volume.
H. No comment.
I. No comment.
J. Average volume, excellent absorption, slightly above average mix time, average stability.
K. Sticky dough, somewhat open, some holes, good volume.
L. No comment.
M. Fair protein and high abs. high stability could be contributing to the wet dough notes. Good final product. Recommend.
N. No comment.

COOP. 21-2419 TX15M8024_TX

A. No comment.
B. Good out of mixer. Average loaf volume, slightly squatty loaf, creamy interior.
C. Nice loaf externals.
D. High water abs. Long MT, slight sticky & strong dough, high volume, yellow crumb, fine elongate cells, good resilient & very smooth texture.
E. Very high absorption, avg grain, dark yellow crumb, good volume.
F. No comment.
G. High absorption, good mixing tolerance, avg grain and volume.
H. No comment.
I. No comment.
J. Low volume, excellent absorption, average mix time, slightly low stability.
K. Large holes, relatively irregular shape, good volume, good texture.
L. No comment.
M. High protein, high abs, could be contributing to the wet dough notes. Fair final product. Recommend.
N. No comment.

COOP. 21-2420 XE4101_WB

A. No comment.
B. Highest protein, short mix, low volume, slightly open grain.
C. Nice loaf externals.
D. High water abs, medium MT, slight sticky & strong dough, high volume, yellow crumb, open elongate cells, soft resilient & slight harsh texture.
E. Very high absorption, sticky dough at make-up, avg grain, excellent volume.
F. No comment.
G. High absorption, poor grain, avg volume.
H. No comment.
I. Considering the crumb grain, the texture exceeded expectations – surprisingly smooth and silky.
J. Poor volume, excellent absorption, slightly low mix time, low stability.
K. Large holes, relatively irregular shape, good volume, good texture, good break and shred.
L. No comment.
M. Higher than avg protein, high absorption and low stability could be contributing to the wet dough notes. Final product has room for improvement. Do not recommend.
N. No comment.

COOP. **21-2421** **WB4401_WB**

A. No comment.
B. Slightly tough out of mixer and make up. Average volume, open grain.
C. Slight cap, rough break.
D. High water abs, medium MT, slight sticky & strong dough, low volume, yellow crumb, dense elongate cells, good resilient & slightly harsh texture.
E. Very high absorption, long mix time, tough dough at make-up, open grain, dark yellow crumb, low volume.
F. No comment.
G. Good absorption, tough dough, open grain, dark yellow crumb, low volume.
H. No comment.
I. Poor crumb color, crumb felt dense and spongy.
J. Low volume, excellent absorption, average mix time, slightly low stability.
K. Medium sized holes, good texture, good break and shred.
L. No comment.
M. Avg. protein, high abs. could be contributing to the wet dough notes. Fair final product. Recommend.
N. Dark yellow color.

Notes: **B, G, J, K, and M** conducted sponge and dough bake tests

MICRO-QUALITY ANALYSIS

Sample No	Comp.ID.	Micro_ID	Locations	Cultivars	Breeding Programs
1	B11	11	KS	Jagalene	Check
2	B12	12	KS	LCH17-4196	Limagrain
3	B13	13	KS	SY Monument	Check
4	B14	14	KS	OK15MASBx7ARS8-29	OSU
5	B15	15	KS	AP Roadrunner	AgriPro(Syngenta)
6	B16	16	KS	OK15MASBx7ARS6-8	OSU
7	B17	17	KS	CO13007-F6R	CSU
8	B18	18	KS	CO16D1487	CSU
9	B19	19	KS	TX15M8024	Texas A&M
10	B20	20	KS	XE4101	Bayer(Westbred)
11	B21	21	KS	WB4401	Bayer(Westbred)
12	B11	11	CO	Jagalene	Check
13	B12	12	CO	LCH17-4196	Limagrain
14	B13	13	CO	SY Monument	Check
15	B14	14	CO	OK15MASBx7ARS8-29	OSU
16	B15	15	CO	AP Roadrunner	AgriPro(Syngenta)
17	B16	16	CO	OK15MASBx7ARS6-8	OSU
18	B17	17	CO	CO13007-F6R	CSU
19	B18	18	CO	CO16D1487	CSU
20	B19	19	CO	TX15M8024	Texas A&M
21	B20	20	CO	XE4101	Bayer(Westbred)
22	B21	21	CO	WB4401	Bayer(Westbred)
23	B11	11	LM	Jagalene	Check
24	B12	12	LM	LCH17-4196	Limagrain
25	B13	13	LM	SY Monument	Check
26	B14	14	LM	OK15MASBx7ARS8-29	OSU
27	B15	15	LM	AP Roadrunner	AgriPro(Syngenta)
28	B16	16	LM	OK15MASBx7ARS6-8	OSU
29	B17	17	LM	CO13007-F6R	CSU
30	B18	18	LM	CO16D1487	CSU
31	B19	19	LM	TX15M8024	Texas A&M
32	B20	20	LM	XE4101	Bayer(Westbred)
33	B21	21	LM	WB4401	Bayer(Westbred)
34	B11	11	OK	Jagalene	Check
35	B12	12	OK	LCH17-4196	Limagrain
36	B13	13	OK	SY Monument	Check
37	B14	14	OK	OK15MASBx7ARS8-29	OSU
38	B15	15	OK	AP Roadrunner	AgriPro(Syngenta)
39	B16	16	OK	OK15MASBx7ARS6-8	OSU
40	B17	17	OK	CO13007-F6R	CSU
41	B18	18	OK	CO16D1487	CSU
42	B19	19	OK	TX15M8024	Texas A&M
43	B20	20	OK	XE4101	Bayer(Westbred)
44	B21	21	OK	WB4401	Bayer(Westbred)
45	B11	11	TX	Jagalene	Check
46	B12	12	TX	LCH17-4196	Limagrain
47	B13	13	TX	SY Monument	Check
48	B14	14	TX	OK15MASBx7ARS8-29	OSU
49	B15	15	TX	AP Roadrunner	AgriPro(Syngenta)
50	B16	16	TX	OK15MASBx7ARS6-8	OSU
51	B17	17	TX	CO13007-F6R	CSU
52	B18	18	TX	CO16D1487	CSU
53	B19	19	TX	TX15M8024	Texas A&M
54	B20	20	TX	XE4101	Bayer(Westbred)
55	B21	21	TX	WB4401	Bayer(Westbred)

1. LOCATIONS AND ENTRIES

A. There are 5 locations:

Kansas - Manhattan = KM;

Colorado = CO;

Limagrain = LM;

Oklahoma = OK.

Texas – Bushland = TB

B. There are 11 entries grown in each of locations:

Jagalene = 11

LCH17-4196 = 12

SY Monument = 13

OK15MASBx7ARS6-29 = 14

AP Roadrunner = 15

OK15MASBx7ARS6-8 = 16

CO13007-F6R = 17

CO16D1487 = 18

TX15M8024 = 19

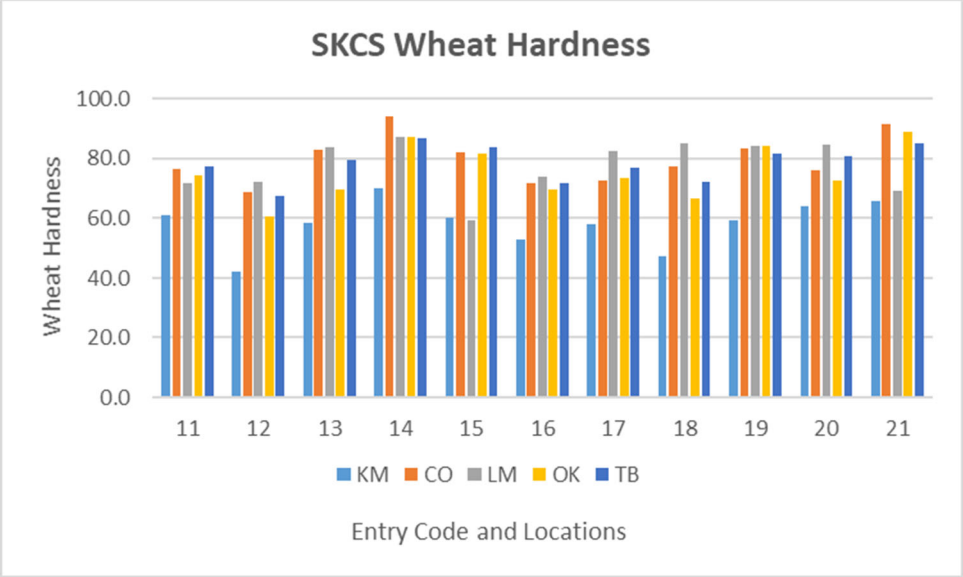
XE4101 = 20

WB4401 = 21

2. SKCS SINGLE KERNEL INFORMATION

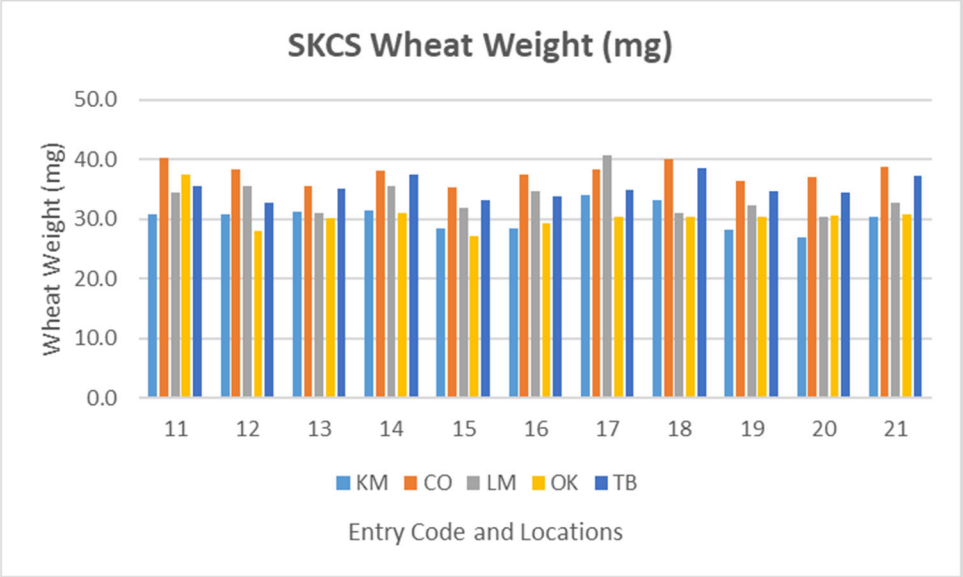
A. Kernel Hardness

SKCS Wheat Kernel Hardness							
	LOCATIONS						
Entry Code	KM	CO	LM	OK	TB	Avg	Std
11	61.1	76.4	71.7	74.2	77.2	72.1	6.52
12	42.0	68.9	72.2	60.7	67.6	62.3	12.09
13	58.5	82.8	83.9	69.7	79.7	74.9	10.75
14	70.0	94.0	87.4	87.2	86.8	85.1	8.94
15	60.2	82.3	59.5	81.6	83.9	73.5	12.49
16	52.7	71.6	73.8	69.5	71.9	67.9	8.63
17	58.2	72.6	82.4	73.5	76.8	72.7	8.97
18	47.2	77.5	85.3	66.8	72.3	69.8	14.37
19	59.3	83.5	84.4	84.1	81.6	78.6	10.83
20	64.0	76.0	84.7	72.8	80.7	75.6	7.93
21	65.7	91.6	69.3	88.8	85.3	80.1	11.82
Avg.	58.1	79.7	77.7	75.4	78.5		
Std	8.10	7.99	8.89	8.96	6.05		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



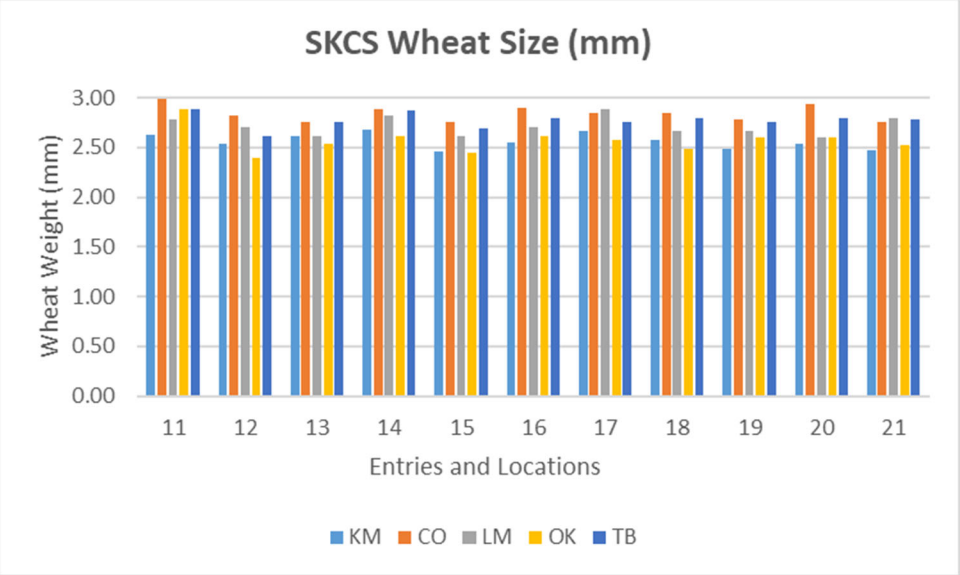
B. Kernel Weight (mg)

SKCS Wheat Kernel Weight (mg)							
	LOCATIONS						
Entry Code	KM	CO	LM	OK	TB	Avg	Std
11	30.7	40.3	34.4	37.5	35.6	35.7	3.57
12	30.7	38.4	35.5	27.9	32.6	33.0	4.09
13	31.1	35.4	31.0	30.1	35.1	32.5	2.51
14	31.4	38.1	35.6	30.9	37.4	34.7	3.35
15	28.3	35.3	31.9	27.1	33.1	31.1	3.40
16	28.5	37.5	34.7	29.3	33.8	32.8	3.79
17	34.0	38.4	40.7	30.3	34.8	35.6	4.04
18	33.2	40.1	30.9	30.3	38.5	34.6	4.46
19	28.2	36.3	32.2	30.3	34.6	32.3	3.24
20	26.9	37.1	30.4	30.6	34.4	31.9	3.94
21	30.3	38.8	32.7	30.7	37.2	33.9	3.86
Avg.	30.3	37.8	33.6	30.5	35.2		
Std	2.18	1.68	3.00	2.63	1.85		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



C. Kernel Size

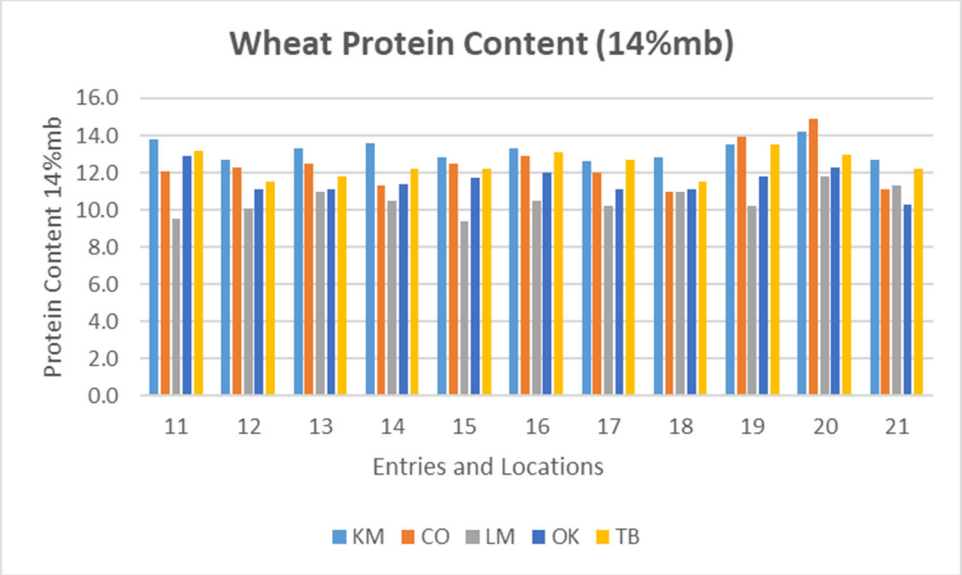
SKCS Wheat Kernel Size (mm)							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	2.63	2.99	2.78	2.89	2.88	2.83	0.14
12	2.54	2.82	2.70	2.39	2.62	2.61	0.16
13	2.61	2.75	2.61	2.54	2.76	2.65	0.10
14	2.68	2.88	2.82	2.62	2.87	2.77	0.12
15	2.46	2.75	2.62	2.44	2.69	2.59	0.14
16	2.55	2.90	2.71	2.61	2.80	2.71	0.14
17	2.66	2.85	2.89	2.57	2.75	2.74	0.13
18	2.57	2.85	2.67	2.49	2.79	2.67	0.15
19	2.49	2.78	2.66	2.60	2.75	2.66	0.12
20	2.53	2.94	2.6	2.6	2.79	2.69	0.17
21	2.47	2.75	2.79	2.52	2.78	2.66	0.15
Avg.	2.56	2.84	2.71	2.57	2.77		
Std	0.07	0.08	0.09	0.13	0.07		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



3. PROTEN CONTENT

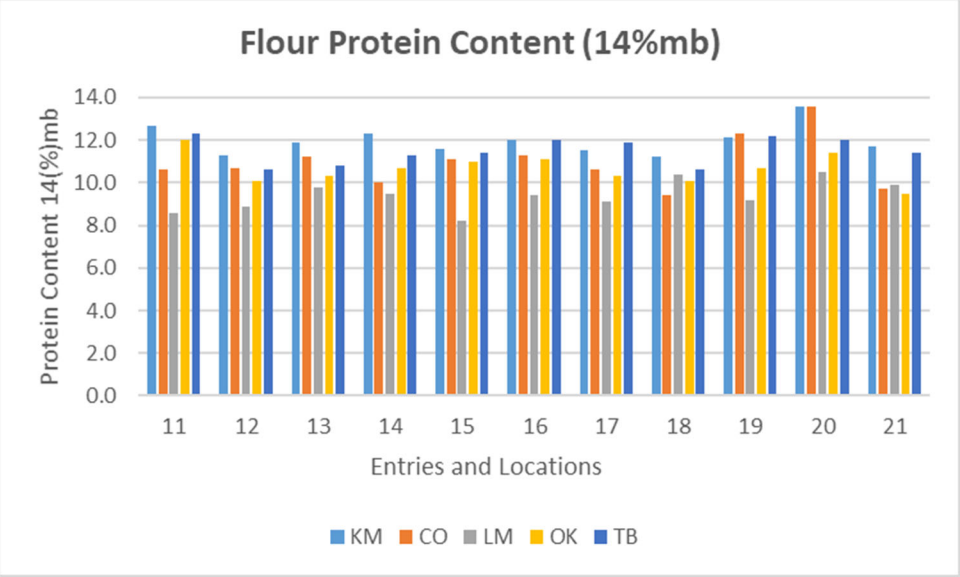
A. Wheat Protein

Wheat Protein Content (14%mb)							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	13.8	12.1	9.5	12.9	13.2	12.3	1.68
12	12.7	12.3	10.1	11.1	11.5	11.5	1.02
13	13.3	12.5	11.0	11.1	11.8	11.9	0.97
14	13.6	11.3	10.5	11.4	12.2	11.8	1.17
15	12.8	12.5	9.4	11.7	12.2	11.7	1.36
16	13.3	12.9	10.5	12.0	13.1	12.4	1.15
17	12.6	12.0	10.2	11.1	12.7	11.7	1.06
18	12.8	11.0	11.0	11.1	11.5	11.5	0.77
19	13.5	13.9	10.2	11.8	13.5	12.6	1.56
20	14.2	14.9	11.8	12.3	13.0	13.2	1.29
21	12.7	11.1	11.3	10.3	12.2	11.5	0.94
Avg.	13.2	12.4	10.5	11.5	12.4		
Std	0.5	1.2	0.7	0.7	0.7		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



B. Flour Protein

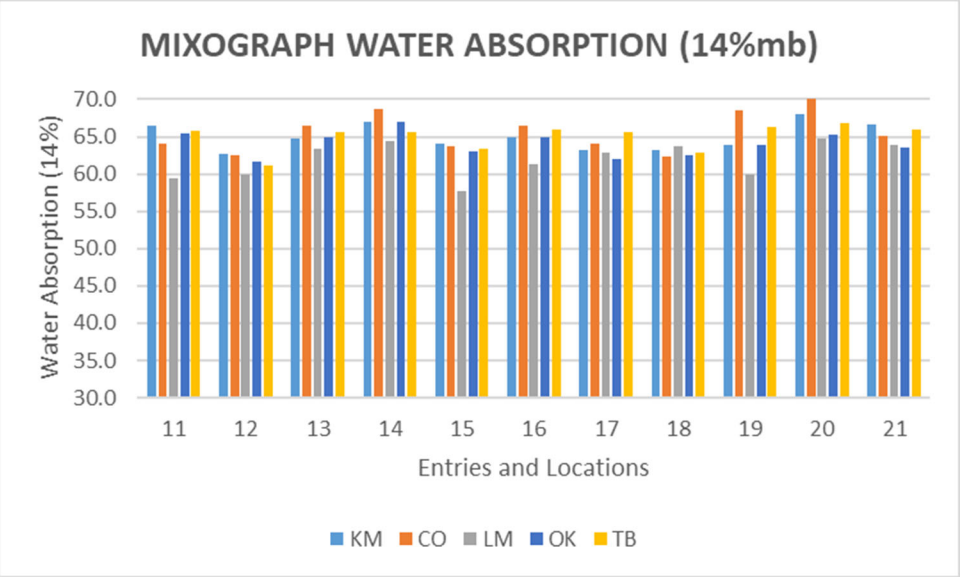
Flour Protein Content (14%)							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	12.7	10.6	8.6	12.0	12.3	11.2	1.67
12	11.3	10.7	8.9	10.1	10.6	10.3	0.90
13	11.9	11.2	9.8	10.3	10.8	10.8	0.81
14	12.3	10.0	9.5	10.7	11.3	10.8	1.10
15	11.6	11.1	8.2	11.0	11.4	10.7	1.40
16	12.0	11.3	9.4	11.1	12.0	11.2	1.06
17	11.5	10.6	9.1	10.3	11.9	10.7	1.10
18	11.2	9.4	10.4	10.1	10.6	10.3	0.66
19	12.1	12.3	9.2	10.7	12.2	11.3	1.34
20	13.6	13.6	10.5	11.4	12.0	12.2	1.37
21	11.7	9.7	9.9	9.5	11.4	10.4	1.03
Avg.	12.0	11.0	9.4	10.7	11.5		
Std	0.69	1.19	0.71	0.70	0.63		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



4. MIXOGRAPH TEST RESULTS

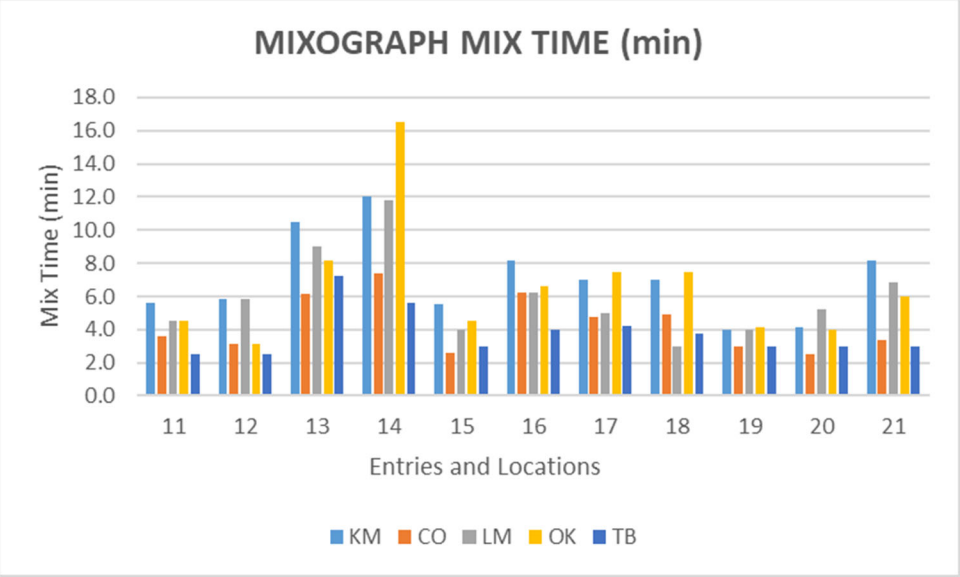
A. Mixograph Water Absorption

Mixograph Water Absorption (14%mb)							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	66.4	64.1	59.5	65.4	65.8	64.2	2.80
12	62.8	62.4	59.9	61.6	61.2	61.6	1.11
13	64.7	66.5	63.4	65.0	65.6	65.0	1.14
14	67.1	68.7	64.4	67.0	65.7	66.6	1.62
15	64.1	63.8	57.8	63.0	63.3	62.4	2.62
16	64.9	66.5	61.3	64.9	66.0	64.7	2.03
17	63.2	64.1	62.8	61.9	65.6	63.5	1.41
18	63.3	62.4	63.7	62.5	62.9	62.9	0.53
19	63.9	68.6	59.9	63.9	66.3	64.5	3.24
20	68.1	70.6	64.8	65.3	66.8	67.1	2.32
21	66.6	65.2	64.0	63.6	66.0	65.1	1.30
Avg.	65.0	65.7	61.9	64.0	65.0		
Std	1.78	2.70	2.37	1.67	1.75		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



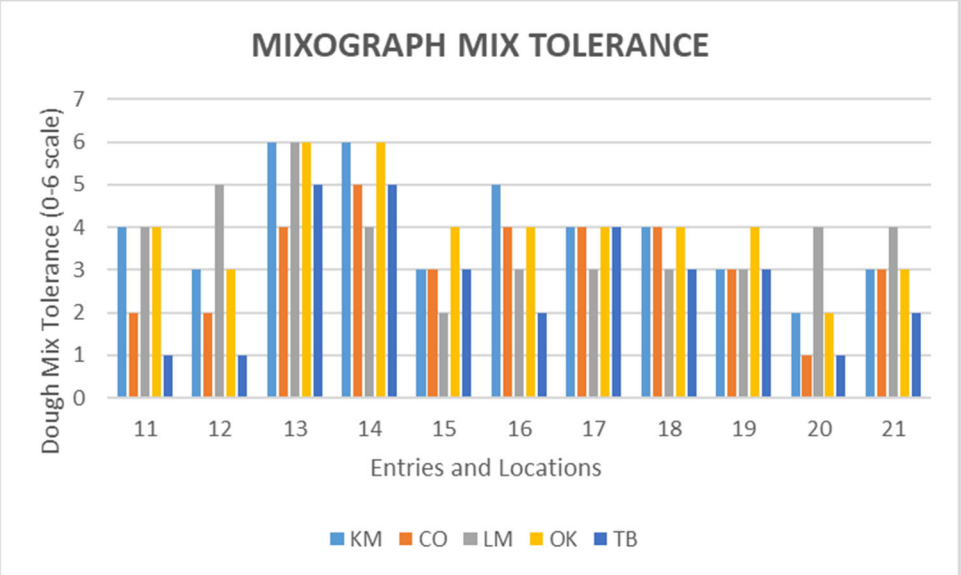
B. Mixograph Mix Time

Mixograph Mix Time (min)							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	5.6	3.6	4.5	4.5	2.5	4.2	1.16
12	5.9	3.1	5.9	3.1	2.5	4.1	1.64
13	10.5	6.1	9.0	8.1	7.3	8.2	1.67
14	12.0	7.4	11.8	16.5	5.6	10.7	4.28
15	5.5	2.6	4.0	4.5	3.0	3.9	1.16
16	8.1	6.3	6.3	6.6	4.0	6.3	1.48
17	7.0	4.8	5.0	7.5	4.3	5.7	1.45
18	7.0	4.9	3.0	7.5	3.8	5.2	1.97
19	4.0	3.0	4.0	4.1	3.0	3.6	0.57
20	4.13	2.5	5.3	4.0	3.0	3.8	1.07
21	8.1	3.4	6.9	6.0	3.0	5.5	2.23
Avg.	7.1	4.3	6.0	6.6	3.8		
Std	2.50	1.66	2.54	3.69	1.46		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



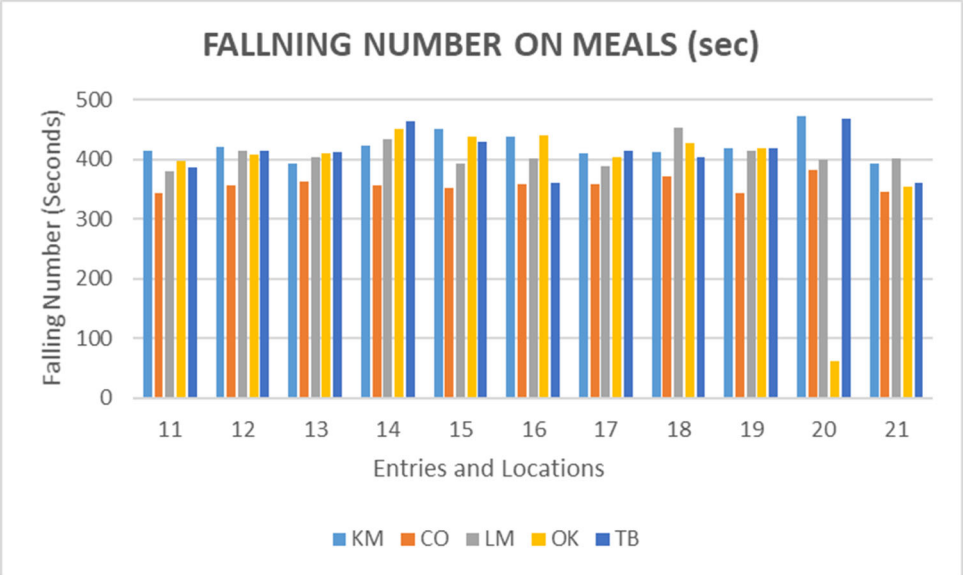
C. Mixograph Mix Tolerance

Mixograph Mix Tolerance							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	4	2	4	4	1	3.0	1.41
12	3	2	5	3	1	2.8	1.48
13	6	4	6	6	5	5.4	0.89
14	6	5	4	6	5	5.2	0.84
15	3	3	2	4	3	3.0	0.71
16	5	4	3	4	2	3.6	1.14
17	4	4	3	4	4	3.8	0.45
18	4	4	3	4	3	3.6	0.55
19	3	3	3	4	3	3.2	0.45
20	2	1	4	2	1	2.0	1.22
21	3	3	4	3	2	3.0	0.71
Avg.	3.9	3.2	3.7	4.0	2.7		
Std	1.30	1.17	1.10	1.18	1.49		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



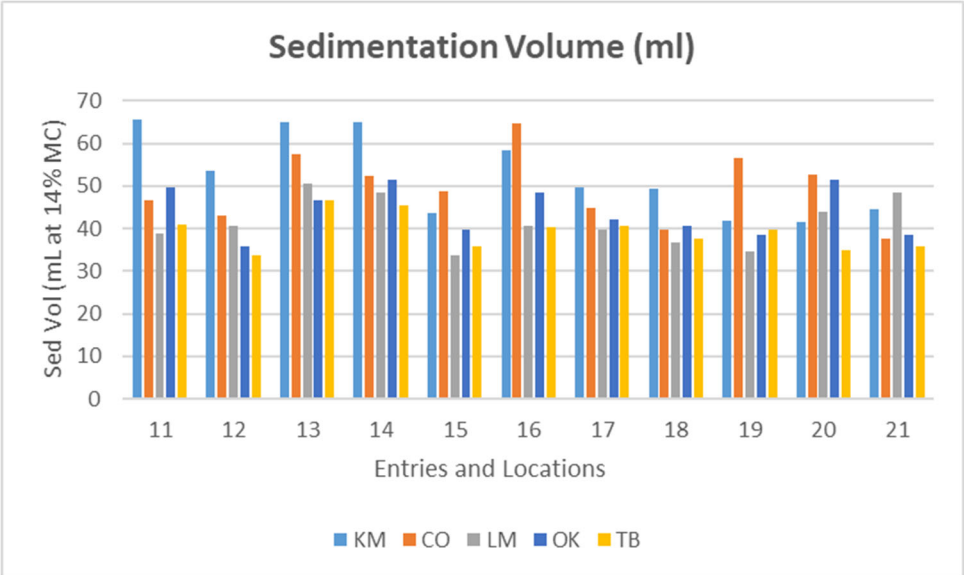
5. FALLING NUMBER TEST

Falling Number on Meals (sec)							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	415	344	379	396	387	384	26
12	420	355	415	407	415	402	27
13	393	363	403	410	413	396	20
14	422	357	434	451	463	425	41
15	450	352	392	438	429	412	40
16	437	358	402	439	361	399	39
17	410	359	388	403	414	395	22
18	411	371	452	426	403	413	30
19	418	344	414	418	418	402	33
20	472	382	398	62	468	356	169
21	392	345	401	353	361	370	25
Avg.	422	357	407	382	412		
Std	24	12	21	109	35		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						



6. SEDIMENTATION TEST

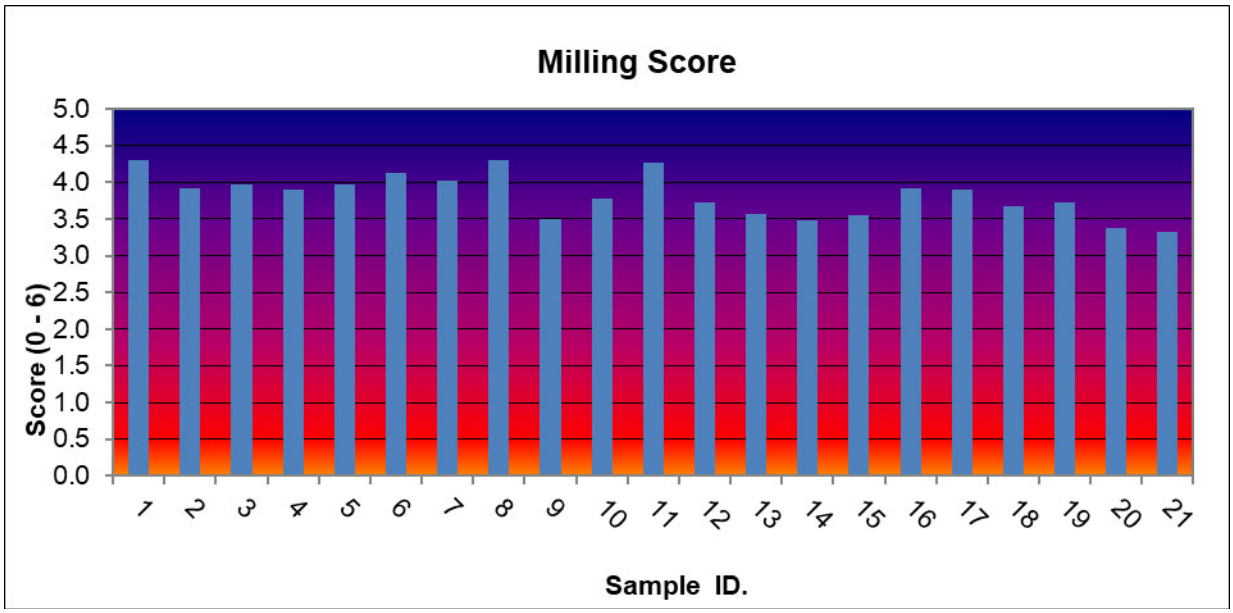
Sedimentation Volume (ml)							
	LOCATIONS						
Sample ID	KM	CO	LM	OK	TB	Avg	Std
11	65.5	46.7	38.8	49.6	40.8	48.3	10.57
12	53.7	42.9	40.7	35.7	33.8	41.4	7.81
13	65.1	57.6	50.5	46.6	46.7	53.3	7.97
14	65.0	52.5	48.5	51.4	45.5	52.6	7.46
15	43.7	48.7	33.7	39.6	35.7	40.3	6.07
16	58.4	64.8	40.6	48.6	40.3	50.5	10.87
17	49.6	44.7	39.7	42.0	40.7	43.3	3.97
18	49.5	39.7	36.7	40.5	37.7	40.8	5.08
19	41.7	56.7	34.7	38.6	39.7	42.3	8.45
20	41.6	52.8	44.0	51.5	34.8	44.9	7.41
21	44.4	37.6	48.5	38.5	35.7	40.9	5.33
Avg.	52.6	49.5	41.5	43.9	39.2		
Std	9.57	8.27	5.72	5.78	4.21		
	KM= Kansas-Manhattan; LM=Limagrain; TB=Texas-Bushland						

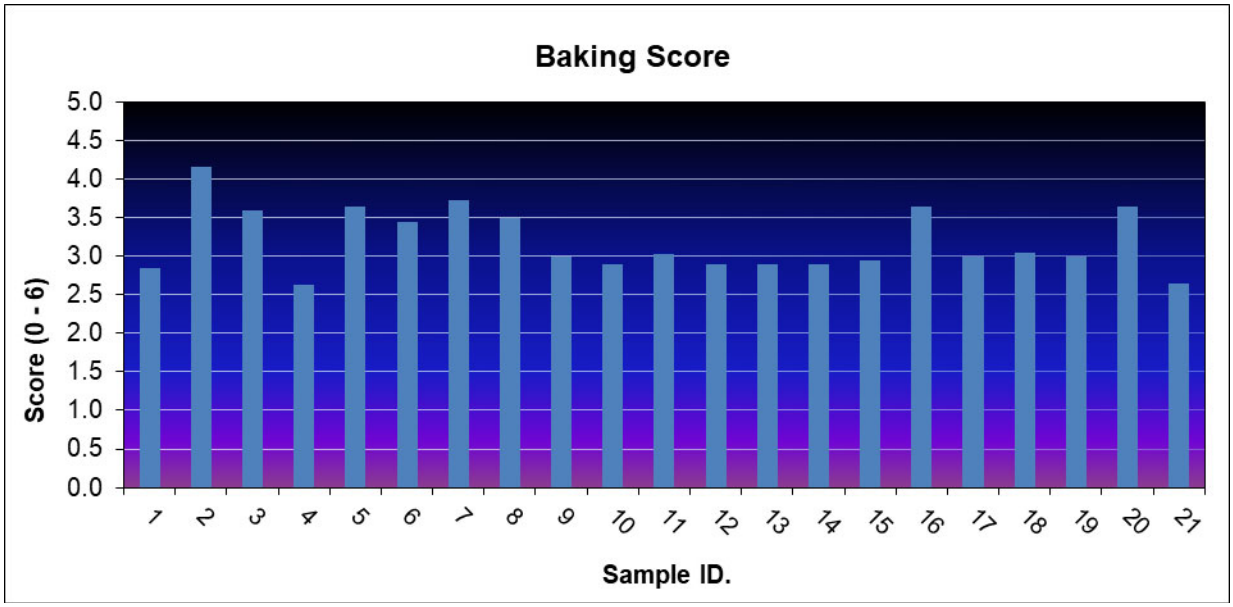


2021 WQC Milling and Baking Marketing Scores

2021 WQC Milling & Baking Marketing Scores

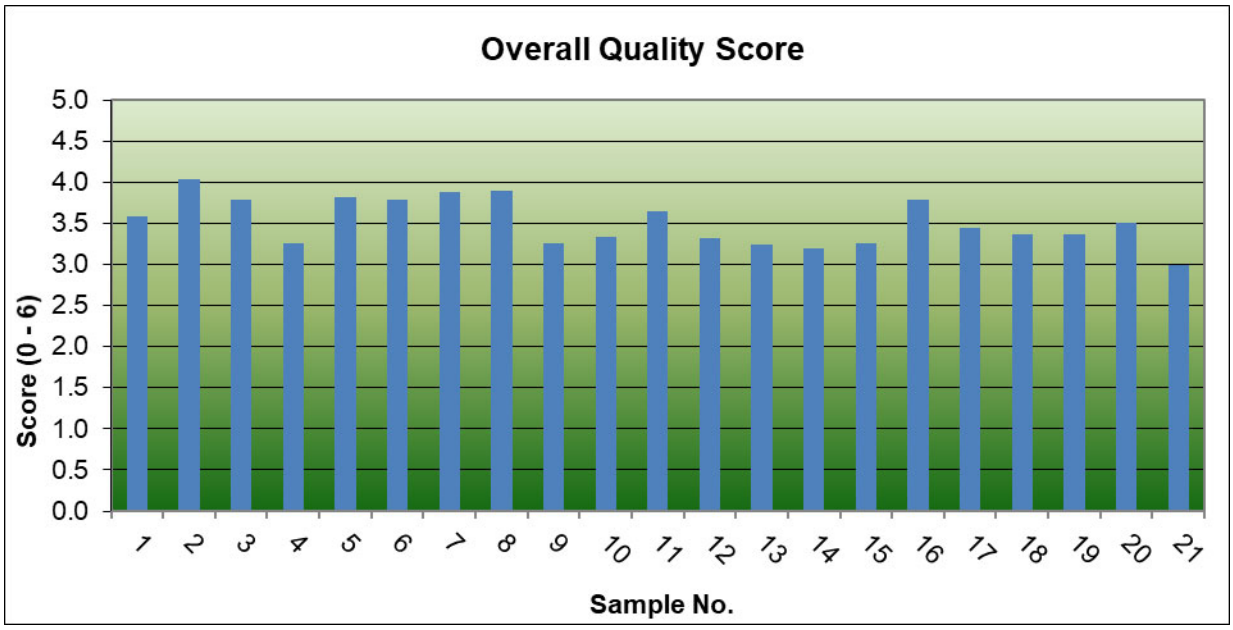
(Based upon HWWQL Quality Data and KSU Milling Data)





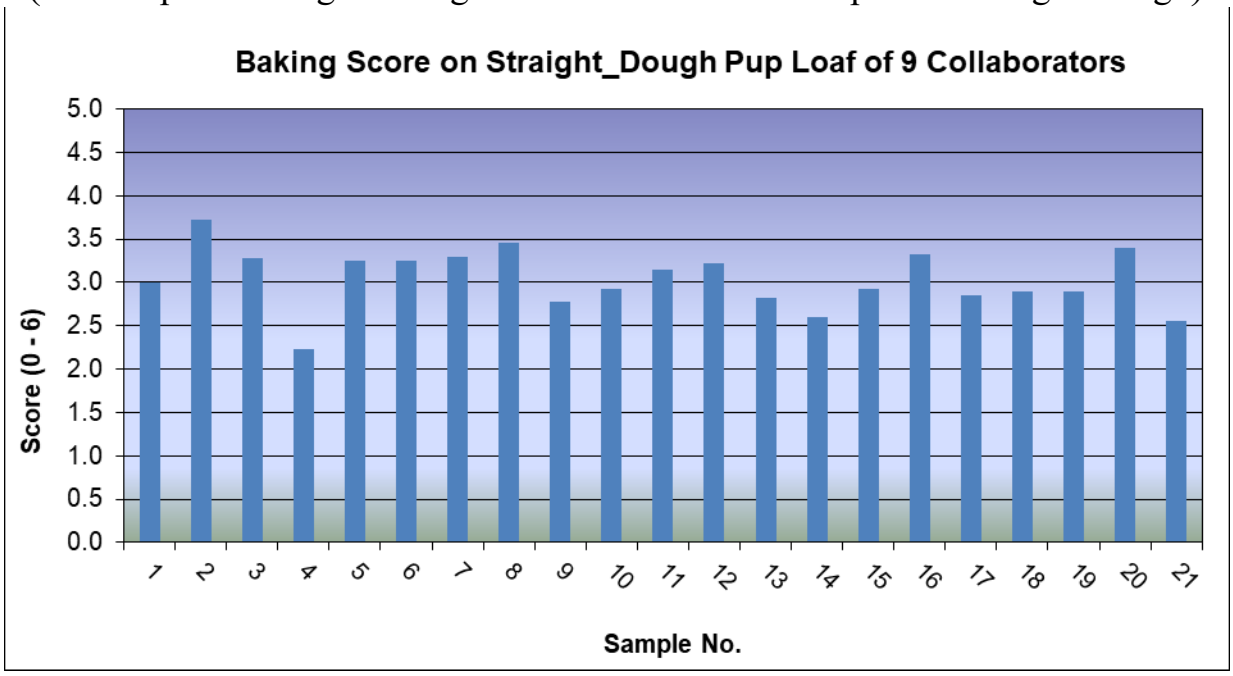
2021 WQC Milling & Baking Marketing Scores

(Based upon HWWQL Quality Data and KSU Milling Data)



2021 WQC Baking Marketing Scores

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



Marketing Scores

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

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

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

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

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

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

Alkaline Noodle Quality Tests
of
2021 WQC Hard Winter Wheat Entries

noodle

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Alkaline Noodle Quality Report

Objectives: Evaluate alkaline noodle color and cooking characteristics.

Materials: 21 WQC hard winter wheat samples harvested in 2021.

Methods:

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

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

Noodle Making:

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

Procedure:

100 g flour ← 1 g Na_2CO_3 + 35 mL Water

↓

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

↓

Rest for 30 min in a plastic bag

↓

Plug roll gap with plastic tubing and pour mixed dough

↓

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

↓

Cutting

Measurement of Noodle Dough Color:

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

Cooking Noodles:

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

Measurement of Cooking Loss and Water Uptake:

Cooking Loss:

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

Water Uptake:

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

Texture Profile Analysis (TPA) of Noodle:

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

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

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

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

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

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

Results:

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

Table I shows the following:

Noodle Color (*L* value, Higher is better.) ***at 0 hr***: 2414 (81.42), 2413(79.89), 2417 (78.73)

Noodle Color (*L* value, Higher is better.) ***at 24 hr***: 2414 (70.87), 2413 (68.03), 2417 (66.63)

Delta L (Change of *L* value, Lower absolute value is better.)
2403 (-9.59), 2402 (-9.98), 2414(-10.55)

PPO (Lower is better.): 2414 (0.198), 2420 (0.223), 2413 (0.266)

Table II shows the following:

Hardness: 2407(2.689), 2405 (2.587), 2410 (2.547)

Springiness: 2413 (0.909), 2412 (0.909), 2417 (0.905)

Chewiness: 2412 (1.527), 2408 (1.504), 2407 (1.497)

Resilience: 2413 (0.457), 2414 (0.442), 2416 (0.434)

Cohesiveness: 2413(0.701), 2414 (0.693), 2416 (0.682)

Water Uptake: 2420 (89.16), 2419 (88.56), 2417 (88.48)

Cooking Loss: 2407 (6.76), 2420 (6.80), 2414 (6.92)

Discussion

Sample 2414 had the highest L-value (brightness) at both 0 and 24 hrs, and had the highest b-value at 24 hrs, the lowest PPO value and third lowest delta *L**value. This sample also had second highest resilience and cohesion in texture after cooking, and had third lowest cooking loss. Bright noodle color 24 hrs after production and a firmer texture following cooking are

considered desirable characteristics for alkaline noodles. Thus, sample 2414 would be considered the most favourable variety overall for alkaline noodle quality.

Sample 2413 had second highest L-value (brightness) at both 0 and 24 hrs and had third lowest PPO value. This sample also had the highest springiness, resilience and chewiness in texture after cooking, and had third lowest PPO value.

Sample 2417 had third highest L-value (brightness) at both 0 and 24 hrs. This sample also had third highest springiness in texture after cooking and third highest water uptake.

Table I. Noodle Color and PPO Level

Sample ID	*L** @ 0	*L** @ 24	*a** @ 0	*a** @ 24	*b** @ 0	*b** @ 24	delta *L**	delta *a**	delta *b**	PPO
2401	76.67	63.52	-0.67	1.63	22.61	24.93	-13.15	2.30	2.32	0.545
2402	72.65	62.68	-0.03	2.10	24.43	23.81	-9.98	2.13	-0.63	0.579
2403	72.43	62.85	0.22	2.39	24.73	24.96	-9.59	2.18	0.23	0.405
2404	73.42	60.99	-0.11	2.13	23.01	23.96	-12.43	2.24	0.95	0.756
2405	71.71	61.02	0.22	2.67	25.14	25.01	-10.69	2.45	-0.13	0.692
2406	71.51	59.76	0.04	2.37	22.70	22.90	-11.75	2.33	0.20	0.717
2407	72.91	62.03	-0.19	2.08	23.79	23.90	-10.89	2.26	0.11	0.707
2408	73.25	60.27	0.26	2.66	22.23	22.81	-12.98	2.41	0.58	0.681
2409	76.49	63.65	-0.65	1.68	22.27	24.90	-12.84	2.33	2.64	0.750
2410	73.98	61.32	0.19	2.64	22.49	24.53	-12.66	2.45	2.04	0.361
2411	75.11	61.36	-0.12	2.50	22.51	24.15	-13.75	2.62	1.64	0.439
2412	77.95	65.26	-0.88	1.46	22.76	25.81	-12.69	2.34	3.05	0.518
2413	79.89	68.03	-1.04	0.68	21.29	24.62	-11.86	1.71	3.33	0.266
2414	81.42	70.87	-1.54	-0.09	21.61	27.47	-10.55	1.46	5.86	0.198
2415	76.32	63.89	-0.32	2.15	23.43	25.64	-12.43	2.47	2.21	0.492
2416	77.03	63.62	-0.53	1.66	21.94	24.15	-13.41	2.19	2.22	0.440
2417	78.73	66.63	-1.01	1.22	22.52	25.43	-12.70	2.23	2.92	0.439
2418	77.59	66.60	-0.79	1.35	23.63	25.53	-10.92	2.14	1.90	0.478
2419	76.36	62.88	-0.30	2.16	22.43	25.30	-13.49	2.46	2.87	0.492
2420	73.85	61.19	0.24	2.88	24.09	25.63	-12.67	2.64	1.55	0.223
2421	77.39	65.88	-0.66	1.59	23.73	26.48	-11.51	2.25	2.76	0.411
Avg	75.55	63.51	-0.36	1.90	23.01	24.85	-12.04	2.26	1.84	0.504

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

Sample ID	Hardness	Springiness	Chewiness	Resilience	Cohesiveness	Water Uptake (%)	cooking loss(%)
2401	2.325	0.900	1.409	0.406	0.673	80.44	7.36
2402	2.508	0.880	1.451	0.386	0.658	73.72	7.48
2403	2.496	0.853	1.368	0.383	0.643	73.56	8.00
2404	2.478	0.855	1.345	0.378	0.635	71.48	9.20
2405	2.587	0.871	1.440	0.385	0.639	79.48	7.52
2406	2.475	0.865	1.385	0.385	0.647	79.92	7.72
2407	2.689	0.869	1.497	0.374	0.640	85.12	6.76
2408	2.495	0.894	1.504	0.404	0.674	81.08	7.60
2409	2.352	0.865	1.331	0.396	0.654	83.68	7.16
2410	2.547	0.878	1.429	0.377	0.639	80.76	7.72
2411	2.451	0.876	1.403	0.405	0.654	82.00	7.48
2412	2.519	0.909	1.527	0.412	0.667	85.44	7.48
2413	2.256	0.909	1.437	0.457	0.701	79.64	7.64
2414	2.213	0.894	1.371	0.442	0.693	83.56	6.92
2415	2.524	0.882	1.480	0.411	0.665	84.48	6.92
2416	2.287	0.900	1.405	0.434	0.682	81.64	7.28
2417	2.302	0.905	1.394	0.424	0.669	88.48	7.40
2418	2.457	0.896	1.430	0.404	0.649	86.08	8.64
2419	2.422	0.888	1.401	0.399	0.651	88.56	7.40
2420	2.342	0.896	1.424	0.422	0.679	89.16	6.80
2421	2.440	0.894	1.457	0.414	0.668	87.84	7.32
Avg	2.436	0.885	1.423	0.405	0.661	82.20	7.51

TORTILLA BAKING TEST RESULTS (2021) WQC SAMPLES

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(December 2021)

SUMMARY

This report includes the methods for production and evaluation of wheat flour tortillas and data of the 2021 WQC samples. The data was collected over 17 days, including baking and shelf stability.

Samples 2402,2403 and 2405 created tortillas that were ranked as "very good", based on their final diameter (> 160 mm) and subjective rollability (v. little cracking when rolled 16 days after baking) as seen in Table 1. These samples also had good dough handling properties. Higher diameter and rollability scores suggest flour that is moderately strong with good extensibility characteristics. Sample 2404 was ranked as "fair-good" because it had a diameter that just missed the cutoff for good (≥156 mm) and had great rollability (≥4.0 = signs of cracking, but no breaking) over 16 days of storage.

Samples 2406, 2407, 2408, 2409, 2411, 2412, 2415 and 2419 ranked as "fair", based on their diameter (150-160 mm), though they had good rollability. This suggests these flours were strong and caused shrinkage to the tortilla dough when hot-pressed.

Samples 2410, 2413, 2416, 2417, 2420 and 2421 ranked as "fair poor", because all of them showed a good range in the rollability test on day 16, however the diameter of these tortillas ranged from 143.7 to 147.2.

Samples 2414 and 2418 were ranked as "poor" due to a low rollability score (< 3).

Table 1- Physical properties of tortillas.

Test #	Moisture [%]	Weight [g]	Thickness [mm]	Diameter [mm]	Sp. Vol [mm³/g]	Lightness [L*-value]	Rollability Day 8	Rollability Day 16
2401	31.40	39.37	2.59	154.4	1.2	75.8	5	3.7
2402	29.53	38.39	2.71	168.3	1.6	78.3	5	4.3
2403	31.73	38.24	2.89	169.3	1.7	77.2	5	3.7
2404	31.37	38.55	2.85	158.1	1.5	76.3	5	4.0
2405	32.05	38.44	2.70	163.0	1.5	75.8	5	4.3
2406	31.10	38.76	2.88	154.6	1.4	74.9	5	4.3
2407	29.76	38.93	2.97	152.2	1.4	77.6	5	4.7
2408	31.48	39.26	2.90	154.0	1.4	76.5	5	4.7
2409	29.07	39.98	3.43	150.9	1.5	76.2	5	3.7
2410	33.30	39.48	3.05	147.2	1.3	73.5	5	3.3
2411	34.05	39.72	2.99	150.6	1.3	75.6	5	3.7
2412	33.23	38.93	2.91	151.0	1.3	78.6	5	3.3
2413	32.64	39.42	2.92	145.0	1.2	78.2	5	3.3
2414	34.79	39.60	3.11	140.0	1.2	79.5	4.5	2.7
2415	32.64	39.29	2.81	154.0	1.3	72.5	4.5	3.0
2416	35.24	39.79	3.05	144.4	1.3	72.7	4.5	3.3
2417	33.94	39.83	2.77	143.7	1.1	73.5	5	3.0
2418	34.80	39.41	2.66	147.9	1.2	71.8	4.5	2.0
2419	34.32	39.65	2.75	150.7	1.2	73.2	5	3.0
2420	32.11	39.79	2.90	146.4	1.2	72.2	5	4.3
2421	32.33	39.75	2.71	144.4	1.1	71.2	4.5	3.3

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

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 Propionate	0.8%
Potassium Sorbate	0.4%
All-purpose Shortening	6.0%
Sodium Bicarbonate	0.6%
Fumaric Acid - encapsulated	0.5%
Sodium Aluminum Phosphate	0.82%
Water	53%

Tortilla Processing

MIX

→

PROOF

10 min, 32 °C, 70% RH

→

DIVIDE and ROUND

PROOF

5 min, 32°C, 70%

HOT-PRESS

Top and bottom of press plate = 360 °F

BAKE

Oven temperature = 340 °F;

Oven residence time = 40 sec

→

COOL and PACKAGE

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

Evaluation of Tortilla Properties

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

1. Weight

Ten tortillas are weighed on an analytical balance. The weight of one tortilla is calculated by dividing total weight by 10. These ranged from 38 to 44 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. These ranged from 2.2 to 3.8 mm.

4. Moisture

Moisture is determined using a two-stage procedure (AACC, Method 44-15A, 2000). These ranged from 19 to 37%.

5. Color Values

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

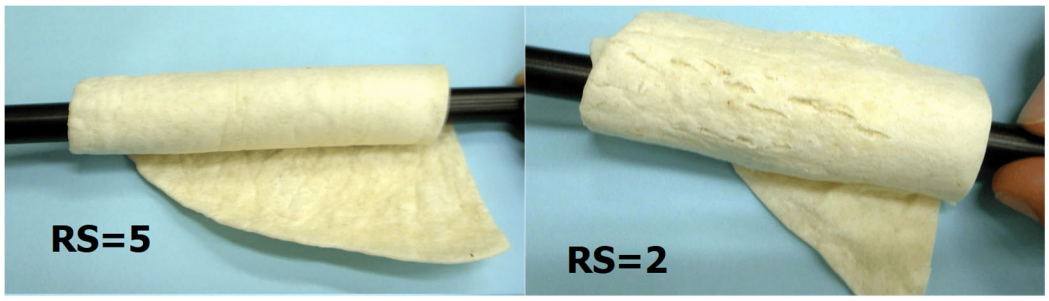
6. Specific Volume

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

7. Tortilla Rollability Score

Two tortillas are evaluated on 1, 8, and 12 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 12th day.



2021 WQC HARD WINTER WHEAT FLOUR PROTEIN ANALYSIS

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Procedures

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

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

Determination of polymeric to monomeric protein ratio

Protein extraction

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

SE-HPLC

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

Results of Flour Protein Analysis
Hard Winter Wheat WQC 2021 Crop Protein Analysis

	High Molecular Weight Glutenin Subunits				Polymeric/Monomeric protein
	Glu-A1	Glu-B1	Glu-D1		
22-2401	1, 2*	17+18	5+10		0.83
22-2402	1,2*	7+8	5+10		0.72
22-2403	1,2*	7+8	5+10		0.66
22-2404	2*	7+9	5+10		0.59
22-2405	1,2*	7+8	2+12		0.82
22-2406	1	7+8	5+10		0.76
22-2407	2*	7+8	5+10		0.92
22-2408	1	7+8	5+10		0.77
22-2409	2*	7+8	5+10		0.97
22-2410	2*	7+9	5+10		0.79
22-2411	1,2*	17+18	5+10		0.83
22-2412	2*	7+8	5+10		0.78
22-2413	2*	7+9	5+10		0.82
22-2414	2*	7^{oe}+8	5+10		0.85
22-2415	1	7+8	5+10		0.94
22-2416	2*	7^{oe}+8	5+10		0.85
22-2417	2*	7+8	5+10		0.94
22-2418	1	7+8	5+10		0.86
22-2419	1	17+18, 7	5+10		0.76
22-2420	1	17+18, 7	5+10		0.67
22-2421	2*	7+8	5+10		1.03

APPENDIX A
Credits and Methods

CREDITS

Milling, Sample Analysis, Ingredients and Report Preparation

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

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Grain Craft I & Q Lab 1990 Kimball Ave. Manhattan, KS 66502	Miller	**Kathy Brower** (785) 317-3901 kbrower@graincraft.com
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CREDITS

Baking Collaborators

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METHODS

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

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

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

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

Wheat and Flour Moisture - AACC Approved Method 44-15A. Wheat (ground in Falling Number 3303 burr-type mill to prevent drying before grinding) or flour is dried in a forced air oven at 130^0 C for one hour.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Cumulative Ash and Protein Curves

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

center of the kernel and increases toward the outer parts because the bran layer contains several times more minerals than pure endosperm.

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

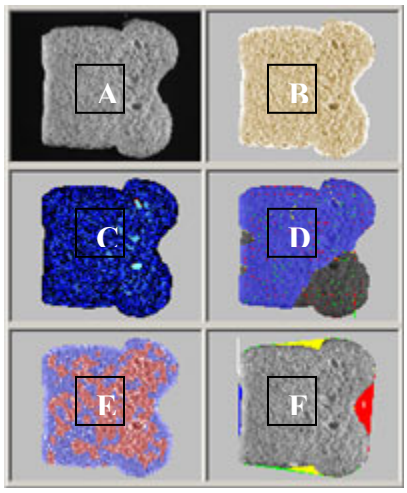
Similarly, cumulative protein curves are determined by arranging millstreams in ascending order of protein content, and tabulating the protein content of the total flour produced with the addition of successive millstreams. Wheat that gives high protein content at low extraction, and a fast rate of protein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

LI, Y. Z., and POSNER, E. S. 1987. The influence of kernel size on wheatmillability. Bull. Assoc. Operative Millers November: 5089-5098.
LI, Y. Z., and POSNER, E. S. 1989. An experimental milling techniquefor various flour extraction levels. Cereal Chem. 66:324-328.
LILLARD, D.W. and HERTSGAARD, D.M. 1983. Computer analysis and plotting of milling data: HRS wheat cumulative ash curves. Cereal Chem. 60:42-46.

C-Cell Image Analysis

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

Images:



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

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

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

Data:

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

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

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

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

Brightness: Sample brightness and cell contrast.

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

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

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

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

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

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

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

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

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

Collaborators' Baking Test Profiles and Other Information

2021 WQC COLLABORATORS' BAKING TEST PROFILES AND OTHER INFORMATION

Coop	No.	Test Methods	Est. Flour and Dough Wt (g)	Mixing Tolerance	Fermentation time (min)	Oven Temp (F)	Baking Time (min)
A	1	Pup-loaf straight dough	100 g	Mixograph	90 min	400	25
B	2	Sponge and dough	600 g flour, 480 g dough	Other	240 min (sponge time) and 45 min (fermentation)	420	20
C	3	Pup-loaf straight dough	100 g, approx 170 g	Mixograph	90 min	400	25
D	4	Pup-loaf straight dough	100 g flour, approx. 175 g dough	Farinograph and Mixograph	180 fermentation and 60 min proof time	400	25
E	5	Pup-loaf straight dough	100 g flour, approx 170 g dough	Mixograph	120 min	420	18
F	6	Pup-loaf straight dough	100 g flour, approx 175 g dough	Mixograph	90 min	425	21
G	7	Sponge and dough	700 g flour, 524 g dough	Farinograph with mixing evalu	240 min (sponge time) and 60 min (fermentation)	420	20
H	8	Pup-loaf straight dough	200g, 170 g dough	Mixograph	180 min	419	24
I	9	Pup-loaf straight dough	100 g flour	Farinograph	120 min	390	25
J	10	Sponge and dough	675 g flour, 540 g dough	Mixing series	210 min	430	23
K	11	Sponge and dough	700 g flour, 500 g dough	Farinograph	180 min (sponge) and 70 min (fermentation)	420	20
L	12	Pup-loaf straight dough	100 g	Miograph	90 min	420	24
M	13	Sponge and dough	600 g flour, 160 g dough	Mixing series	240 min	425	16
N	14	Pup-loaf straight dough	100 g flour, approx 160 g dough	Farinograph	120 min	425	20

APPENDIX B

HWWQC Technical Board and Goals for HWW Breeders

Hard Winter Wheat Quality Council

2021 Technical Board Officers

CHAIR: **Rich Kendrick**, Great Plains Analytical lab

VICE CHAIR: **Chris Kirby,** Oklahoma Wheat Commission

SECRETARY: **Dale Nellor,** NAMA

MEMBER: **Mark Hodges,** Plain Grains

MEMBER: **Gang Guo,** Ardent Mills

2021 Quality Evaluation & Advisory Committee

Brad Seabourn, USDA/ARS/HWWQL

Reuben McLean, Grain Craft

Jon Rich, Syngenta/AgriPro

Shawn Simpson, BIMBO Bakeries USA

Richard Chen, USDA/ARS/HWWQL

Hard Winter Wheat Quality Council (HWWQC)

Charter
Revised and Approved (February 20, 2003)

Mission, Policy, and Operating Procedure

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

Objectives

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

Membership

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

HWWQC Technical Board

- The Technical Board shall be the administrative unit responsible for managing the functions of the HWWQC.
- The Technical Board shall consist of five members, elected from the membership, to serve three-year terms.
- Officers of the technical board shall consist of a chair, vice-chair, and secretary.
- Each officer serves three years in his or her office.
- Terms start the day after the annual meeting of the HWWQC.
- The vice-chair generally replaces the chair at the conclusion of the chair's term and the secretary generally replaces the vice-chair at the conclusion of the vice-chair's term.
- Officers (normally only the secretary) shall be elected annually at the annual meeting of the HWWQC by nomination and majority vote.
- Any eligible member may be reelected after being out of office for one year.
- Vacancies that occur during the term of office of the members of the technical board shall be filled by nomination and majority vote of the remaining members of the technical board and the WQC Executive Vice President. The appointee will serve the remaining term of the vacancy (up to three years).
- Exceptions to the above may be granted if voted on by the Technical Board or by majority vote of the HWWQC at the annual meeting.

Duties of the Technical Board

- The chair shall be responsible to establish a meeting place and preside at all meetings of the technical board and Wheat Quality Council (selected elements of the General Meeting).
- The vice-chair shall preside at meetings in absence of the chair and assume such duties as may be assigned by the chair of the technical board.
- The secretary shall be responsible for taking minutes of the technical board meetings.
- The Technical Board will direct the Executive Vice President of the WQC on disbursement of allocated funds.
- The chair shall be responsible for communicating budget needs to the Executive Vice President.
- The Technical Board is responsible for presenting budget updates to the general membership at the annual meeting.

Compensation

- Technical Board members shall serve without compensation.

Expenses

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

Hard Winter Wheat Quality Evaluation and Advisory Committee

Committee Purpose

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

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

Evaluation and Responsibilities

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

Sample/Locations

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

Annual Meeting

- The annual meeting of the HWWQC shall coincide with the annual meeting of the WQC. If for some reason the WQC annual meeting is not held, it shall be the duty of the technical board chair to establish an annual meeting time and place.
- The purpose of the meeting shall be to discuss the results of the cooperators quality testing program, elect board members and carry on other business as required by the HWWQC.
- The Technical Board may establish other meetings determined to be necessary.

Finances and Budget

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

Amendments

- Amendments to the policy and operation procedure of the HWWQC can be made by majority vote of the HWWQC members.
- The proposed changes must be submitted in writing and must be in the hands of the membership two weeks prior to voting on the change.

Outlined Goals for Hard Winter Wheat Breeders

Developed by the Grain Trade, Operative Millers, and Mill Chemists Subcommittees of the Wheat Quality Council Hard Winter Wheat Technical Committee

1. Adaptability. Varieties should be adaptable and retain their quality integrity over a large geographic area.

2. Varieties should be resistant to diseases, to insect infestation (including stored grain insects), and to sprouting.

3. Emphasize quality evaluation in earlier generations. Obtain milling and baking data before F7. Grain and Texture should be considered along with loaf volume, absorption, mixing, and dough properties when evaluating baking quality.
4. Kernel Characteristics:
   A. Visual Appearance typical of class.
   B. Hardness significantly greater than soft wheat, but not so hard that milling or flour properties are negatively influenced.
   C. Uniformly large, plump, vitreous.

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

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

Performance on KSU Pilot Mill

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

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

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

7. Improved Mixing Tolerance with ‘extensible gluten’, not bucky or tough.

APPENDIX C

Hard Red Winter Wheat Quality Targets

RECOMMENDED* QUALITY TARGETS FOR HARD RED WINTER WHEAT

HWW Quality Targets Committee
Approved February, 2006

** "The purpose of Recommended Quality Targets (RQT) for Hard Red Winter Wheat (HRW) is to provide specific quality 'goals' for the breeding community, wheat producers, and marketing programs in order to assist and guide the decisions needed to maintain the consistency and end-use quality of the U.S. HRW market class. The RQT will be dynamic over time in direct response to the primary needs of the marketplace (domestic and foreign), and the needs of the U.S. industry to breed, produce and market wheats to meet market needs. The RQT should NOT be used as essential criteria for variety release decisions in breeding programs, or as marketing/grading standards for private companies or federal/state agencies. This* ***Statement of Purpose*** *must accompany all published forms of the RQT."* *HWWQT Committee, 2006*

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

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APPENDIX D

Hard White Wheat Quality Targets
Adopted from PNW for Great Plains

Hard White Wheat Quality Targets

Dual Purpose -- Chinese Noodles and Western Pan Bread

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

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

Notes:

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

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

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

(4) Noodle formula: straight-grade flour, 100%; water, 28%; and sodium chloride, 1.2%.
Noodle sizes: 2.5 mm (width) x 1.2 mm (thickness).
Noodle textural measurement: cook 100 g noodles in 1000 ml deionized water for 5 min, rinse in 27^0C water and drain. Measure noodle texture on five noodle strands by compressing to 70% of noodle thickness with a 5-mm flat probe attached to TA.XT2 Texture Analyzer.

These end-use quality targets emphasize the broadest possible utilization of hard white wheats.

Wheat Marketing Center, Portland, Oregon

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

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

APPENDIX E

WQC Business Meeting Minutes
Feb. 17, 2021

Minutes for 2021 Virtual Hard Winter Wheat Quality Council

February 17, 2021

Welcome & Opening Comments – Dave Green and Tess Brensing

Review of 2020 Minutes – Rich Kendrick, Secretary

Minutes approved and accepted by council.

Nomination and election of new members – Tess Brensing, Chair

Tim Aschbrenner nominated Mark Hodges as new member of HWW board.
Second – Brian Walker, Miller Milling.
Approved by the council

2021 Board announced by Tess Brensing -

Chairman	Rich Kendrick	Great Plains Analytical Lab
Vice Chairman	Chris Kirby	Oklahoma Wheat Commission
Secretary	Dale Nellor	NAMA
Member	Mark Hodges	Plains Grains
Member	Gang Guo	Ardent Mills

Overview of Wheat Tours – Dave Green, WQC
Dave provided an overview of the 2020 wheat tours that changed to a virtual format due to Covid-19 pandemic. It was announced that it is likely that the 2021 HWW tour will be virtual again and is usually around the first week of May. While virtual is certainly not the ideal situation, it will give us a glimpse of the 2021 Kansas crop conditions with the goal of being back in person for the 2022 HWW tour. There is also a HRS tour scheduled in July that was virtual in 2020 but may happen in some form of in-person since scheduled later in the year.

Overview of Milling of Wheat Samples - Paul Blodgett, KSU Manhattan
40 samples blended in Manhattan through the MIAG mill and no major breakdowns. Samples started on October 9, completed on November 5.

Wheat Quality Council HRW Report for 2020 – Richard Chen, USDA/ARS Manhattan – Over 400 page report covering 48 entries and 8 breeders.

Review of 2020 Wheat Crop – Mark Hodges, Plains Grains Inc.- Over all end-use quality and performance (mill/dough/bake) was particularly good. Little disease or insect damage. Over 92% of the crop graded #2 or better. 431 samples of HWW were pulled from 11 states by USDA NASS. There were no samples pulled in North Dakota.

Review of Hard Winter Wheat Quality Targets – Brad Seabourn, USDA/ARS Manhattan
This is the first year for a change in the growout process of the HWW entries. Both pros and concerns were discussed and will know more after completing this year, the first year.

Soft Wheat Update – Byung-Kee Baik, USDA/ARS Wooster
In soft wheat, there were 20 entries and 4 locations. Extended invitation to attend Soft Wheat Quality council on March 16

State Crop Reports –

Texas – Rodney Mosier, Texas Wheat
Oklahoma – Mike Schulte, Oklahoma Wheat Commission
Kansas – Aaron Harries, Kansas Wheat Commission
Nebraska – Royce Schaneman, Nebraska Wheat Board
Colorado – Brad Erker, Colorado Wheat
South Dakota – Reid Christopherson, South Dakota Wheat Commission
Montana – Cassidy Marn, Montana Wheat and Barley Committee

Financial Report – Dave Green, WQC- Financials are good but income has decreased due to not having the wheat tour 2020 & 2021 or the annual conference 2021. Dave thanked the sponsor for supporting the annual HWW portion of the conference enabling WQC to provide the meeting free of charge for participants.

Sponsor's Session - Thank you to Central Life Sciences and Paul Drache for sponsoring the 2021 HWW Virtual Annual Conference.

Adjourn

APPENDIX F

Historical WQC Hard Winter
Wheat Entries
from 2001 to 2021

A History of WQC Hard Winter Wheat Entries

2021

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Jagalene	21-2401					Check
19NORD122	21-2402					NDSU
19NORD127	21-2403					NDSU
10BC329-17-5	21-2404	HRW	yes	AP Bigfoot	2021	AgriPro(Syngenta)
NHH17450	21-2405	HRW	no			UNL
NHH17612	21-2406	HRW	no			UNL
SD12DHA01373	21-2407	HRW	yes	SD Midland		SDSU
SD15035-2	21-2408					SDSU
LCH18-7071	21-2409					Limagrain
SY Monument	21-2410					Check
Jagalene	21-2411					Check
LCH17-4196	21-2412					Limagrain
SYMonument	21-2413					Check
OK15MASBx7 ARS 8-29	21-2414		Not yet			OSU
AP Roadrunner	21-2415	HRW	yes	AP Roadrunner	2020	AgriPro(Syngenta)
OK15DMASBx7 ARS 6-8	21-2416		Not yet			OSU
CO13007-F6R	21-2417					CSU
CO16D1487	21-2418					CSU
TX15M8024	21-2419	HRW	yes	TX15M8024	2021	Texas A&M
XE4101	21-2420					Westbred(Bayer)
WB4401	21-2421					Westbred(Bayer)

2020

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Byrd	20-2401					Colorado
Jagalene (CC01)	20-2402					Colorado
CO14A055-258	20-2403	HRW	yes	Kivari AX	2020	Colorado
CO15D098R	20-2404	HRW	yes	Steamboat	2020	Colorado
CO16SF070	20-2405					Colorado
Jagalene (CC02)	20-2406					BASF
BASF1	20-2407					BASF
BASF2	20-2408					BASF
Jagalene (CC03)	20-2409					Limagrain
DH11HRW55-4	20-2410					Limagrain
LCH13DH-47-1675	20-2411	HRW	yes	LCSJULEP	2020	Limagrain
LCH15ACC-13-4	20-2412	HRW	yes	LCSPHOTONAX	2020	Limagrain
Jagalene (CC04)	20-2413					Kansas-Hays
Danby	20-2414					Kansas-Hays
KS15H137-2-2	20-2415	HRW	yes	KS Hamilton	2020	Kansas-Hays
Jagalene (CC05)	20-2416					Bayer
MODI4-6036	20-2417					Bayer
NEDI4-5064	20-2418					Bayer
Jagalene (CC06)	20-2419					Oklahoma
Baker's Ann	20-2420					Oklahoma
OK14124-2	20-2421	HRW	Yes	Butler's Gold	2020	Oklahoma
OK15MASBx7 ARS8-22	20-2422		not yet			Oklahoma

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
OK15818	20-2423	HRW	unofficiall	Gallagher	2019	Oklahoma
OK12716W Comp I	20-2424		not yet			Oklahoma
Jagalene (CC07)	20-2425					Montana
Yellowstone	20-2426					Montana
MTCL1737	20-2427		no			Montana
MT1745	20-2428					Montana
Everest	20-2429					Kansas-Manhattan
Jagalene (CC08)	20-2430					Kansas-Manhattan
KS12DH0156-88	20-2431					Kansas-Manhattan
KS090616K-1	20-2432					Kansas-Manhattan
Jagalene (CC09)	20-2433					Northern States
17NORD-94	20-2434		no			North Dakota
17NORD-96	20-2435		no			North Dakota
NE14434	20-2436		no			Nebraska
NE14696	20-2437		no			Nebraska
PSB13NEDH-14-83W	20-2438		no			Nebraska
09BC308-14-16	20-2439	HRW	yes	AP EverRock		Syngenta
SD12DHA03282	20-2440	HRW	yes	SD Andes		South Dakota
2019						
Byrd	19-2401	HRW	check			Colorado
Jagalene (CC01)	19-2402	HRW	check			Colorado
CO13D0787	19-2403	HRW	yes	Guardian	2019	Colorado
CO15SFD107	19-2404	HRW	yes	Fortify SF	2019	Colorado
CO15D098R	19-2405	HRW	yes	Steamboat	2020	Colorado
TAM 114	19-2406					Texas
TX14A001035	19-2407					Texas
TX14M7061	19-2408					Texas
Jagalene (CC02)	19-2409					Oklahoma
Ruby Lee	19-2410					Oklahoma
OK16D101089	19-2411	HRW	yes	Uncharted	2020	Oklahoma
OK168512	19-2412	HRW	yes	Breakthrough	2020	Oklahoma
OCW04S717T-6W	19-2413	HW	yes	Big Country	2020	Oklahoma
OK12912C-138407-2	19-2414	HRW	yes	Strad CL+	2020	Oklahoma
Jagalene (CC03)	19-2415					Limagrain
ERYTHR02420-2010	19-2416					Limagrain
Jagalene (CC04)	19-2417					Kansas-Hays
KS15H116-6-1	19-2418	HRW	yes	KS DALLAS	2019	Kansas-Hays
KS15H161-1-4	19-2419	HRW	yes	KS WESTERN STAR	2019	Kansas-Hays
Danby	19-2420					Kansas-Hays
Jagalene (CC05)	19-2421					Monsanto
MODI4-5179	19-2422	HRW	yes	WB4505	2019	Monsanto
NEDI4-5304	19-2423	HRW	yes	WB4309	2019	Monsanto
Jagalene (CC06)	19-2424					Northern States
NW13493	19-2425	HWW	yes	NW13493	2021	Nebraska
NE14691	19-2426	HRW	no			Nebraska
SD14113-3	19-2427	HRW	yes	Draper	2019	South Dakota
MTCS1601R	19-2428	HRW	yes	StandClear CLP	2019	Montana
MT1683	19-2429					Montana

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
2018						
Jagalene (CC01)	18-2401					Texas
TAM 111	18-2402					Texas
TX12V7415	18-2403	HRW	yes	TAM 205	2019	Texas
LINK	18-2404					Limagrain
Jagalene (CC02)	18-2405					Limagrain
DH11HRW53-34	18-2406					Limagrain
LCI13DH-22-22	18-2407					Limagrain
MOD14-4919	18-2408				TBD	Monsanto
Jagalene (CC03)	18-2409					Monsanto
H4N13-0253	18-2410	HRW	yes	N/A	2017	Monsanto
Danby	18-2411					Kansas-Hays
Jagalene (CC04)	18-2412					Kansas-Hays
KS14H180-4-63	18-2413		no			Kansas-Hays
Jagalene (CC05)	18-2414					Syngenta
10BC107#115	18-2415					Syngenta
SY Monument	18-2416					Syngenta
08BC379-40-1	18-2417					Syngenta
Jagalene (CC06)	18-2418					Oklahoma
Ruby Lee	18-2419					Oklahoma
OK12716-159319-13	18-2420	HRW	yes	Showdown	2018	Oklahoma
OK13621	18-2421	HRW	yes	Baker's Ann	2018	Oklahoma
OK12206-127206-2	18-2422	HRW	yes	OK Corral	2019	Oklahoma
OK1059018-129332-5	18-2423	HRW	no			Oklahoma
Jagalene (CC07)	18-2424					Northern States
NE10478-1	18-2425	HRW		LCS Valiant	2019	Nebraska
NHH144913-3	18-2426	SRW	no			Nebraska
MT1564	18-2427	HWW	yes	Flathead	2019	Montana
MTS1588	18-2428	HRW	yes	Bobcat	2019	Montana
NORD58	18-2429	HWW	no			North Dakota
NORD62	18-2430	HWW	no			North Dakota
SD09227	18-2431	HRW	yes	Thompson	2017	Sourth Dakota
SD14115-5	18-2432	HRW	yes	Winner	2019	Sourth Dakota
2017						
SY Monument	17-2401	HRW				Syngenta
SY Achieve CL2	17-2402	XWHT	yes	SY Achieve CL2	2017	Syngenta
SY 517 CL2	17-2403	HRW	yes	S 517 CL2	2017	Syngenta
Jagalene (CC01)	17-2404	HRW				Syngenta
Jagalene (CC02)	17-2405	HRW				Texas
TAM 111	17-2406	HRW				Texas
TX11A001295	17-2407	HRW	yes	TAM 115	2019	Texas
TX12M4068	17-2408	HRW	no			Texas
Byrd	17-2409	HRW				Colorado
CO12D1770	17-2410	HRW	yes	Canvas	2018	Colorado
Jagalene (CC03)	17-2411	HRW				Colorado
CO13D1783	17-2412	HRW	yes	Whistler	2018	Colorado
CO12D2011	17-2413	HDWH	yes	Breck	2017	Colorado

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Jagalene (CC04)	17-2414	HRW				Kansas-Hays
KS13HW92-3	17-2415	HDWH	yes	Venada	2018	Kansas-Hays
Danby	17-2416	HDWH				Kansas-Hays
KS14HW106-6-6	17-2417	HDWH	YES	KS SILVERADO	2019	Kansas-Hays
Yellowstone	17-2418	HRW				Montana
MT1465	17-2419	HRW	yes	FourOsix	2018	Montana
Jagalene (CC05)	17-2420	HRW				Montana
MTW1491	17-2421	HDWH	yes	Numont	2020	Montana
NI13706	17-2422	HRW	no			Nebraska
NE12561	17-2423	HRW	yes	Siege	2020	Nebraska
Jagalene (CC06)	17-2424	HRW				Nebraska
Jagalene (CC07)	17-2425	HRW				Monsanto
WB4623CLP	17-2426	HRW	yes	WB4623CLP	2014	Monsanto
WB4721	17-2427	HRW	yes	WB4721	2015	Monsanto
Ruby Lee	17-2428	HRW				Oklahoma
OK13621	17-2429	HRW	yes	Baker's Ann	2018	Oklahoma
OK12D22004-016	17-2430	HRW	no			Oklahoma
OCW04S7171T-6W	17-2431	HDWH	pending		2020	Oklahoma
Jagalene (CC08)	17-2432	HRW				Oklahoma
2016						
LCH13-048	16-2401	HRW				Limagrain
LCH13NEDH-12-27	16-2402	HRW				Limagrain
Jagalene (CC01)	16-2403	HRW				Limagrain
PSB13NEDH-11-26	16-2404	HRW				Limagrain
LCI13-069	16-2405	HWW				Limagrain
PSB13NEDH-14-83	16-2406	HWW				Limagrain
KS1256-6-4	16-2407	HRW	yes	Tatanka	2016	Kansas-Hays
Danby	16-2408	HWW				Kansas-Hays
Jagalene (CC02)	16-2409	HRW				Kansas-Hays
LCH13NEDH-14-53	16-2410	HWW	no			Nebraska
Jagalene (CC03)	16-2411	HRW				Nebraska
LCHNEDH-4-16	16-2412	HWW	no			Nebraska
Postrock	16-2413	HRW				Syngenta
Jagalene (CC04)	16-2414	HRW				Syngenta
AP11T2409	16-2415	HRW				Syngenta
Jagalene (CC05)	16-2416	HRW				Monsanto
HV9W10-0458	16-2417	HRW	yes	WB4515	2015	Monsanto
Jagalene (CC06)	16-2418	HRW				Oklahoma
Ruby Lee	16-2419	HRW				Oklahoma
OK10126	16-2420	HRW	yes	Spirit Rider	2017	Oklahoma
OK12D22004-016	16-2421	HRW	no			Oklahoma
OK12912C	16-2422	HRW	under Consideration			Oklahoma
OK13209	16-2423	HRW	yes	Green Hammer	2018	Oklahoma
Everest	16-2424	HRW				Kansas-Manhattan
Jagalene (CC07)	16-2425	HRW				Kansas-Manhattan
Larry	16-2426	HRW				Kansas-Manhattan
Zenda	16-2427	HRW				Kansas-Manhattan

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
2015						
Jagalene (CC01)	15-2401	HRW				Kansas-Hays
Danby (IC)	15-2402	HRW				Kansas-Hays
KS11HW39-5	15-2403	HRW	yes	Joe	2015	Kansas-Hays
Jagalene (CC04)	15-2404	HRW				Nebraska
NE1059	15-2405	HRW	yes	Ruth	2016	Nebraska
Jagalene (CC06)	15-2406	HRW				Monsanto
BZ9W09-2075	15-2407	HWW	yes	WB4575	2015	Monsanto
HV9W10-1002	15-2408	HWW	yes	WB4303	2015	Monsanto
Jagalene (CC09)	15-2409	HRW				Colorado
Byrd (IC)	15-2410	HRW				Colorado
CO11D1397	15-2411	HRW				Colorado
CO11D1539	15-2412	HRW				Colorado
CO11D1767	15-2413	HRW				Colorado
Jagalene (CC14)	15-2414	HRW				Oklahoma
Gallagher (IC)	15-2415	HRW				Oklahoma
OK11D25056	15-2416	HRW	yes	Smith's Gold	2017	Oklahoma
OK13625	15-2417	HRW	yes	Skydance	2017	Oklahoma
OK10728W	15-2418	HWW	yes	Stardust	2017	Oklahoma
Jagalene (CC19)	15-2419	HRW				Montana
Yellowstone (IC)	15-2420	HRW				Montana
MTS1224	15-2421	HRW	yes	Loma	2016	Montana
MT1265	15-2422	HRW				Montana
Ideal (IC)	15-2423	HRW				South Dakota
SD10257-2	15-2424	HRW	yes	Oahe	2016	South Dakota
LCH13DH-20-87	15-2425	HRW	yes	LCS Chrome	2015	Limagrain
2014						
Jagalene (CC01)	14-2401	HRW				Kansas_Hays
Danby (IC)	14-2402	HWW				Kansas_Hays
KS11HW15-4	14-2403	HWW				Kansas_Hays
KS11W39-5	14-2404	HWW				Kansas_Hays
Jagalene (CC05)	14-2405	HRW				Texas_Amarillo
TAM 111 (IC)	14-2406	HRW				Texas_Amarillo
TX08A001249	14-2407	HRW				Texas_Amarillo
TX09A001194	14-2408	HRW				Texas_Amarillo
TX09D1172	14-2409	HRW				Texas_Amarillo
Jagalene (CC10)	14-2410	HRW				Colorado
Byrd (IC)	14-2411	HRW				Colorado
CO11D174	14-2412	HRW	yes	Avery	2015	Colorado
CO11D446	14-2413	HRW	yes	Langin	2016	Colorado
Jagalene (CC)	14-2414	HRW				Nebraska
Camelot (IC)	14-2415	HRW				Nebraska
NE07531	14-2416	HRW				Nebraska
NE09521	14-2417	HRW				Nebraska
Jagalene (CC18)	14-2418	HRW				Montana
Yellowstone (IC)	14-2419	HRW				Montana
MT1078	14-2420	HRW				Montana
MT1138	14-2421	HRW				Montana

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Jagalene (CC22)	14-2422	HRW				Oklahoma
Ruby Lee (IC)	14-2423	HRW				Oklahoma
OK09125	14-2424	HRW	yes	Bentley	2015	Oklahoma
OK10126	14-2425	HRW	yes	Spirit Rider	2017	Oklahoma
Jagalene (CC26)	14-2426	HRW				Kansas_Manhattan
KanMark	14-2427	HRW				Kansas_Manhattan
06BC722#25	14-2428	HRW	yes	SY Flint	2015	Agripro
06BC796#68	14-2429	HRW	yes	SY Sunrise	2015	Agripro
2013						
Check Blend (check)	13-2401	HRW				Limagrain
LCH08-80	13-2402	HRW				Limagrain
lCS Mint	13-2403	HRW	yes	LCS Mint	2012	Limagrain
Danby (check)	13-2404	HWW				Kansas-Hays
Oakley CL	13-2405	HRW	yes	Oakley CL	2013	Kansas-Hays
KS10HW78-1	13-2406	HWW				Kansas-Hays
Lyman (check)	13-2407	HRW				South Dakota
SD08200	13-2408	HRW				South Dakota
SD09192	13-2409	HRW				South Dakota
Postorock (check)	13-2410	HRW				Agripro
04BC574-2	13-2411	HRW	yes	SY Monument	2014	Agripro
Millennium (check)	13-2412	HRW				Nebraska
NE09521	13-2413	HRW				Nebraska
NE08499	13-2414	HRW				Nebraska
Yellowstone (check)	13-2415	HRW				Montana
MT1090	13-2416	HRW				Montana
MTW08168	13-2417	HWW	yes	WB3768	2013	Montana
Ruby Lee (check)	13-2418	HRW				Oklahoma
Doublestop CL+	13-2419	HRW	yes	Doublestop CL+	2013	Oklahoma
OK09125	13-2420	HRW	yes	Bentley	2015	Oklahoma
2012						
WB-Stout (check)	12-2401	HRW				Westbred
HV9W07-1028	12-2402	HRW				Westbred
Millennium (check)	12-2403	HRW				Nebraska
NW07505	12-2404	HWW				Nebraska
NE06545	12-2405	HRW	yes	Freeman	2012	Nebraska
NE06607	12-2406	HRW				Nebraska
Byrd (check)	12-2407	HRW				Colorado
Snowmass (check)	12-2408	HWW				Colorado
CO07W245	12-2409	HWW	yes	Antero	2012	Colorado
CO07W722-F5	12-2410	HWW				Colorado
Billings (check)	12-2411	HRW				Oklahoma
Ruby Lee	12-2412	HRW				Oklahoma
Gallagher (OK07214)	12-2413	HRW	yes		2012	Oklahoma
Iba (OK07209)	12-2414	HRW	yes		2012	Oklahoma
OK09634	12-2415	HRW	no			Oklahoma
Lyman (check)	12-2416	HRW				South Dakota
SD08080	12-2417	HRW				South Dakota

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
SD06158	12-2418	HRW	yes	Redfield	2013	South Dakota
Yellowstone (check)	12-2419	HRW				Montana
MT08172	12-2420	HRW	yes	Colter	2012	Montana
MT0978	12-2421	HRW	yes	Northern	2015	Montana
TAM 111 (check)	12-2422	HRW				Texas
TX07A001505	12-2423	HRW				Texas
TX03A0563-07	12-2424	HRW				Texas
2011						
Danby (check)	11-2401	HWW				Kansas-Hays
Tiger	11-2402	HWW	yes			Kansas-Hays
KS08HW35-1	11-2403	HWW	yes	Clara CL	2011	Kansas-Hays
PostRock (check)	11-2404	HRW				AgriPro
SY Wolf	11-2405	HRW	yes			AgriPro
Syngenta Exp 138-45	11-2406	HRW	yes	SY Southwind	2012	AgriPro
Fuller (check)	11-2407	HRW				Kansas-Manhattan
KS020319-7-3	11-2408	HRW	yes	1863	2012	Kansas-Manhattan
KS020633M-13	11-2409	HRW	no			Kansas-Manhattan
McGill (check)	11-2410	HRW				Nebraska
NE05496	11-2411	HRW	no			Nebraska
NE05548	11-2412	HRW	no			Nebraska
NI08708	11-2413	HRW	no			Nebraska
Jagalene (check)	11-2414	HRW				Westbred
HV9W06-509	11-2415	HWW	yes	WB-Grainfield	2012	Westbred
Yellowstone (check)	11-2416	HRW				Montana
MTS0808	11-2417	HRW	yes	Warhorse	2013	Montana
MT0871	11-2418	HRW	no			Montana
Lyman (check)	11-2419	HRW				South Dakota
SD06158	11-2420	HRW	yes	Redfield		South Dakota
SD07184	11-2421	HRW	no			South Dakota
2010						
Lyman (check)	10-2401	HRW				SDSU
SD05118-1	10-2402	HRW	yes	Ideal	2011	SDSU
SD06158	10-2403	HRW	yes	Redfield		SDSU
Hatcher (check)	10-2404	HRW				CSU
CO050303-2	10-2405	HRW	yes	Denali	2011	CSU
CO06052	10-2406	HRW	yes	Brawl CL Plus	2011	CSU
CO06424	10-2407	HRW	yes	Byrd	2011	CSU
Millennium (check)	10-2408	HRW				NU
NE03490	10-2409	HRW	no			NU
NE04490	10-2410	HRW	no			NU
Billings (check)	10-2411	HRW				OSU
OK05526	10-2412	HRW	yes	Ruby Lee	2011	OSU
OK05212	10-2413	HRW	yes	Garrison	2011	OSU
OK07231	10-2414	HRW	no			OSU
Smoky Hill (check)	10-2415	HRW				Westbred
HV9W06-262R	10-2416	HRW	no			Westbred
HV9W06-218W	10-2417	HWW	no			Westbred

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Yellowstone (check)	10-2418	HRW				MSU
MTS0721	10-2419	HRW	yes	Bearpaw	2011	MSU
TAM 111 (check)	10-2420	HRW				TAMU
TX05A001822	10-2421	HRW	no			TAMU
TX06A001263	10-2422	HRW	no			TAMU

2009

Smoky Hill (check)	09-2401	HRW				Westbred
Stout (HV9W03-539R)	09-2402	HRW	yes	WB-Stout	2009	Westbred
RonL (check)	09-2403	HWW				KSU-Hays
Tiger	09-2404	HWW	yes			KSU-Hays
Hatcher (check)	09-2405	HRW				CSU
CO04393	09-2406	HRW	no			CSU
CO04499	09-2407	HRW	no			CSU
OK Bullet (check)	09-2408	HRW				OSU
Billings	09-2409	HRW	yes			OSU
OK05526	09-2410	HRW	yes	Ruby Lee	2011	OSU
PostRock (check)	09-2411	HRW				AgriPro
CJ	09-2412	HRW	yes			AgriPro
SY Gold (AP00x0100-51)	09-2413	HRW	yes	SY Gold	2010	AgriPro
Yellowstone (check)	09-2414	HRW				MSU
MT06103	09-2415	HRW	no			MSU
MTS0713	09-2416	HRW	yes	Judee	2011	MSU
TAM 111 (check)	09-2417	HRW				TAMU
TX02A0252	09-2418	HRW	yes	TAM 113	2010	TAMU
Millennium (check)	09-2419	HRW				NU
NE01481	09-2420	HRW	yes	McGill	2010	NU
NI04421	09-2421	HRW	yes	Robidoux	2010	NU

2008

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

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
SD05W030	08-2418	HWW	no			SDSU
2007						
Hatcher (check)	07-2401	HRW				CSU
CO03W239	07-2402	HWW	yes	Thunder CL	2008	CSU
CO03W054	07-2403	HWW	yes	Snowmass		CSU
CO02W237	07-2404	HWW	no			CSU
Millennium (check)	07-2405	HRW				NU
NH03614	07-2406	HRW	yes	Settler CL	2008	NU
OK Bullet (check)	07-2407	HRW				OSU
OK00514-05806	07-2408	HRW	no			OSU
OK05737W	07-2409	HWW	no			OSU
OK03522	07-2410	HRW	yes	Billings	2009	OSU
OK02405	07-2411	HRW	no			OSU
Tandem (check)	07-2412	HRW				SDSU
SD98W175-1	07-2413	HRW	no			SDSU
SD01058	07-2414	HRW	no			SDSU
SD0111-9	07-2415	HRW	yes	Lyman	2008	SDSU
SD01273	07-2416	HRW	no			SDSU
Genou (check)	07-2417	HRW				MSU
MT0495	07-2418	HRW	no			MSU
MTS04114	07-2419	HRW	no			MSU
2006						
Overley (check)	06-2401	HRW				KSU-Manhattan
Fuller	06-2402	HRW	yes			KSU-Manhattan
KS990498-3-&~2	06-2403	HRW	no			KSU-Manhattan
KS970274-14*9	06-2404	HRW	no			KSU-Manhattan
Overley (check)	06-2405	HRW				Westbred
Smoky Hill	06-2406	HRW	yes			Westbred
Aspen	06-2407	HRW	yes			Westbred
Millennium (check)	06-2408	HRW				NU
NW98S097	06-2409	HRW	yes	Anton	2008	NU
N02Y5117	06-2410	HRW	yes	Mace	2007	NU
NE01643	06-2411	HRW	yes	Overland	2007	NU
NE02584	06-2412	HRW	no			NU
OK Bullet (check)	06-2413	HRW				OSU
Duster	06-2414	HRW	yes			OSU
OK01420	06-2415	HRW	no			OSU
OK02405	06-2416	HRW	no			OSU
OK02522W	06-2417	HWW	yes	OK Rising	2008	OSU
Tandem (check)	06-2418	HRW				SDSU
SD96240-3-1	06-2419	HRW	no			SDSU
SD01122	06-2420	HRW	no			SDSU
SD01W065	06-2421	HWW	no			SDSU
TAM 111 (check)	06-2422	HRW				TAMU
TAM 112	06-2423	HRW	yes			TAMU
TX01A5936	06-2424	HRW	no			TAMU
TX01D3232	06-2425	HRW	yes	TAM 304	2006	TAMU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
TX01V5314	06-2426	HRW	yes	TAM 203	2007	TAMU
2005						
Akron (check)	05-2401	HRW				CSU
CO00016	05-2402	HRW	yes	Ripper	2006	CSU
Jagger (check)	05-2403	HRW				KSU-Hays
2137	05-2404	HRW	yes			KSU-Hays
KS03HW6-6	05-2405	HWW	no			KSU-Hays
KS03HW158-1	05-2406	HWW	yes	RonL		KSU-Hays
Jagger (check)	05-2407	HRW				AgriPro
Neosho	05-2408	HRW	yes			AgriPro
W03-20	05-2409	HRW	yes	Postrock	2005	AgriPro
Goodstreak (check)	05-2410	HRW				NU
Infinity CL	05-2411	HRW	yes			NU
OK Bullet (check)	05-2412	HRW				OSU
OK93p656H3299-2c04	05-2413	HRW	yes	Duster	2006	OSU
OK01307	05-2414	HRW	no			OSU
OK03918C	05-2415	HRW	yes	Centerfield	2006	OSU
OK00611W	05-2416	HWW	no			OSU
Tandem (check)	05-2417	HRW				SDSU
Crimson	05-2418	HRW	yes			SDSU
SD97059-2	05-2419	HRW	no			SDSU
SD01W064	05-2420	HWW	no			SDSU
2004						
Jagger (check)	04-2401	HRW				KSU-Hays
2137	04-2402	HRW	yes			KSU-Hays
KS02HW34	04-2403	HWW	yes	Danby	2005	KSU-Hays
KS02HW35-5	04-2404	HWW	no			KSU-Hays
KS03HW158	04-2405	HWW	yes	RonL	2006	KSU-Hays
Antelope (check)	04-2406	HRW				NE-USDA-ARS
Arrowsmith	04-2407	HRW	yes			NE-USDA-ARS
NW99L7068	04-2408	HRW	no			NE-USDA-ARS
Millennium (check)	04-2409	HRW				NU
NE99495	04-2410	HRW	yes	NE99495	2005	NU
OK102 (check)	04-2411	HRW				OSU
OK00618W	04-2412	HWW	yes	Guymon	2005	OSU
OK99212	04-2413	HRW	no			OSU
OK00514	04-2414	HRW	yes	OK Bullet	2005	OSU
OK02909C	04-2415	HRW	yes	Okfield	2005	OSU
Tandem (check)	04-2416	HRW				SDSU
SD97W609	04-2417	HWW	yes	Alice	2006	SDSU
SD97538	04-2418	HRW	no			SDSU
SD98102	04-2419	HRW	yes	Darrell	2006	SDSU
2003						
Akron (check)	03-2401	HRW				CSU
CO980607	03-2402	HRW	yes	Hatcher	2004	CSU
CO00D007	03-2403	HRW	yes	Bond CL	2004	CSU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Jagger (check)	03-2404	HRW				KSU-Hays
2137	03-2405	HRW	yes			KSU-Hays
KS01HW152-6	03-2406	HWW	no			KSU-Hays
KS01HW163-4	03-2407	HWW	no			KSU-Hays
KS02HW34	03-2408	HWW	yes	Danby	2005	KSU-Hays
Jagger (check)	03-2409	HRW				KSU-Manhattan
2137	03-2410	HRW	yes			KSU-Manhattan
Overley	03-2411	HRW	yes			KSU-Manhattan
KS940786-6-9	03-2412	HRW	no			KSU-Manhattan
OK 102 (check)	03-2413	HRW				OSU
OK94P549-11	03-2414	HRW	yes	Endurance	2004	OSU
OK98690	03-2415	HRW	yes	Deliver	2004	OSU
Crimson (check)	03-2416	HRW				SDSU
SD97W604	03-2417	HWW	yes	Wendy	2004	SDSU
SD92107-5	03-2418	HRW	no			SDSU

2002

Jagger (check)	02-2401	HRW				AgriPro
Cutter	02-2402	HRW	yes			AgriPro
Dumas	02-2403	HRW	yes			AgriPro
Jagalene	02-2404	HRW	yes			AgriPro
G1878 (check)	02-2405	HRW				Cargill
G980723	02-2406	HRW	no			Cargill
G970252W	02-2407	HWW	no			Cargill
Prowers (check)	02-2408	HRW				CSU
CO980376	02-2409	HRW	no			CSU
CO980607	02-2410	HRW	yes	Hatcher	2004	CSU
CO980630	02-2411	HRW	no			CSU
Jagger (check)	02-2412	HRW				KSU-Manhattan
KS940748-2-2	02-2413	HRW	no			KSU-Manhattan
KS940786-6-7	02-2414	HRW	yes	Overley	2003	KSU-Manhattan
KS940786-6-9	02-2415	HRW	no			KSU-Manhattan
Millennium (check)	02-2416	HRW				NU
NE97V121	02-2417	HRW	no			NU
NE98466	02-2418	HRW	no			NU
NE98471	02-2419	HRW	yes	Hallam	2004	NU
NI98439	02-2420	HRW	no			NU
2174 (check)	02-2421	HRW				OSU
OK102	02-2422	HRW	yes			OSU
OK95548-54	02-2423	HRW	no			OSU
OK95616-56	02-2424	HRW	no			OSU
OK96705-38	02-2425	HRW	no			OSU
OK98699	02-2426	HRW	no			OSU

2001

Jagger (check)	01-2401	HRW				Cargill
G970380A	01-2402	HRW	no			Cargill
G970209W	01-2403	HWW	no			Cargill
Prowers 99 (check)	01-2404	HRW				CSU
CO970547	01-2405	HRW	no			CSU

Entry ID	Entry No.	Entry Class	Released	Release Name	Release Year	Program
Millennium (check)	01-2406	HRW				NU
NE97426	01-2407	HRW	no			NU
NE97465	01-2408	HRW	yes	Goodstreak	2002	NU
NE97638	01-2409	HRW	yes	Empire	2002	NU
NE97669	01-2410	HRW	no			NU
NE97689	01-2411	HRW	yes	Harry	2002	NU
2174 (check)	01-2412	HRW				OSU
OK96717-99-6756	01-2413	HRW	no			OSU
OK97508	01-2414	HRW	yes	Ok102	2002	OSU

Thank you for reviewing this report of 2021 WQC Hard Winter Wheat milling and baking. Please let me know if you have any comments on this report. I can be reached at (785)776-2750 or by email, Richard.chen@usda.gov