# Milling and Baking Test Results for Hard Winter Wheat

## Harvested in 2023


## 74th 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, as well as private wheat breeding companies including Syngenta (AgriPro Wheat), Bayer (WestBred), Limagrain, BASF, and other collaborators from milling, baking, grain trade, other firms and academic 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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# 2023

## Milling and Baking Test Results for

# Hard Winter Wheats


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# The MISSION
## of the WHEAT QUALITY COUNCIL:

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

# The GOAL
## of the WHEAT QUALITY COUNCIL:

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

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# Description of the 2023 Testing Program

Founded in 1949, this is the **74th** 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 28 composite entries this year were grown in two different Uniform Growout Systems (Northern and Southern) and Montana. The Northern has 7 composite entries including 1 check and 6 breeding lines from 4 breeding programs (ND, SD, NE, and AP) and The Southern has 16 composite entries including 1 check and 15 breeding lines from 7 breeding programs (CO, OK, LM, KM, KH, WB, and TX). The wheat samples were milled on the Miag Multomat mill in the Kansas State University Department of Grain Science and Industry (Methods, Appendix A). The flour was distributed to 15 cooperators (15 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.

# 2023 WQC HWW Entries & Breeding Programs

| Breeding Programs | Entry Number | Sample Identification |
|---|---|---|
| **SOUTHERN** | 23-2401 | SY Monument_CK |
| | 23-2402 | CO18035RA_CO |
| | 23-2403 | CO18042RA_CO |
| | 23-2404 | CO18D007W_CO |
| | 23-2405 | OK15MASBx7 ARS 8-19-18-4_OK |
| | 23-2406 | OK16107123-19-9_OK |
| | 23-2407 | OK19225_OK |
| | 23-2408 | LCH19DH-152-6_LM |
| | 23-2409 | LCH16ACC421-64_LM |
| | 23-2410 | KS16DH0010-17_KM |
| | 23-2411 | KS19H10_KH |
| | 23-2412 | XF4412_WB |
| | 23-2413 | XF4402_WB |
| | 23-2414 | WB4422_WB |
| | 23-2415 | TX18A001119_TX |
| | 23-2416 | TX18A001132_TX |
| **NORTHERN** | 23-2417 | SY Monument_CK |
| | 23-2418 | 21Nord-160_ND |
| | 23-2419 | XF4102_WB |
| | 23-2420 | SD18B072-2_SD |
| | 23-2421 | SD19B033-2_SD |
| | 23-2422 | NE16562_NE |
| | 23-2423 | NW15443_NE |
| **MONTANA** | 23-2424 | Yellowstone_CK |
| | 23-2425 | SY Monument_CK |
| | 23-2426 | MT2019_MT |
| | 23-2427 | MTCL2010_MT |
| | 23-2428 | MTF20189_MT |

CK=Check; CO=Colorado; OK=Oklahoma; LM=Limagrain; WB=Westbred (Bayer); TX=Texas; NE=Nebraska; KH= KSU-Hays; KM=KSU-Manhattan; MT=Montana; SD=South Dakota; ND=North Dakota; UM=USDA Manhattan.

# 2023 Wheat Classification Results from GIPSA

# GIPSA Wheat Market Classification

| ID | CL | DKG | TW | M | ODOR | HT | DKT | FM | SHBN | DEF | CCL | WOCL | GRADE | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **23-2401** | HRW | 0.0 | 60.4 | 11.5 | OK | 0.0 | 0.1 | 0.0 | 0.3 | 0.4 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2402** | HRW | 0.1 | 60.1 | 11.6 | OK | 0.0 | 0.1 | 0.0 | 0.9 | 1.0 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.1% | |
| **23-2403** | HRW | 0.0 | 60.3 | 11.7 | OK | 0.0 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 | 0.0 | U.S NO. 1 HRW, DKG 0.0% | |
| **23-2404** | HDWH | 0.0 | 60.0 | 11.4 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S.NO. 1 HDWH, DKG 0.0% | |
| **23-2405** | HRW | 0.1 | 60.5 | 11.4 | OK | 0.0 | 0.2 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.1% | |
| **23-2406** | HRW | 0.0 | 61.8 | 11.2 | OK | 0.0 | 0.2 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2407** | HRW | 0.0 | 62.9 | 11.4 | OK | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | U.S NO. 1 HRW, DKG 0.0% | |
| **23-2408** | HRW | 0.0 | 59.8 | 11.2 | OK | 0.0 | 0.1 | 0.0 | 0.1 | 0.2 | 0.0 | 0.4 | U.S NO. 2 HRW, DKG 0.0% | |
| **23-2409** | HRW | 0.0 | 61.2 | 11.5 | OK | 0.0 | 0.1 | 0.0 | 0.7 | 0.8 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2410** | HRW | 0.0 | 61.2 | 11.3 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2411** | HRW | 0.0 | 61.8 | 11.1 | OK | 0.0 | 0.2 | 0.0 | 0.2 | 0.4 | 0.0 | 0.2 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2412** | HRW | 0.1 | 59.9 | 11.3 | OK | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | U.S NO. 2 HRW, DKG 0.1% | |
| **23-2413** | HRW | 0.1 | 62.2 | 11.4 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.1% | |
| **23-2414** | HRW | 0.1 | 61.3 | 11.2 | OK | 0.0 | 0.2 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.1% | |
| **23-2415** | HRW | 0.0 | 62.2 | 11.4 | OK | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | U.S NO. 1 HRW, DKG 0.0% | |
| **23-2416** | HRW | 0.0 | 59.5 | 11.5 | OK | 0.0 | 0.2 | 0.0 | 0.5 | 0.7 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% | |
| **23-2417** | HRW | 0.0 | 59.0 | 11.7 | OK | 0.0 | 0.2 | 0.0 | 0.5 | 0.7 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% | |
| **23-2418** | HRW | 0.0 | 58.9 | 11.7 | OK | 0.0 | 0.0 | 0.0 | 0.8 | 0.8 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% | |
| **23-2419** | HRW | 0.0 | 59.9 | 11.8 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% | |
| **23-2420** | HRW | 0.0 | 59.4 | 11.8 | OK | 0.0 | 0.3 | 0.0 | 0.3 | 0.6 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% | |
| **23-2421** | HRW | 0.0 | 60.5 | 11.7 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2422** | HRW | 0.1 | 59.8 | 11.9 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.7 | U.S. NO. 2 HRW, DKG 0.1% | |
| **23-2423** | XWHT | 0.0 | 59.8 | 11.8 | OK | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | U.S. NO. 2 XWHT, DKG 0.0% | 89% HDWH 11% HRW |
| **23-2424** | HRW | 0.0 | 61.1 | 11.3 | OK | 0.0 | 0.2 | 0.0 | 0.3 | 0.5 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2425** | HRW | 0.0 | 61.1 | 11.3 | OK | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2426** | HRW | 0.0 | 61.7 | 11.3 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2427** | HRW | 0.0 | 61.6 | 11.3 | OK | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% | |
| **23-2428** | HRS | 0.0 | 62.1 | 11.3 | OK | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | U.S. NO. 1 HRS, DKG 0.0% | Interesting, 15.2% protein |

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*

# SOUTHERN GROWOUT

| | |
|---|---|
| 23-2401 | SY Monument_CK |
| 23-2402 | CO18035RA_CO |
| 23-2403 | CO18042RA_CO |
| 23-2404 | CO18D007W_CO |
| 23-2405 | OK15MASBx7 ARS 8-19-18_OK |
| 23-2406 | OK16107123-19-9_OK |
| 23-2407 | OK19225_OK |
| 23-2408 | LCH19DH-152-6_LM |
| 23-2409 | LCH16ACC421-64_LM |
| 23-2410 | KS16DH0010-17_KM |
| 23-2411 | KS19H10_KH |
| 23-2412 | XF4412_WB |
| 23-2413 | XF4402_WB |
| 23-2414 | WB4422_WB |
| 23-2415 | TX18A001119_TX |
| 23-2416 | TX18A001132_TX |

CK=Check; LM=Limagrain; WB=Westbred (Bayer); OK=Oklahoma; KH=KSU Hays; KM=KSU Manhattan; CO=Colorado; TX=Texas A&M Bushland.

# Description of Test Plots and Breeder Entries

## Southern Growout:

There are 16 composited entries including one check and 15 breeding lines from 7 breeding programs (CO, OK, LM, KM, KH, WB and TX). The Southern growout consisted of 10 locations (AP, WB, BF, KM, KH, LM, OK, CO, UM, and TX), but only 5 locations (AP, LM, OK, UM, and TX) submitted the entries for the composites used for end-use quality testing.

### USDA-MANHATTAN by Mary Guttieri

The 2023 winter Wheat Quality Council samples from USDA-ARS (Manhattan, KS) originated from strip increases grown at the USDA-ARS Meat Animal Research Center near Clay Center, NE located in south-central Nebraska. The WQC strips were planted on Sept. 26, 2022. The previous crop was silage corn, which was chopped to clear the plot area. Pre-plant N (100 lb/A) was applied. Good soil moisture was available at planting, and 0.5" of irrigation was applied on Oct. 3, 2022. The field had excellent fall stand and growth. Based on soil test analyses conducted in March 2023, no additional fertilizer was applied. No fungicide was applied, and only traces of stripe rust and stem rust were observed in the nursery after flowering. Weeds were controlled with Prowl + Finesse (3/28/23) followed by Zidua (5/2/23). The region had severe drought conditions in Spring 2023 (<4.5" from Jan 1 to Jun 1, 0.15" in April). Therefore, supplemental irrigation was applied: 0.5" (3/29), 0.6" (4/28), 0.6" (4/30), and 0.8" (5/24). The growout was harvested on Jul 10, 2023. The trial was harvested between rainstorms at an average of ~ 17% moisture. Grain was promptly cleaned with an orbital seed sizer and dried in a forced air drier to an average of ~13% moisture. Mean test weight was 59.6 lb/bu and average protein (12% mb) was 13%. Average yields of SY Monument and Bob Dole in an adjacent trial were 58 and 62 bu/ac, respectively.

### LIMAGRAIN by Marla Dale Barnett

**Growing Location & Conditions**

The 2023 hard winter Wheat Quality Council samples from Limagrain Cereal Seeds originated from strip increases grown in Benton, KS located in south central Kansas. The WQC strips were planted on October 17th, 2022 into dry conditions following a failed corn crop. Emergence was good going into winter. The field received 100 lbs/acre actual N in March 2022 at Feekes growth stage 4. No fungicide was applied, and no foliar diseases were noted. The mean grain yield of the 16 entries was 34.7 bushels/acre with an average grain protein content of 13.57% (Table 1). Drought

was the most persistent stress factor. Temperatures ranged from -7°F on December 22nd, 2022 to 96°F on June 24th, 2023 during the growing season at the location. The field received 10.98 inches of rainfall (not counting snowfall) from planting through harvest.

**Table 1.** Grain yield, test weight, and grain protein from sixteen winter wheat experimental entries and checks grown in Benton, KS 2023, Limagrain Cereal Seeds.

| | **Grain Yield (bu/ac)** | **Test Weight (lbs/bu)** | **Grain Protein (%)** |
|---|---|---|---|
| SY Monument | 39.82 | 61.4 | 12.34 |
| CO18035RA | 36.33 | 61.5 | 12.86 |
| CO18042RA | 42.72 | 61.3 | 12.15 |
| CO18D007W | 48.53 | 60.6 | 12.62 |
| OK15MASBx7ARS8-19-18-4 | 28.27 | 60.3 | 13.87 |
| OK16107123-19-9 | 24.91 | 61.4 | 15.66 |
| OK19225 | 26.65 | 62.3 | 15.63 |
| LCH19DH152-6 | 35.43 | 60.0 | 14.94 |
| LCH16ACC421-64 | 33.36 | 61.0 | 14.13 |
| KS16DH0010-17 | 30.14 | 60.4 | 13.27 |
| KS19H10 | 34.07 | 60.6 | 12.86 |
| XF4412 | 31.62 | 60.0 | 14.65 |
| XF4402 | 26.01 | 61.6 | 12.60 |
| WB4422 | 34.14 | 60.2 | 13.19 |
| TX18A001119 | 35.24 | 61.6 | 14.40 |
| TX18A001132 | 48.21 | 60.9 | 11.93 |
| Mean | 34.7 | 60.94 | 13.57 |

**LCH19DH152-6**

LCH19DH152-6 is a medium maturing hard red winter wheat with an excellent disease package and broad adaptation including the High Plains and Central Plains. The pedigree of LCH19DH152-6 is LCS Chrome / NW13669. Tolerance to acidic soils and wheat streak mosaic virus, with resistance to stripe rust, leaf rust and soil-borne mosaic virus make this medium maturing line very attractive to growers in both the High Plains and central plains of Oklahoma and Kansas. Moderate resistance to FHB and stem rust are nice additions that give LCH19DH152-6 a large area of adaptation. Straw strength and yield performance is excellent in both dryland and irrigated production. This line was tested in the 2022 Southern Regional Performance Nursery.

Milling and baking quality data from LCS show desirable milling quality, dough properties and baking quality. Small pup (100g) loaf volumes are noted as very good,

typically ranging from 920 cc to exceeding 1000 cc. Flour protein content and strength are noted as desirable with good to acceptable mixograph water absorption.

**LCH16ACC421-64**

LCH16ACC421-64 is a medium maturing hard red winter wheat with two genes of tolerance to CoAXium brand herbicide. The pedigree of LCH16ACC421-64 is T158/ACC854-10. Adult plant resistance to stripe rust and leaf rust combined with wheat curl mite resistance and moderate Fusarium head blight resistance make this medium maturing line very attractive to growers in both the High Plains and central plains of Oklahoma and Kansas. Straw strength and yield performance is excellent in both dryland and irrigated production.

Milling and baking quality data from LCS show desirable milling quality and desirable baking quality. Flour protein content is acceptable with very strong mixograph strength and tolerance. Small pup (100g) loaf volumes typically exceed 1000 cc.

## OKLAHOMA by Brett Carver

The North Central Agronomy Research Station at Lahoma (12 miles west of Enid) is the Oklahoma site for the southern uniform WQC growout. The WQC growout has occurred at this same location in a wheat-fallow rotation for more than 20 years. Grain yield in 2023 averaged 52 bu/ac across the growout, reduced mainly by severe season-long drought stress except in the 10-day period leading up to harvest. Test weight averaged 59.3 lb/bu. Harvest occurred on June 25, 2023, delayed by about two weeks due to frequent rainfall events.

**OK15MASBx7 ARS 8-19-18-4 (23-2405)**

Currently under foundation seed production, OK15MASBx7 ARS 8-19-18-4 bears close resemblance to its full-sib Paradox (Gallagher*3/ Snowmass), tested previously as OK15MASBx7 ARS 8-29 (WQC 21-2414). The key difference is this experimental line appears to perform better in far western Oklahoma, including the panhandle, and is taller. Both show susceptibility to Septoria nodorum blotch on leaf tissue. Both exhibit extremely strong dough characteristics with long hydration time and high farinograph water absorption (>62%), long dough development time, long stability times exceeding one hour, and low MTI (<15).

These varieties and others like Breadbox and Firebox (WQC 21-2416) are informally characterized as “Ox” wheats. OK15MASBx7 ARS 8-19-18-4 is the leading candidate to supplement acreage of Paradox and would be commercialized in a similar fashion as an ingredient flour source.

**OK16107123-19-9 (23-2406)**

One of several OSU HRW candidates derived from Doublestop CL Plus, this one comes without any *AHAS* genes conferring imazamox herbicide tolerance. Its

powerhouse pedigree, OK12621/Doublestop CL+, provides the rare opportunity to stack true resistance to BYD (*Bdv1+Bdv2*), Hessian fly resistance, acid soil tolerance, stripe rust and leaf rust resistance, powdery mildew resistance, acid-soil tolerance, and grazing tolerance with large kernel size and high test weight. Doublestop's functionality, however, has been a tough act to follow with this pedigree.

**OK19225 (23-2407)**

Highest yielding among the three OSU entries, OK19225 is a progeny of KS06O3A~58-2/OK10408//Ruby Lee. It never ranked lower than 4$^{th}$ for yield in statewide breeder trials from 2019 through 2023. It fell back in the pack in 2023 trials, but it was targeted primarily for intensive wheat management systems where a plant growth regulator might be included to restrict height expression. A Ruby Lee direct descendent with acid-soil tolerance also made this line very attractive. High Cotton, another Ruby Lee progeny (WQC 22-2417) with above-average functionality and high yield, preceded OK19225 for release in 2023. We will probably stop writing the Ruby Lee sequel with High Cotton's release.

## TEXAS A&M by Jackie C. Rudd and Amir M. Ibrahim

The Texas southern growout of the Wheat Quality Council entries was at Bushland, TX (near Amarillo in the Texas Panhandle). Strips were planted adjacent to our intensively managed irrigated yield trials. We fertilized for a yield goal of 100 bu/a and harvested yield was 85 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. Russian wheat aphid and stripe rust were present in some areas of the field, but yield losses were low due to these.

**TX18A001119**

This hard red winter wheat line was developed by the TAM Wheat Improvement Program in Amarillo from the cross TAM 112/TX98D1158 (TAM 303 sib)//TX07A001418. It is resistant to leaf rust, stripe rust, and stem rust and is well adapted to the High Plains, Rolling Plains, and Blacklands of Texas. It is medium-late maturing and medium height. It has good test weight and strong mixing and baking strength.

**TX18A001132**

This hard red winter wheat was selected from TAM 303/TX99U8618//TAM 114 by the TAM Wheat Improvement Program in Amarillo. It has excellent foliar disease resistance; including leaf rust, stripe rust, and stem rust. It also has medium resistance to both Wheat Streak Mosaic Virus and Fusarium Head Blight. Adapted throughout Texas, with medium early maturity and medium height. Testweight is average and mixing and baking strength are high.

## SYNGENTA (AGRIPRO) by Josh Coltrain

Northern and Southern uniform growout increase strips were planted on 10/5/22 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. Timely rains created excellent growing conditions at the site which was unique for most of the growing region. The increase strips were harvested on June 29, 2023 with very high yield levels.

## COLORADO by Esten Mason

### Growing Location & Conditions

Colorado did not submit samples in 2023 due to a errant application of Beyond Herbicide

CO18035RA
CO18042RA
CO18D007W

### CO18035RA

CO18035RA is a CoAXium hard red winter wheat (HRW) breeding line developed at Colorado State University. CO18035RA is derived from multiple CoAXium versions of Byrd containing different resistance genes and is also 50% Langin by pedigree. It has three genes for resistant to Aggressor herbicide, one on each of the three wheat genomes. CO18035RA has acidic soil tolerance and wheat curl mite resistance derived from Byrd. It has good yield potential across diverse growing environments and has shown very good milling and baking quality. It is targeted for potential release in 2023.

### CO18042RA

CO18042RA is derived from the same population as CO18035RA. It is a CoAXium hard red winter wheat (HRW) breeding line developed at Colorado State University. CO18042RA is derived from multiple CoAXium versions of Byrd containing different resistance genes and is also 50% Langin by pedigree. It has three genes for resistant to Aggressor herbicide, one on each of the three wheat genomes. CO18042RA has acidic soil tolerance and wheat curl mite resistance derived from Byrd. It has good yield potential across diverse growing environments and has shown very good milling and baking quality. It is targeted for potential release in 2023.

**CO18D007W**

CO18D007W is a doubled-haploid line developed using the wheat x maize hybridization method from the cross CO12D906/CO07W722-F5. CO18D007W is an awned, white-glumed, hard white winter wheat. It has medium height, medium maturity, medium length coleoptile, strong straw strength. CO18D007W was evaluated in the AYND1 (DH) nursery in 2019, the CSU Elite Trial from 2020-2023 and the Uniform Variety Performance Trial from 2021-2023. CO18D007W was evaluated in cooperative stripe rust evaluations in Washington State and Kansas from 2019-2023 and is currently in testing in the Southern Regional Performance Nursery. It is high yielding in both dryland and irrigated environments in Colorado. It has excellent milling and baking quality and confirmed presence of Bx7oe which confers strong mixing properties.

## KANSAS-MANHATTAN by Allan Fritz

**KS16DH0010-17** was released as KS Mako in 2023 by the Kansas Agricultural Experiment Station. KS Mako is a hard red winter wheat selected from the cross LCS Chrome/3/KS030810NT-9/90RN2491//3*KS020617~9. LCS Chrome is a hard red winter wheat adapted to the Great Plains with a positive protein deviation but is also photoperiod sensitive. KS030810NT-9 was used as a source of *Lr34* and 90RN2491 was used as a source of *Lr67*, though neither gene is present is KS16DH0010-17. KS020617~9 is a breeding line from the KSU program with a strong Jagger parentage.

KS Mako has performed well statewide but is best adapted to regions of Kansas east of a north-south line through Hays. In four-year data, it has averaged 1.9 bu/ac more than WB 4699 and 5.4 bu/ac more than SY Monument, including both fungicide treated and untreated locations. Under fungicide treatment, it has yielded significantly higher than SY Monument and equal to WB 4699. It has performed well across a wide variety of conditions and has a very good test weight pattern.

KS Mako is moderately susceptible to leaf and stem rust and Fusarium head blight. It will benefit from a fungicide application in most environments. KS Mako has moderate resistance to stem rust race QFCS due to the presence of *Sr38.* It also has an intermediate response to acid soils, with a reaction very similar to KS Ahearn. It has an intermediate reaction to barley yellow dwarf virus. KS Mako carries the *Wsm2* gene for resistance to wheat streak mosaic virus but is susceptible to the wheat curl mite and Triticum mosaic virus. KS Mako is susceptible to Hessian fly.

KS Mako is a medium to medium-early maturing variety which heads about 2.5 days later than Everest. It is a medium height semi-dwarf with very good straw strength, good threshability and good tolerance to shattering.

KS Mako has good milling quality and very good baking quality. Compared to SY Monument, KS Mako has significantly higher milling yield (67.0% versus 64.8%), similar

farinograph absorption and farinograph stability and superior loaf volumes (743 cc versus 708cc).

## KANSAS-HAYS by Guorong Zhang

The 15 lines and SY Monument (check) were planted on Oct. 6, 2022 in a field at Hays experimental station with sandy-loam soil. The field was fertilized with 60 lb/a N before planting. The field had very limited soil moisture at planting and the plots did not have good stands. Plots were not irrigated and were not treated with fungicide. Due to the severe drought, plots looked very poor and they were abandoned.

### KS19H10 (KS Bill Snyder)

KS19H10 was released as KS Bill Snyder in August 2023. It is a hard red winter wheat with medium maturity and medium-short stature. KS19H10 has high grain yield potential and good drought tolerance. KS19H10 has a good disease resistance package, including resistance to wheat streak mosaic virus, stripe rust, leaf rust, and Soilborne mosaic virus; moderate resistance to stem rust and powdery mildew; and intermediate resistance to *Triticum* mosaic virus and Barley yellow dwarf virus. KS19H10 has resistance to grain shattering, very good straw strength and good winter hardiness. KS19H10 has above average test weight, and good milling and bread-making qualities. KS19H10 can be used for both dryland and irrigated production in western Kansas and surrounding regions.

## BAYER (WESTBRED) by Adam Bray

## XF4412 (2434412 Out-license)

XF4412 is a medium-early maturity hard red winter wheat with excellent straw strength, improved protein and test weight, and good milling and baking quality. It is moderately resistant to FHB, Stripe and Leaf Rust, Bacterial Leaf Streak and Soilborne Mosaic Virus. It has improved yield, protein, and test weight compared to WB4523. Internal quality testing indicates good mixing and baking quality from eastern locations. 2434412 was offered for Out-licensing in 2023 targeting the Eastern Central Plains.

## XF4402 (2484402 Out-license)

XF4402 is a late maturity hard red winter wheat with good Wheat Streak, Soilborne and low pH tolerance. It is adapted to non-irrigated Western Central Plains acres. It is moderately susceptible to FHB, and moderately resistant to Leaf and Stripe Rust. Internal quality testing indicates above average test weight, average protein, and good mixing and baking quality. 2484402 was offered for Out-licensing in 2023 in the Central Plains.

# Southern Growout: 2023 (Small-Scale) Samples

| Test entry number | 23-2401 | 23-2402 | 23-2403 | 23-2404 |
|---|---|---|---|---|
| **Sample identification** | **SY Monument_CK** | **CO18035RA_CO** | **CO18042RA_CO** | **CO18D007W_CO** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW | 1 HDWH |
| **Test weight (lb/bu)** | 60.4 | 60.1 | 60.3 | 60.0 |
| **Hectoliter weight (kg/hl)** | 79.5 | 79.1 | 79.3 | 78.9 |
| **1000 kernel weight (gm)** | 32.1 | 28.4 | 30.9 | 30.2 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 79.9 | 59.8 | 62.5 | 67.9 |
| Over 9 wire (%) | 19.9 | 38.7 | 36.0 | 31.8 |
| Through 9 wire (%) | 0.3 | 1.6 | 1.6 | 0.4 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 64.7/16.6 | 57.2/15.4 | 55.3/16.8 | 54.7/17.1 |
| Weight (mg) (avg/s.d) | 33.1/9.3 | 31.7/10.3 | 30.1/9.7 | 31.3/7.9 |
| Diameter (mm)(avg/s.d) | 2.73/0.41 | 2.57/0.39 | 2.56/0.38 | 2.69/0.34 |
| Moisture (%) (avg/s.d) | 11.7/0.5 | 11.8/0.6 | 11.9/0.5 | 11.3/0.4 |
| SKCS distribution | 04-10-23-63-01 | 05-18-34-43-01 | 08-23-34-35-01 | 09-24-31-36-01 |
| Classification | Hard | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 12.7 | 12.8 | 12.5 | 12.8 |
| **Wheat ash (12% mb)** | 1.51 | 1.61 | 1.58 | 1.60 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 76.7 | 76.5 | 76.9 | 76.5 |
| Quadrumat Sr. Mill | 69.4 | 69.3 | 69.5 | 69.3 |
| **Flour moisture (%)** | 12.5 | 12.2 | 12.1 | 12.5 |
| **Flour protein (14% mb)** | 11.4 | 11.6 | 11.3 | 11.5 |
| **Flour ash (14% mb)** | 0.53 | 0.59 | 0.51 | 0.48 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 6.1 | 5.9 | 6.0 | 6.2 |
| Peak viscosity (RVU) | 204.4 | 200.5 | 202.6 | 201.8 |
| Breakdown (RVU) | 77.8 | 84.3 | 81.7 | 69.7 |
| Final viscosity at 13 min (RVU) | 241.3 | 224.1 | 232.0 | 246.7 |
| **Minolta color meter** | | | | |
| L* | 91.21 | 91.32 | 91.18 | 91.55 |
| a* | -0.99 | -1.20 | -1.03 | -1.22 |
| b* | 8.60 | 9.12 | 8.40 | 8.82 |
| **PPO** | 0.250 | 0.554 | 0.514 | 0.542 |
| **Falling number (sec)** | 411 | 410 | 415 | 433 |
| **Damaged Starch** | | | | |
| (AI%) | 96.9 | 97.0 | 97.3 | 96.4 |
| (AACC76-31) | 7.0 | 7.1 | 7.3 | 6.6 |

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

# Southern Growout: 2023 (Small-Scale) Samples (continued)

| Test entry number | 23-2405 | 23-2406 | 23-2407 | 23-2408 |
|---|---|---|---|---|
| **Sample identification** | **OK15MASBx7 ARS 8-19-18-4_OK** | **OK16107123-19-9_OK** | **OK19225_OK** | **LCH19DH-152-6_LM** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW | 2HRW |
| **Test weight (lb/bu)** | 60.5 | 61.8 | 62.9 | 59.8 |
| **Hectoliter weight (kg/hl)** | 79.6 | 81.3 | 82.7 | 78.7 |
| **1000 kernel weight (gm)** | 33.6 | 36.5 | 32.1 | 27.2 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 78.1 | 89.3 | 75.4 | 59.6 |
| Over 9 wire (%) | 21.7 | 10.7 | 24.5 | 39.8 |
| Through 9 wire (%) | 0.2 | 0.0 | 0.2 | 0.7 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 70.9/15.0 | 69.2/17.3 | 60.2/15.2 | 50.4/16.5 |
| Weight (mg) (avg/s.d) | 33.7/8.7 | 35.9/9.5 | 32.0/9.0 | 26.9/7.8 |
| Diameter (mm)(avg/s.d) | 2.80/0.33 | 2.98/0.37 | 2.74/0.41 | 2.53/0.34 |
| Moisture (%) (avg/s.d) | 11.3/0.5 | 11.3/0.5 | 11.2/0.5 | 10.8/0.5 |
| SKCS distribution | 01-03-17-79-01 | 01-07-21-71 | 04-15-21-54-01 | 14-28-26-32-03 |
| Classification | Hard | Hard | Hard | Mixed |
| **Wheat protein (12% mb)** | 13.1 | 14.9 | 14.0 | 13.7 |
| **Wheat ash (12% mb)** | 1.59 | 1.82 | 1.57 | 1.64 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 76.2 | 73.4 | 75.2 | 75.1 |
| Quadrumat Sr. Mill | 66.2 | 67.9 | 69.3 | 69.2 |
| **Flour moisture (%)** | 12.2 | 11.9 | 12.5 | 12.3 |
| **Flour protein (14% mb)** | 12.0 | 13.2 | 12.7 | 12.4 |
| **Flour ash (14% mb)** | 0.52 | 0.55 | 0.48 | 0.53 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 6.2 | 6.1 | 6.1 | 6.1 |
| Peak viscosity (RVU) | 197.1 | 182.0 | 185.9 | 189.1 |
| Breakdown (RVU) | 71.4 | 69.2 | 74.8 | 70.8 |
| Final viscosity at 13 min (RVU) | 233.2 | 205.9 | 207.9 | 220.7 |
| **Minolta color meter** | | | | |
| L* | 90.80 | 90.53 | 91.52 | 91.45 |
| a* | -1.10 | -1.46 | -0.96 | -1.07 |
| b* | 9.09 | 10.37 | 8.09 | 8.51 |
| **PPO** | 0.162 | 0.576 | 0.416 | 0.540 |
| **Falling number (sec)** | 461 | 453 | 438 | 396 |
| **Damaged Starch** | | | | |
| (AI%) | 97.2 | 97.5 | 96.7 | 96.6 |
| (AACC76-31) | 7.3 | 7.5 | 6.9 | 6.8 |

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

# Southern Growout: 2023 (Small-Scale) Samples (continued)

| Test entry number | 23-2409 | 23-2410 | 23-2411 | 23-2412 |
|---|---|---|---|---|
| **Sample identification** | **LCH16ACC421-64_LM** | **KS16DH0010-17_KM** | **KS19H10_KH** | **XF4412_WB** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW | 2HRW |
| **Test weight (lb/bu)** | 61.2 | 61.2 | 61.8 | 59.9 |
| **Hectoliter weight (kg/hl)** | 80.5 | 80.5 | 81.3 | 78.8 |
| **1000 kernel weight (gm)** | 27.8 | 29.9 | 32.9 | 31.8 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 57.2 | 73.6 | 82.1 | 82.9 |
| Over 9 wire (%) | 41.5 | 25.8 | 17.7 | 17.0 |
| Through 9 wire (%) | 1.3 | 0.6 | 0.3 | 0.2 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 52.9/16.3 | 54.3/16.1 | 60.7/15.2 | 56.5/16.4 |
| Weight (mg) (avg/s.d) | 29.1/8.2 | 29.0/8.7 | 33.1/8.6 | 31.2/8.6 |
| Diameter (mm)(avg/s.d) | 2.54/0.37 | 2.66/0.39 | 2.81/0.39 | 2.74/0.38 |
| Moisture (%) (avg/s.d) | 10.9/0.6 | 10.8/0.7 | 10.7/0.5 | 11.2/0.6 |
| SKCS distribution | 11-23-33-33-03 | 08-23-32-37-01 | 03-12-32-53-01 | 06-17-38-39-01 |
| Classification | Mixed | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 13.5 | 13.3 | 13.0 | 13.4 |
| **Wheat ash (12% mb)** | 1.56 | 1.52 | 1.55 | 1.65 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 76.2 | 77.3 | 76.5 | 74.9 |
| Quadrumat Sr. Mill | 70.1 | 69.6 | 66.9 | 70.9 |
| **Flour moisture (%)** | 12.3 | 12.9 | 12.4 | 12.4 |
| **Flour protein (14% mb)** | 12.3 | 12.2 | 11.8 | 11.9 |
| **Flour ash (14% mb)** | 0.46 | 0.48 | 0.53 | 0.53 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 5.9 | 6.1 | 6.1 | 6.0 |
| Peak viscosity (RVU) | 197.2 | 225.1 | 202.3 | 188.8 |
| Breakdown (RVU) | 84.3 | 87.3 | 76.6 | 76.8 |
| Final viscosity at 13 min (RVU) | 215.1 | 249.8 | 232.8 | 211.4 |
| **Minolta color meter** | | | | |
| L* | 91.57 | 90.94 | 90.64 | 91.15 |
| a* | -1.13 | -1.16 | -1.13 | -1.13 |
| b* | 8.50 | 9.52 | 9.43 | 8.39 |
| **PPO** | 0.527 | 0.575 | 0.443 | 0.367 |
| **Falling number (sec)** | 416 | 475 | 455 | 415 |
| **Damaged Starch** | | | | |
| (AI%) | 97.0 | 96.5 | 97.4 | 97.2 |
| (AACC76-31) | 7.0 | 6.7 | 7.4 | 7.2 |

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

# Southern Growout: 2023 (Small-Scale) Samples (continued)

| Test entry number | 23-2413 | 23-2414 | 23-2415 | 23-2416 |
|---|---|---|---|---|
| **Sample identification** | **XF4402_WB** | **WB4422_WB** | **TX18A001119_TX** | **TX18A001132_TX** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW | 2HRW |
| **Test weight (lb/bu)** | 62.2 | 61.3 | 62.2 | 59.5 |
| **Hectoliter weight (kg/hl)** | 81.8 | 80.6 | 81.8 | 78.3 |
| **1000 kernel weight (gm)** | 32.5 | 31.5 | 30.3 | 28.0 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 73.7 | 77.3 | 68.2 | 61.3 |
| Over 9 wire (%) | 26.1 | 22.5 | 31.5 | 38.0 |
| Through 9 wire (%) | 0.3 | 0.3 | 0.3 | 0.8 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 68.1/17.8 | 65.5/14.8 | 72.7/18.4 | 60.0/16.0 |
| Weight (mg) (avg/s.d) | 32.3/9.1 | 31.5/8.2 | 30.2/8.2 | 29.6/9.4 |
| Diameter (mm)(avg/s.d) | 2.72/0.38 | 2.78/0.37 | 2.72/0.37 | 2.51/0.38 |
| Moisture (%) (avg/s.d) | 11.5/0.5 | 10.9/0.5 | 10.9/0.6 | 11.3/0.6 |
| SKCS distribution | 03-06-21-70-01 | 01-08-24-67-01 | 01-07-16-76-01 | 05-16-26-53-01 |
| Classification | Hard | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 12.8 | 13.2 | 13.6 | 12.6 |
| **Wheat ash (12% mb)** | 1.74 | 1.59 | 1.69 | 1.57 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 75.7 | 76.2 | 74.7 | 76.2 |
| Quadrumat Sr. Mill | 66.8 | 67.7 | 64.3 | 65.1 |
| **Flour moisture (%)** | 12.2 | 12.8 | 12.4 | 12.9 |
| **Flour protein (14% mb)** | 11.5 | 12.2 | 12.3 | 11.3 |
| **Flour ash (14% mb)** | 0.62 | 0.58 | 0.61 | 0.61 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 6.2 | 6.2 | 6.2 | 6.1 |
| Peak viscosity (RVU) | 193.7 | 221.5 | 194.9 | 187.7 |
| Breakdown (RVU) | 71.8 | 93.8 | 71.9 | 77.7 |
| Final viscosity at 13 min (RVU) | 222.1 | 221.8 | 224.3 | 214.3 |
| **Minolta color meter** | | | | |
| L* | 90.79 | 90.79 | 90.52 | 90.85 |
| a* | -0.86 | 0.98 | -0.84 | -1.30 |
| b* | 8.58 | 8.80 | 8.90 | 9.80 |
| **PPO** | 0.407 | 0.144 | 0.212 | 0.545 |
| **Falling number (sec)** | 435 | 458 | 398 | 435 |
| **Damaged Starch** | | | | |
| (AI%) | 97.5 | 97.1 | 97.9 | 97.2 |
| (AACC76-31) | 7.5 | 7.1 | 7.8 | 7.2 |

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

# Southern Growout: Physical Dough Tests and Gluten Analysis 2023 (Small-Scale) Samples

| Test Entry Number | 23-2401 | 23-2402 | 23-2403 | 23-2404 |
|---|---|---|---|---|
| Sample Identification | SY Monument_CK | CO18035RA_CO | CO18042RA_CO | CO18D007W_CO |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 66.3 | 67.0 | 68.1 | 68.1 |
| Flour Abs (14% mb) | 64.7 | 65.1 | 66.0 | 66.3 |
| Mix Time (min) | 8.9 | 10.6 | 8.1 | 6.6 |
| Mix tolerance (0-6) | 6 | 6 | 6 | 6 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 63.8 | 61.8 | 64.2 | 64.2 |
| Flour Abs (14% mb) | 62.2 | 59.9 | 62.1 | 63.1 |
| Peak time (min) | 5.7 | 4.7 | 3.8 | 12.5 |
| Mix stability (min) | 11.6 | 14.9 | 11.1 | 22.4 |
| Mix Tolerance Index (FU) | 29 | 17 | 28 | 9 |
| Breakdown time (min) | 11.3 | 14.0 | 10.3 | 24.3 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 174 | 114 | 137 | 145 |
| L(mm): Extensibility | 30 | 66 | 61 | 69 |
| G(mm): Swelling index | 12.2 | 18.0 | 17.3 | 18.4 |
| W($10^{-4}$ J): strength (curve area) | 244 | 309 | 340 | 405 |
| P/L: curve configuration ratio | 5.80 | 1.73 | 2.25 | 2.10 |
| Ie($P_{200}$/P): elasticity index | 0 | 64.6 | 62.3 | 63.7 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 817/1135/1268 | 866/1491/1586 | 553/735/782 | 477/852/872 |
| Extensibility (mm at 45/90/135 min) | 127/101/92 | 129/87/83 | 151/141/134 | 141/125/112 |
| Energy ($cm^2$ at 45/90/135 min) | 176/159/154 | 191/161/154 | 165/182/181 | 118/172/141 |
| Resist $_{max}$ (BU at 45/90/135min) | 1130/1337/1442 | 1251/1638/1638 | 881/1065/1126 | 655/1193/1062 |
| Ratio (at 45/90/135 min) | 6.5/11.3/13.7 | 6.7/17.1/19.1 | 3.7/5.2/5.8 | 3.4/6.8/7.8 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 2*, 7+9, 5+10 | 2*, 7+8, 5+10 | 2*, 7+8, 5+10 | 2*, $7^{OE}$+8, 5+10 |
| TPP/TMP | 0.86 | 1.08 | 1.05 | 0.85 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 66.4 | 65.7 | 64.6 | 57.0 |

# Southern Growout: Physical Dough Tests and Gluten Analysis 2023 (Small-Scale) Samples (continued)

| Test Entry Number | 23-2405 | 23-2406 | 23-2407 | 23-2408 |
|---|---|---|---|---|
| Sample Identification | OK15MASBx7 ARS8-19-18-4_OK | OK16107123-19-9_OK | OK19225_OK | LCH19DH-152-6_LM |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 71.0 | 69.5 | 68.7 | 66.1 |
| Flour Abs (14% mb) | 69.0 | 67.4 | 67.0 | 64.3 |
| Mix Time (min) | 10.1 | 3.3 | 4.0 | 5.1 |
| Mix tolerance (0-6) | 6 | 3 | 4 | 4 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 70.6 | 72.1 | 67.3 | 62.1 |
| Flour Abs (14% mb) | 68.5 | 69.9 | 65.7 | 60.4 |
| Peak time (min) | 40.6 | 6.0 | 3.9 | 4.2 |
| Mix stability (min) | 52.3 | 8.7 | 12.4 | 11.2 |
| Mix Tolerance Index (FU) | 8 | 27 | 16 | 13 |
| Breakdown time (min) | 54.6 | 12.1 | 12.0 | 12.7 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 195 | 164 | 144 | 104 |
| L(mm): Extensibility | 47 | 63 | 87 | 109 |
| G(mm): Swelling index | 15.2 | 17.6 | 20.7 | 23.2 |
| W($10^{-4}$ J): strength (curve area) | 400 | 370 | 453 | 376 |
| P/L: curve configuration ratio | 4.15 | 2.60 | 1.66 | 0.95 |
| Ie($P_{200}$/P): elasticity index | 63.4 | 51.5 | 61.7 | 60.3 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 771/1263/1386 | 312/330/336 | 361/462/494 | 474/588/695 |
| Extensibility (mm at 45/90/135 min) | 150/123/119 | 136/146/144 | 147/146/142 | 144/141/131 |
| Energy ($cm^2$ at 45/90/135 min) | 229/238/235 | 70/83/85 | 98/122/124 | 114/142/151 |
| Resist $_{max}$ (BU at 45/90/135min) | 1274/1638/1638 | 374/423/444 | 528/677/705 | 615/787/932 |
| Ratio (at 45/90/135 min) | 5.1/10.3/11.6 | 2.3/2.3/2.3 | 2.5/3.2/3.5 | 3.3/4.2/5.3 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 2*, $7^{OE}$+8, 5+10 | 1, 7+8, 5+10 | 1, 7+8, 5+10 | Null,7+9,5+10 |
| TPP/TMP | 0.91 | 0.88 | 0.93 | 1.02 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 65.6 | 58.7 | 65.4 | 62.4 |

# Southern Growout: Physical Dough Tests and Gluten Analysis 2023 (Small-Scale) Samples (continued)

| Test Entry Number | 23-2409 | 23-2410 | 23-2411 | 23-2412 |
|---|---|---|---|---|
| Sample Identification | LCH16ACC421-64_LM | KS16DH0010-17_KM | KS19H10_KH | XF4412_WB |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 67.6 | 67.4 | 68.1 | 66.7 |
| Flour Abs (14% mb) | 65.9 | 66.2 | 66.4 | 65.0 |
| Mix Time (min) | 8.8 | 3.6 | 5.1 | 3.3 |
| Mix tolerance (0-6) | 6 | 3 | 4 | 3 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 62.7 | 64.0 | 69.5 | 65.5 |
| Flour Abs (14% mb) | 61.0 | 62.7 | 67.8 | 63.9 |
| Peak time (min) | 4.0 | 5.8 | 5.3 | 5.8 |
| Mix stability (min) | 18.7 | 13.0 | 13.8 | 10.2 |
| Mix Tolerance Index (FU) | 21 | 17 | 13 | 24 |
| Breakdown time (min) | 11.4 | 14.1 | 14.4 | 11.4 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 130 | 124 | 188 | 140 |
| L(mm): Extensibility | 59 | 90 | 47 | 77 |
| G(mm): Swelling index | 17.1 | 21.1 | 15.2 | 19.5 |
| W($10^{-4}$ J): strength (curve area) | 331 | 404 | 379 | 383 |
| P/L: curve configuration ratio | 2.20 | 1.38 | 4.00 | 1.82 |
| Ie($P_{200}$/P): elasticity index | 67.1 | 61.5 | 59.6 | 57.0 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 708/1132/1341 | 390/499/509 | 454/513/533 | 412/490/481 |
| Extensibility (mm at 45/90/135 min) | 141/110/104 | 166/181/159 | 147/146/145 | 144/139/137 |
| Energy ($cm^2$ at 45/90/135 min) | 175/189/184 | 130/181/158 | 125/139/137 | 104/117/109 |
| Resist $_{max}$ (BU at 45/90/135min) | 970/1480/1540 | 618/782/830 | 655/803/795 | 549/658/625 |
| Ratio (at 45/90/135 min) | 5.0/10.3/12.9 | 2.4/2.8/3.2 | 3.1/3.5/3.7 | 2.9/3.5/3.5 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 2*, 7+8, 5+10 | 1, 7+8, 5+10 | 2*, 7+9, 5+10 | 2*,7+8,5+10 |
| TPP/TMP | 0.93 | 0.98 | 0.86 | 0.95 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 69.3 | 64.2 | 59.0 | 59.0 |

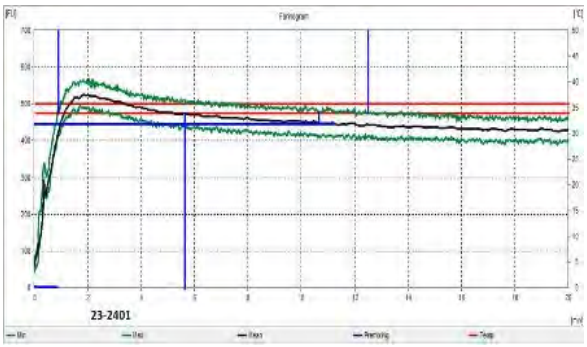
# Southern Growout: Physical Dough Tests and Gluten Analysis 2023 (Small-Scale) Samples (continued)

| Test Entry Number | 23-2413 | 23-2414 | 23-2415 | 23-2416 |
|---|---|---|---|---|
| Sample Identification | XF4402_WB | WB4422_WB | TX18A001119_TX | TX18A001132_TX |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 67.9 | 68.4 | 69.2 | 67.0 |
| Flour Abs (14% mb) | 66.0 | 67.2 | 67.5 | 65.9 |
| Mix Time (min) | 5.8 | 3.5 | 6.4 | 6.5 |
| Mix tolerance (0-6) | 4 | 3 | 5 | 5 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 70.4 | 70.1 | 73.4 | 69.0 |
| Flour Abs (14% mb) | 68.6 | 68.9 | 71.8 | 68.0 |
| Peak time (min) | 4.8 | 7.4 | 3.9 | 3.8 |
| Mix stability (min) | 11.8 | 12.9 | 7.2 | 11.3 |
| Mix Tolerance Index (FU) | 20 | 16 | 32 | 23 |
| Breakdown time (min) | 11.7 | 16.1 | 7.9 | 11.0 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 195 | 158 | 224 | 192 |
| L(mm): Extensibility | 38 | 70 | 45 | 36 |
| G(mm): Swelling index | 13.7 | 18.6 | 14.9 | 13.3 |
| W($10^{-4}$ J): strength (curve area) | 327 | 384 | 433 | 285 |
| P/L: curve configuration ratio | 5.13 | 2.26 | 4.98 | 5.33 |
| Ie($P_{200}$/P): elasticity index | 0.0 | 52.7 | 56.8 | 0.0 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 568/727/743 | 332/413/413 | 544/717/871 | 602/969/1112 |
| Extensibility (mm at 45/90/135 min) | 121/124/110 | 144/157/144 | 134/125/97 | 132/113/85 |
| Energy ($cm^2$ at 45/90/135 min) | 111/144/113 | 83/117/104 | 124/139/117 | 137/165/122 |
| Resist $_{max}$ (BU at 45/90/135min) | 708/929/857 | 425/558/567 | 739/918/1065 | 831/1280/1270 |
| Ratio (at 45/90/135 min) | 4.7/5.9/6.8 | 2.3/2.6/2.9 | 4.1/5.7/9.0 | 4.6/8.6/13.2 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 2*, 7+8, 5+10 | 1, 7+8, 5+10 | 2*, 7+8, 5+10 | 2*,7+9,5+10 |
| TPP/TMP | 1.01 | 0.93 | 0.95 | 0.99 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 61.8 | 53.4 | 64.9 | 65.3 |

# Physical Dough Tests – Farino and Mixo

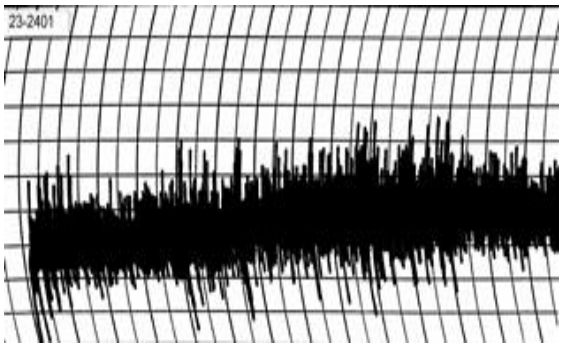
## 2023 (Small Scale) Samples – Southern Growout

### Farinograms



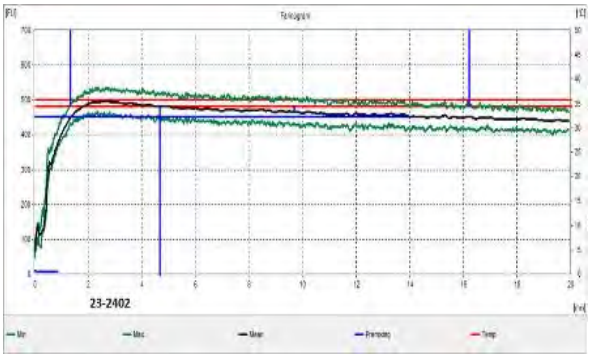

Water abs = 62.2%, Peak time = 5.7 min,
Mix stab = 11.6 min, MTI = 29 FU

### Mixograms

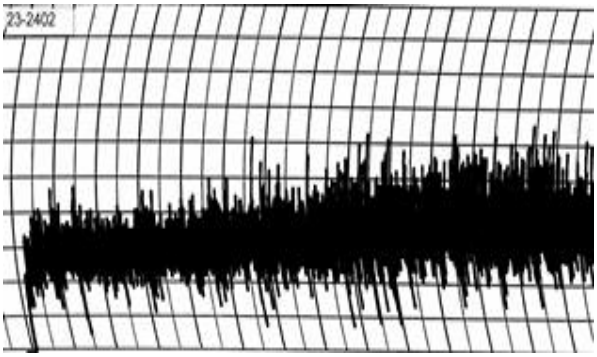



Water abs = 64.7%
Mix time = 8.9 min

### 23-2401, SY Monument_CK




Water abs = 59.9%, Peak time = 4.7 min,
Mix stab = 14.9 min, MTI = 17 FU



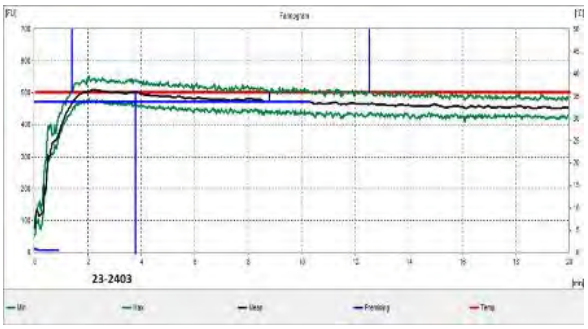

Water abs = 65.1%
Mix time = 10.6 min

### 23-2402, CO18035RA_CO

# Physical Dough Tests – Farino and Mixo

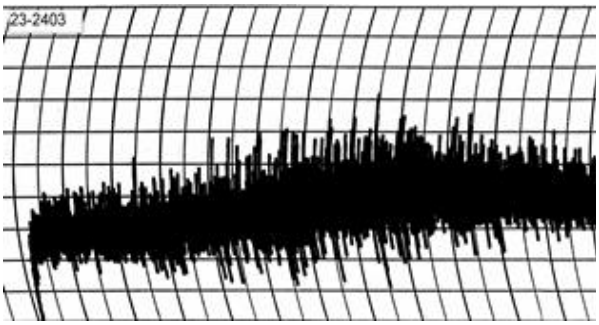
## 2023 (Small Scale) Samples – Southern Growout (Continued)

### Farinograms



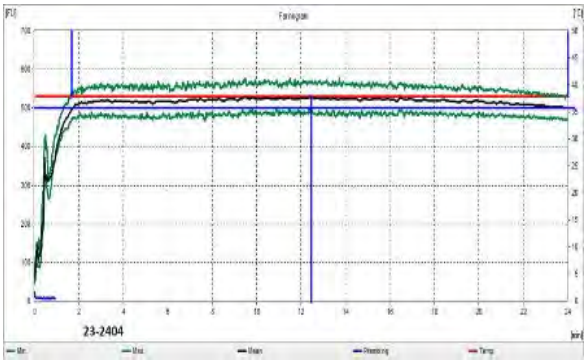

Water abs = 62.1%, Peak time = 3.8 min,
Mix stab = 11.1 min, MTI = 28 FU

### Mixograms

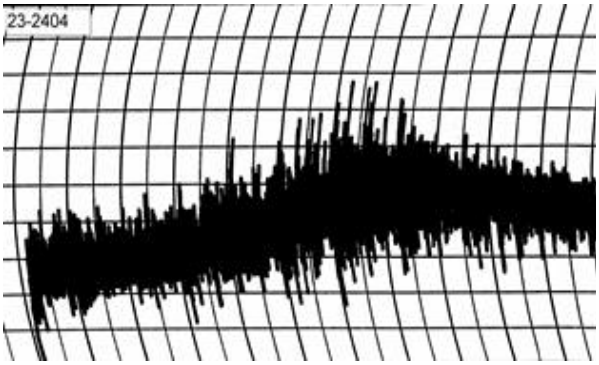



Water abs = 66.0%
Mix time = 8.1 min

## 23-2403, CO18042RA_CO




Water abs = 63.1%, Peak time = 12.5 min,
Mix stab = 22.4 min, MTI = 9 FU



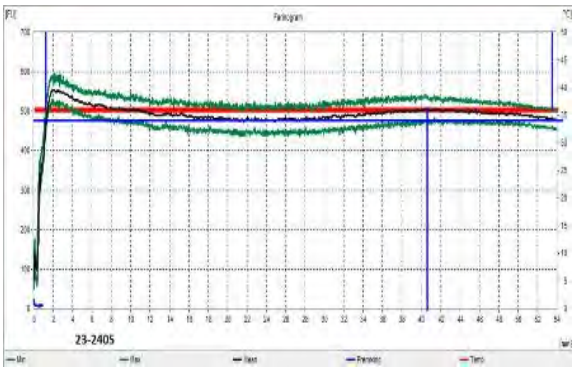

Water abs = 66.3%
Mix time = 6.6 min

## 23-2404, CO18D007W_CO

# Physical Dough Tests – Farino and Mixo

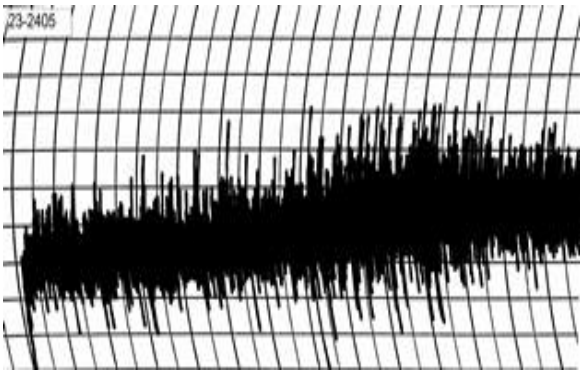
## 2023 (Small Scale) Samples – Southern Growout (Continued)

### Farinograms



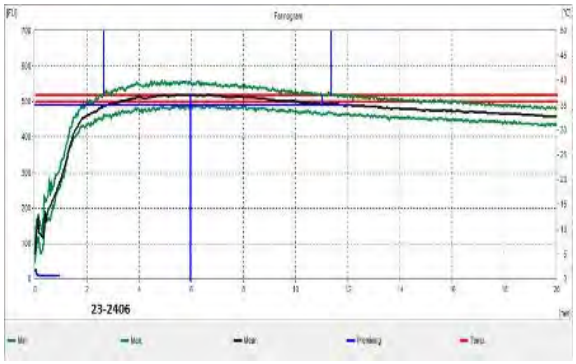

Water abs = 68.5%, Peak time = 40.6 min,
Mix stab = 52.3 min, MTI = 8 FU

### Mixograms

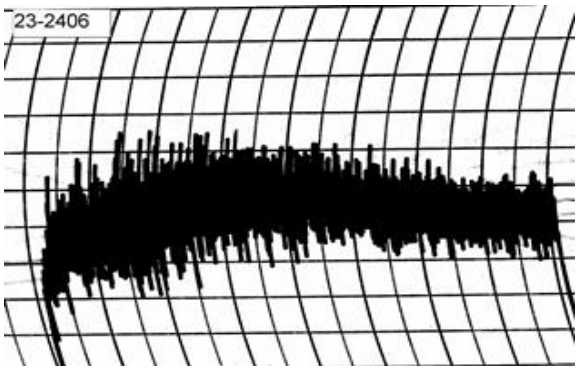



Water abs = 69.0%
Mix time = 10.1 min

## 23-2405, OK15MASBx7 ARS 8-19-18-4_OK




Water abs = 69.9%, Peak time = 6.0 min,
Mix stab = 8.7 min, MTI = 27 FU



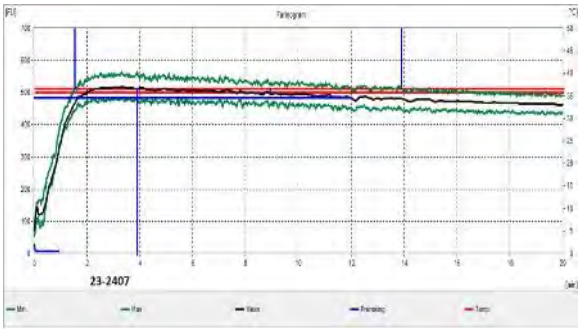

Water abs = 67.4%
Mix time = 3.3 min

## 23-2406, OK16107123-19-9_OK

# Physical Dough Tests – Farino and Mixo

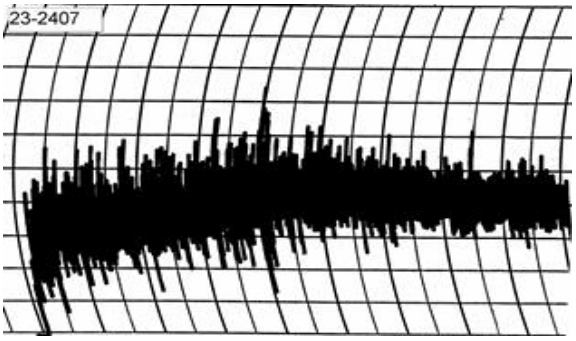
## 2023 (Small Scale) Samples – Southern Growout (Continued)

### Farinograms



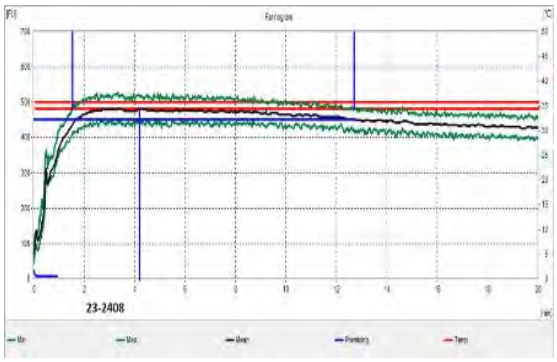

Water abs = 65.7%, Peak time = 3.9 min,
Mix stab = 12.4 min, MTI = 16 FU

### Mixograms

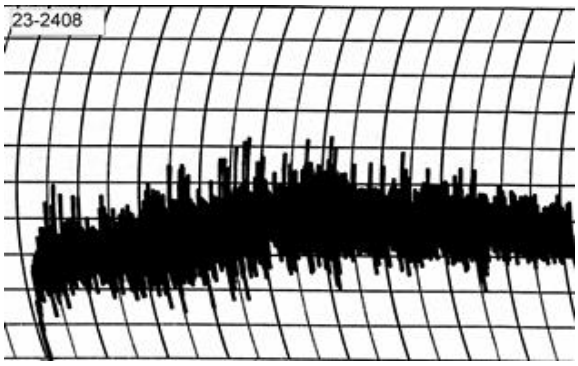



Water abs = 67.0%
Mix time = 4.0 min

## 23-2407, OK19225_OK




Water abs = 60.4%, Peak time = 4.2 min,
Mix stab = 11.2 min, MTI = 13 FU

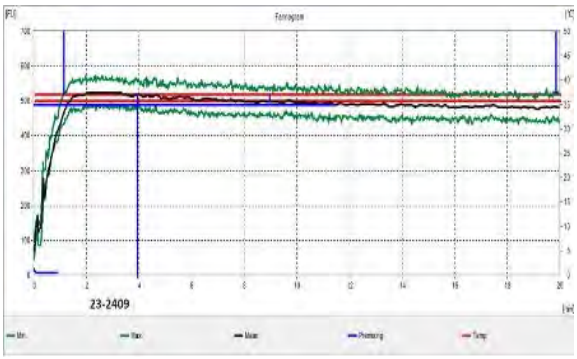



Water abs = 64.3%
Mix time = 5.1 min

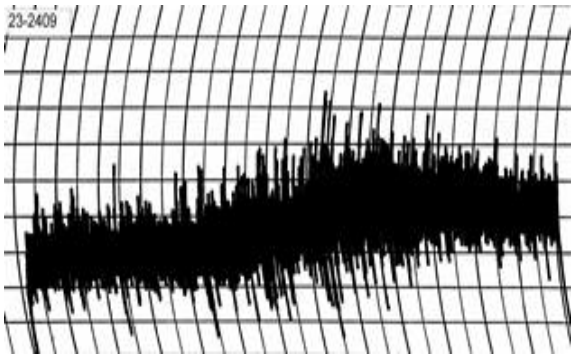
## 23-2408, LCH19DH-152-6_LM

# Physical Dough Tests – Farino and Mixo

## 2023 (Small Scale) Samples – Southern Growout (Continued)

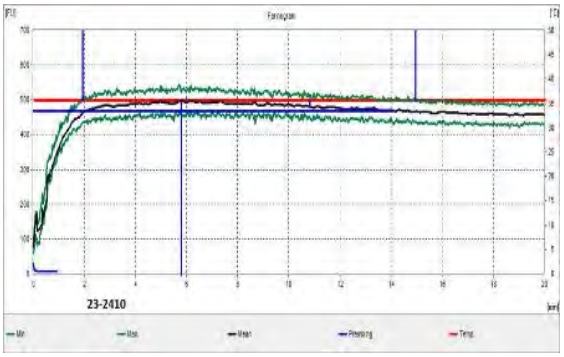



Water abs = 61.0%, Peak time = 4.0 min,
Mix stab = 18.7 min, MTI = 21 FU

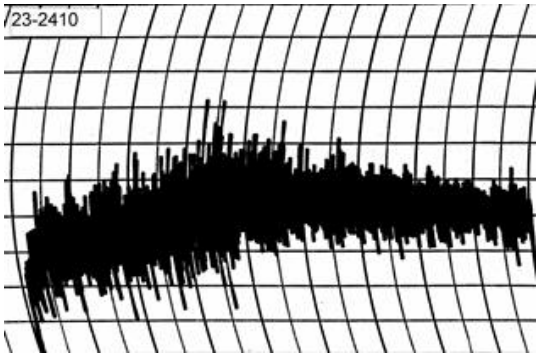



Water abs = 65.9%
Mix time = 8.8 min

### 23-2409, LCH16ACC421-64_LM




Water abs = 62.7%, Peak time = 5.8 min,
Mix stab = 13.0 min, MTI = 17 FU

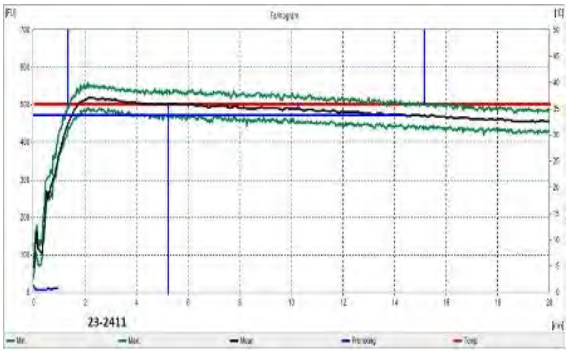



Water abs = 66.2%
Mix time = 3.6 min

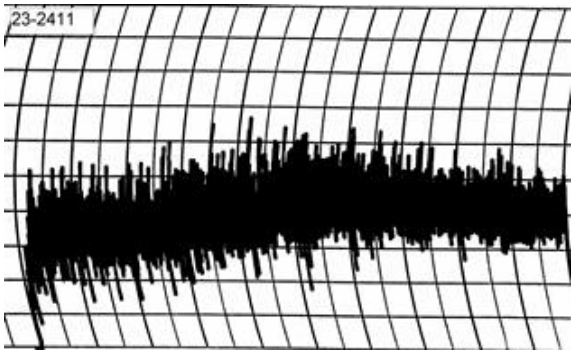
### 23-2410, KS16DH0010-17_KM

# Physical Dough Tests – Farino and Mixo

## 2023 (Small Scale) Samples – Southern Growout (Continued)

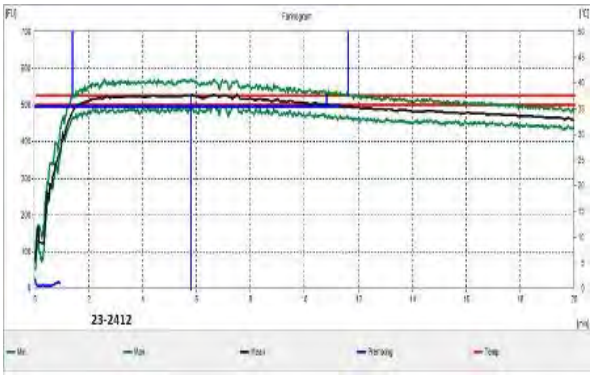



Water abs = 67.8%, Peak time = 5.3 min,
Mix stab = 13.8 min, MTI = 13 FU

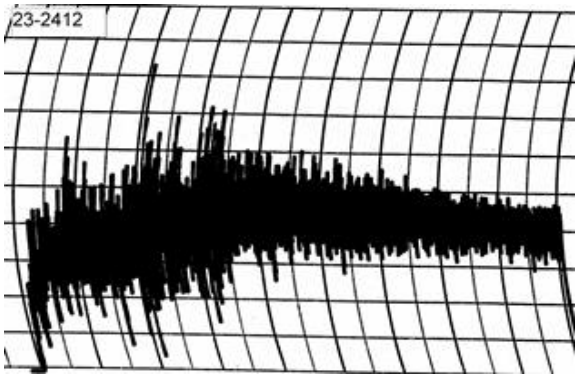



Water abs = 66.4%
Mix time = 5.1 min

### 23-2411, KS19H10_KH




Water abs = 63.9%, Peak time = 5.8 min,
Mix stab = 10.2 min, MTI = 24 FU

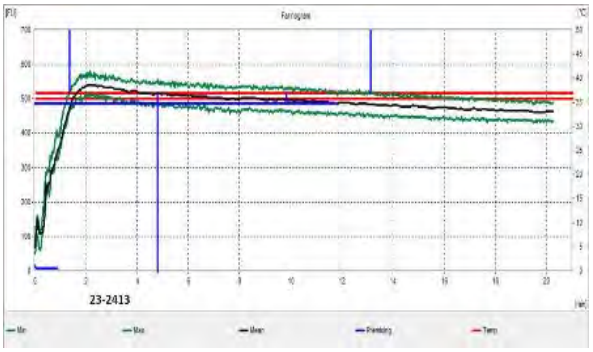



Water abs = 65.0%
Mix time = 3.3 min

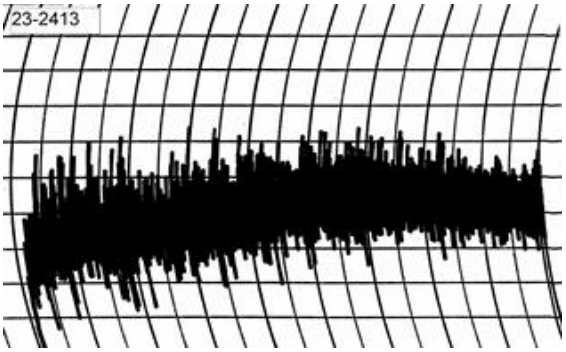
### 23-2412, XF4412_WB

# Physical Dough Tests – Farino and Mixo

## 2023 (Small Scale) Samples – Southern Growout (Continued)

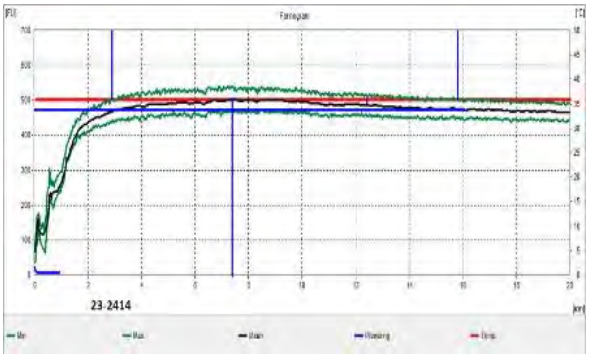



Water abs = 68.6%, Peak time = 4.8 min,
Mix stab = 11.8 min, MTI = 20 FU

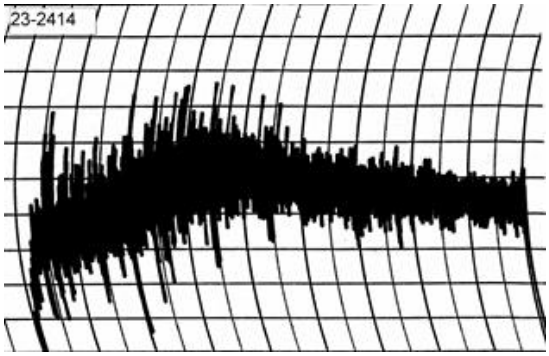



Water abs = 66.0%
Mix time = 5.8 min

### 23-2413, XF4402_WB




Water abs = 68.9%, Peak time = 7.4 min,
Mix stab = 12.9 min, MTI = 16 FU

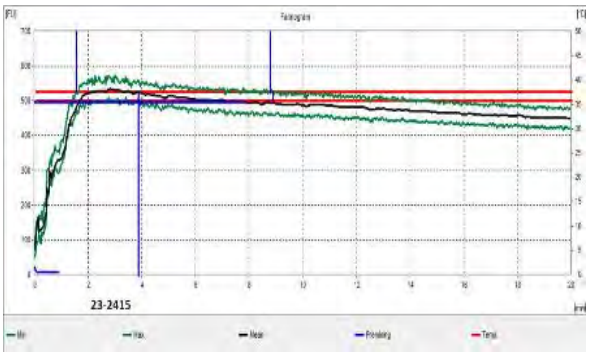



Water abs = 67.2%
Mix time = 3.5 min

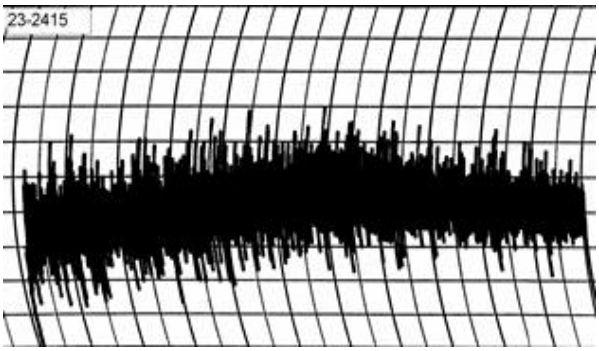
### 23-2414, WB4422_WB

# Physical Dough Tests – Farino and Mixo

## 2023 (Small Scale) Samples – Southern Growout (Continued)

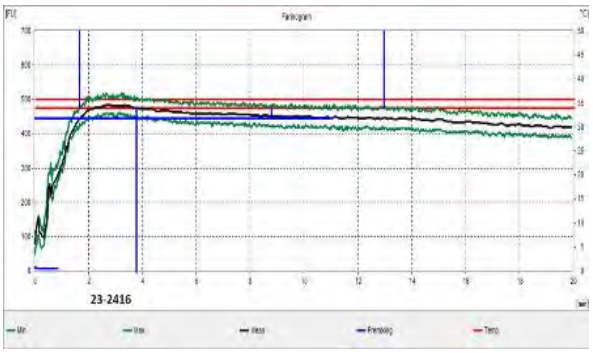



Water abs = 71.8%, Peak time = 3.9 min,
Mix stab = 7.2 min, MTI = 32 FU

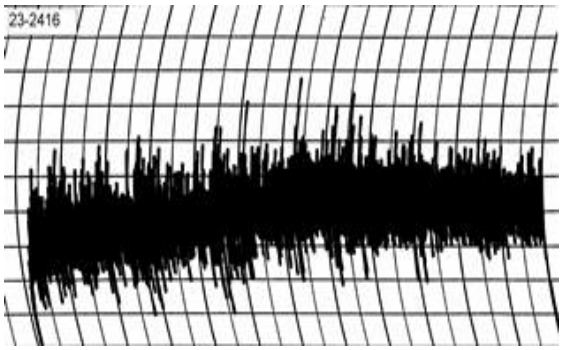



Water abs = 67.5%
Mix time = 6.4 min

### 23-2415, TX18A001119_TX




Water abs = 68.0%, Peak time = 3.8 min,
Mix stab = 11.3 min, MTI = 23 FU

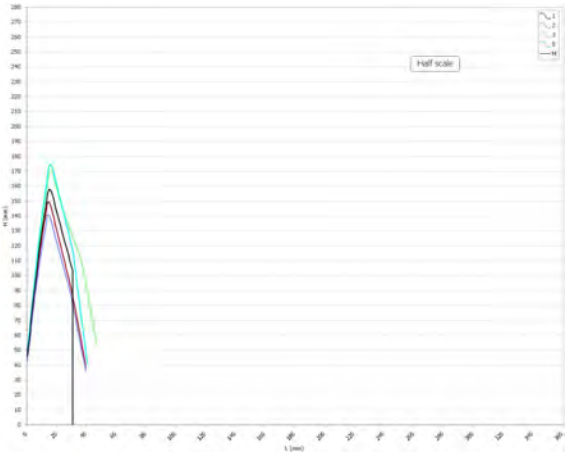



Water abs = 65.9%
Mix time = 6.5 min

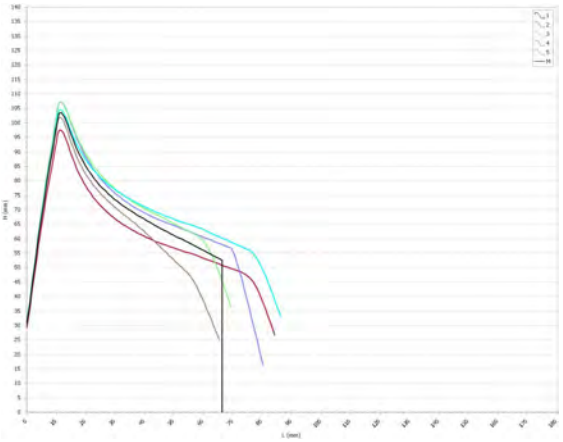
### 23-2416, TX18A001132_TX

# Physical Dough Tests - Alveograms

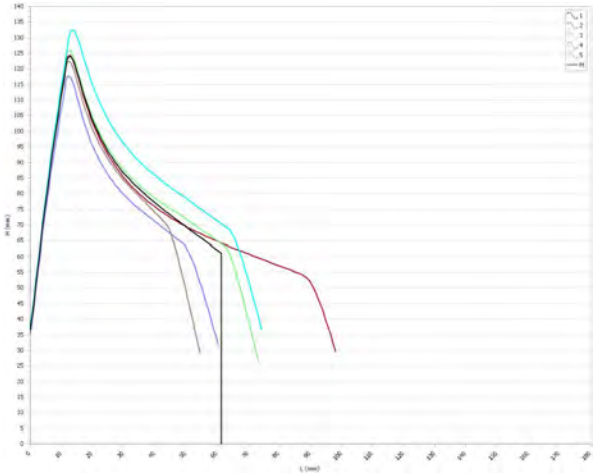
## 2023 (Small Scale) Samples – Southern Growout



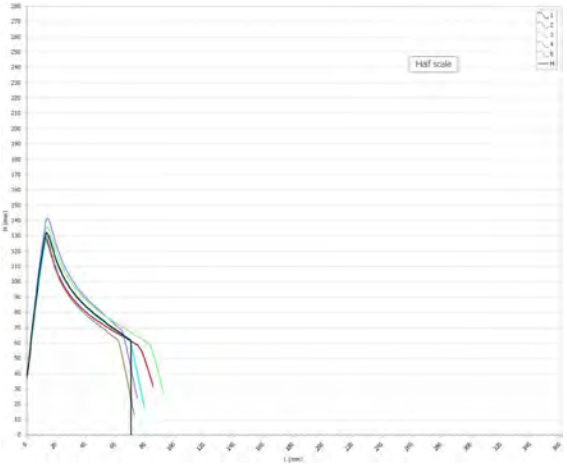

**23-2401, SY Monument_CK**
P(mm $H_20$) =174, L(mm) = 30, W($10E^{-4}$ J) = 244



**23-2402, CO18035RA_CO**
P(mm $H_20$) =114, L(mm) = 66, W($10E^{-4}$ J) = 309



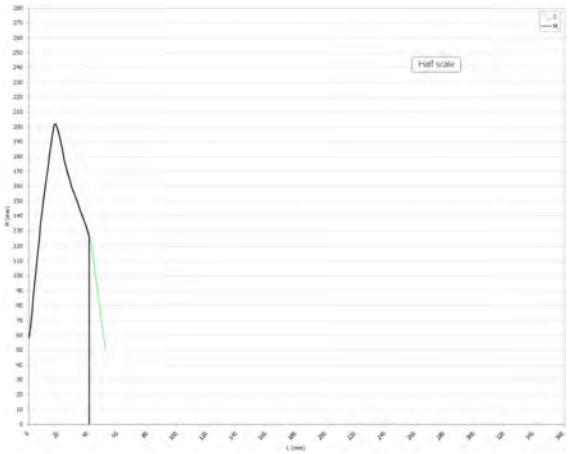
**23-2403, CO18042RA_CO**
P(mm $H_20$) = 137, L(mm) = 61, W($10E^{-4}$ J) = 340



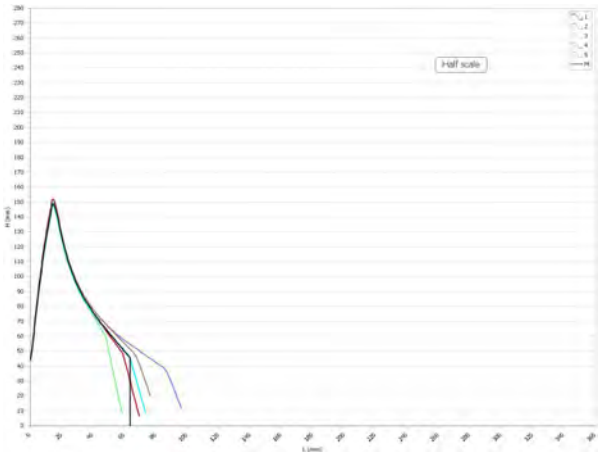

**23-2404, CO18D007W_CO**
P(mm $H_20$) =145, L(mm) = 69, W($10E^{-4}$ J) = 405

# Physical Dough Tests - Alveograms

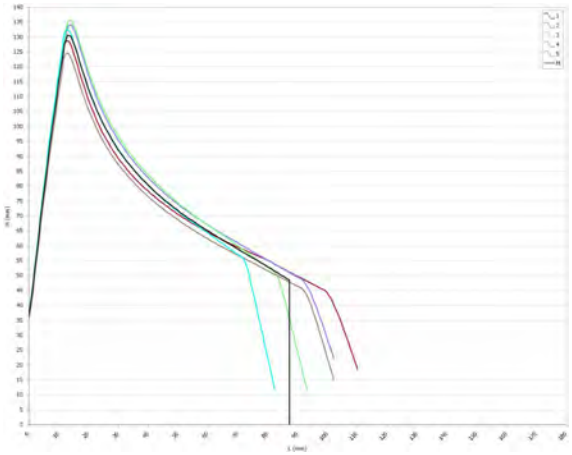
## 2023 (Small Scale) Samples – Southern Growout (Continued)



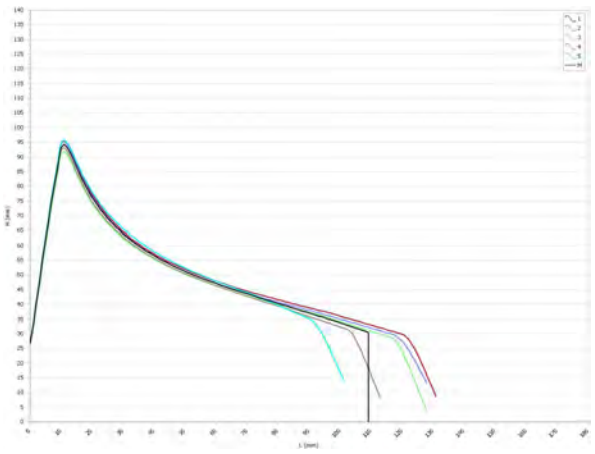
**23-2405, OK15MASBx7 ARS 8-19-18-4_OK**
P(mm $H_20$) = 195, L(mm) = 47, W($10E^{-4}$ J) = 400



**23-2406, OK16107123-19-9_OK**
P(mm $H_20$) = 164, L(mm) = 63, W($10E^{-4}$ J) = 370



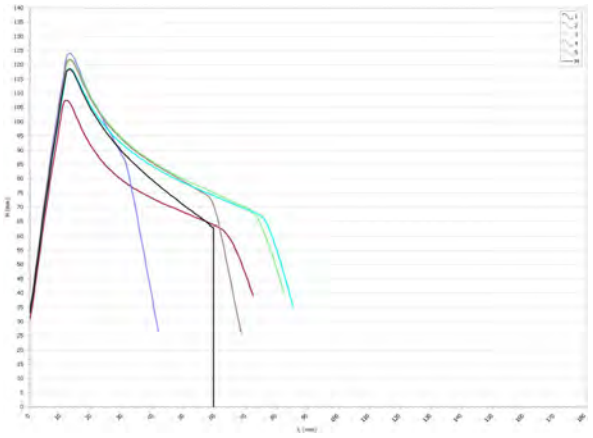
**23-2407, OK19225_OK**
P(mm $H_20$) = 144, L(mm) = 87, W($10E^{-4}$ J) = 453



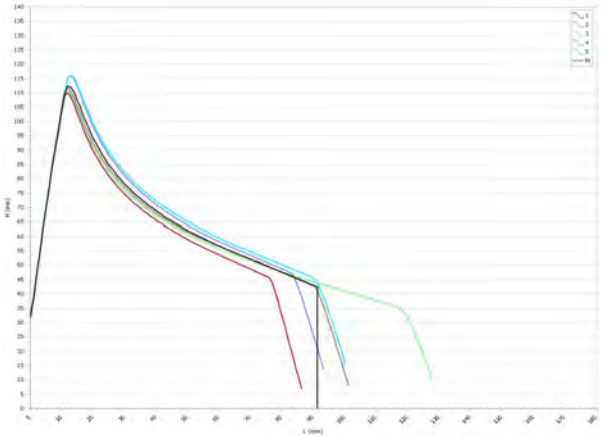
**23-2408, LCH19DH-152-6_LM**
P(mm $H_20$) = 104, L(mm) = 109, W($10E^{-4}$ J) = 376

# Physical Dough Tests - Alveograms

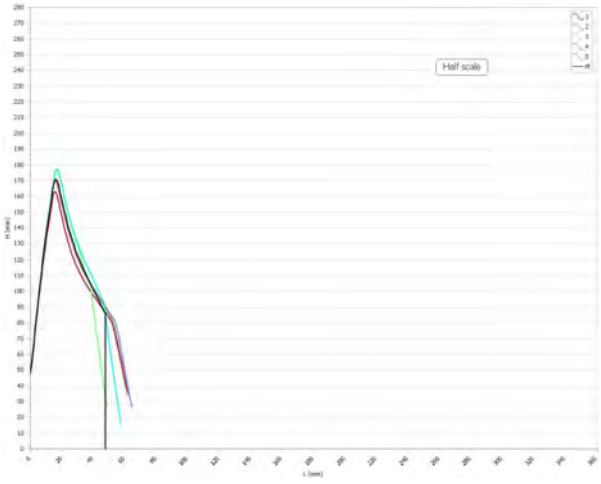
## 2023 (Small Scale) Samples – Southern Growout (Continued)



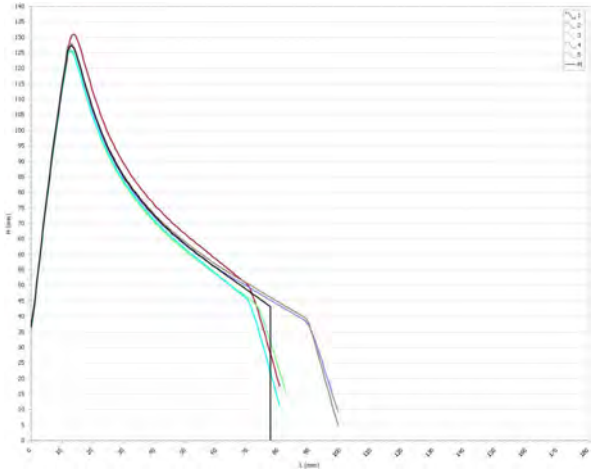
**23-2409, LCH16ACC421-64_LM**
P(mm $H_20$) = 130, L(mm) = 59, W($10E^{-4}$ J) = 331



**23-2410, KS16DH0010-17_KM**
P(mm $H_20$) = 124, L(mm) = 90, W($10E^{-4}$ J) = 404



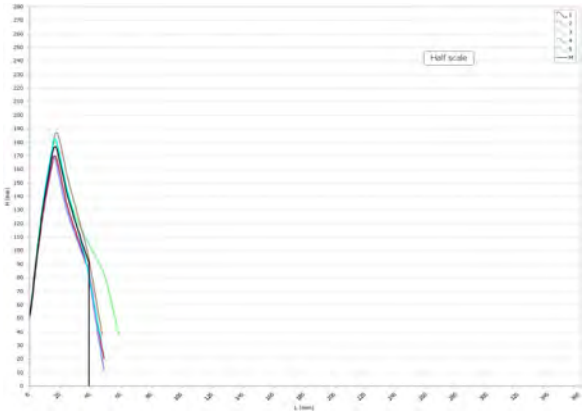

**23-2411, KS19H10_KH**
P(mm $H_20$) = 188, L(mm) = 47, W($10E^{-4}$ J) = 379



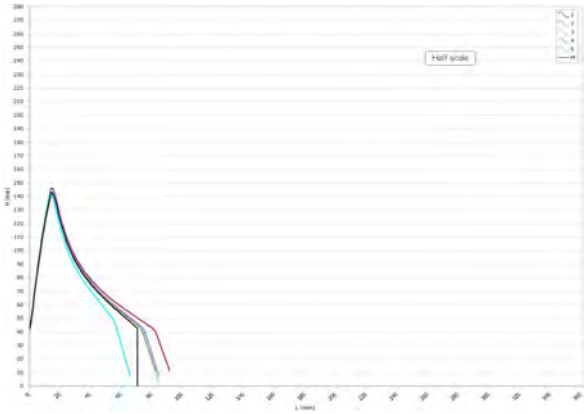
**23-2412, XF4412_WB**
P(mm $H_20$) = 140, L(mm) = 77, W($10E^{-4}$ J) = 383

# Physical Dough Tests - Alveograms

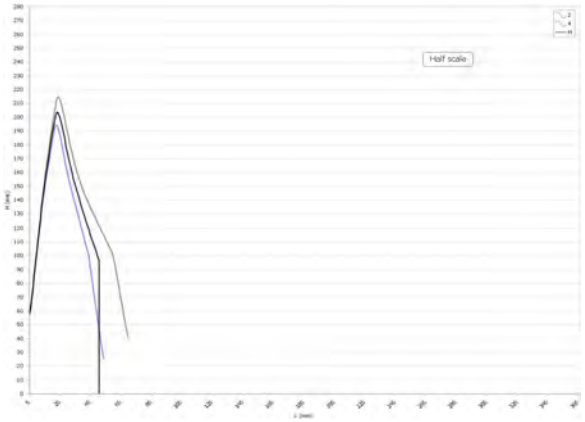
## 2023 (Small Scale) Samples – Southern Growout (Continued)



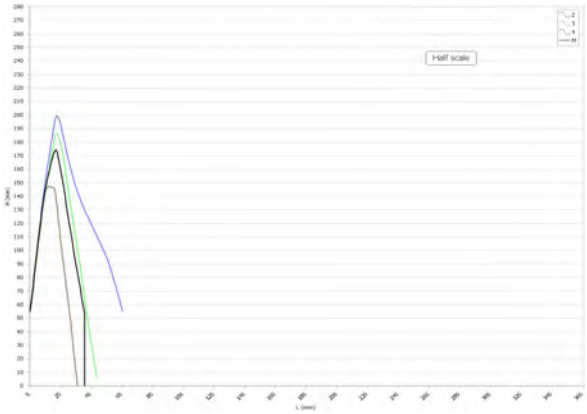

**23-2413, XF4402_WB**
P(mm $H_20$) = 195, L(mm) = 38, W(10E$^{-4}$ J) = 327




**23-2414, WB4422_WB**
P(mm $H_20$) = 158, L(mm) = 70, W(10E$^{-4}$ J) = 384



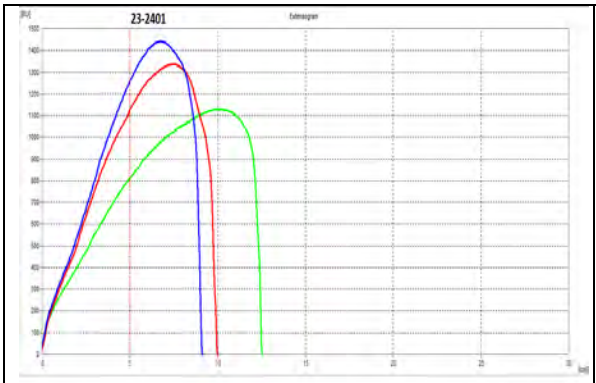

**23-2415, TX18A001119_TX**
P(mm $H_20$) = 224, L(mm) = 45, W(10E$^{-4}$ J) = 433



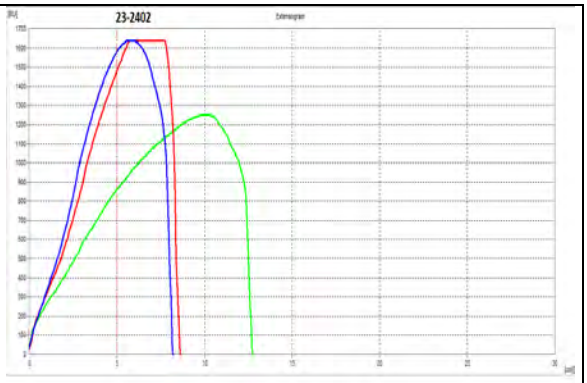

**23-2416, TX18A001132_TX**
P(mm $H_20$) = 192, L(mm) = 36, W(10E$^{-4}$ J) = 285

# Physical Dough Tests - Extensigrams

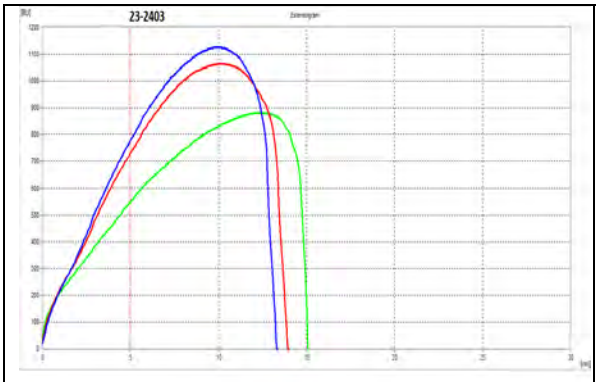
## 2023 (Small Scale) Samples – Southern Growout



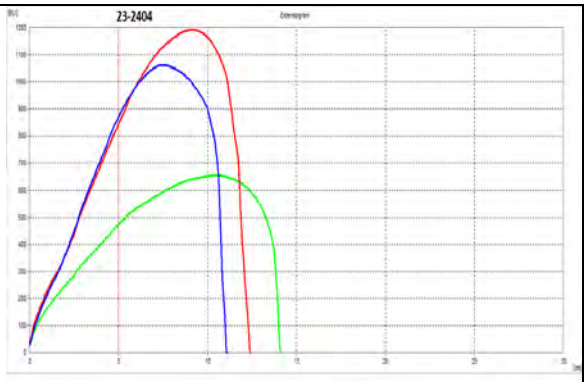

**23-2401, SY Monument_CK**
R (BU) = 1135, E (mm) = 101, W ($cm^2$) = 159
Rmax (BU) = 1337, Ratio = 11.1 at 90 min




**23-2402, CO18035RA_CO**
R (BU) = 1491, E (mm) = 87, W ($cm^2$) = 161
Rmax (BU) = 1638, Ratio = 17.1 at 90 min




**23-2403, CO18042RA_CO**
R (BU) = 735, E (mm) = 141, W ($cm^2$) = 182
Rmax (BU) = 1065, Ratio = 5.2 at 90 min

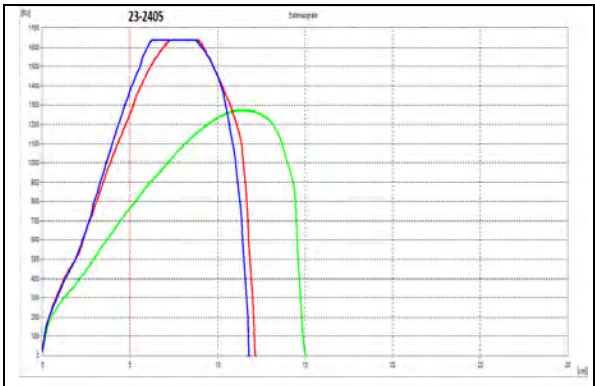



**23-2404, CO18D007W_CO**
R (BU) = 852, E (mm) = 125, W ($cm^2$) = 172
Rmax (BU) = 1193, Ratio = 6.8 at 90 min

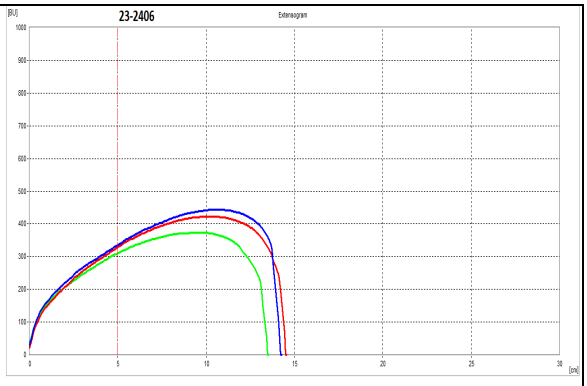
Notes: R (BU) = Resistance; E (mm) = Extensibility; W ($cm^2$) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

# Physical Dough Tests - Extensigrams

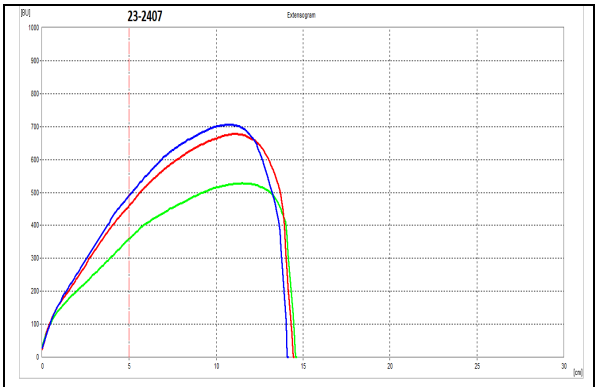
## 2023 (Small Scale) Samples – Southern Growout (Continued)



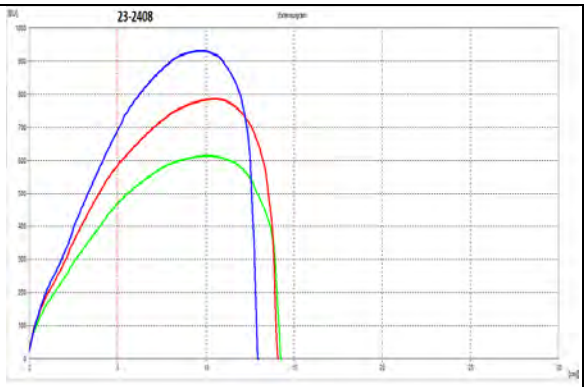

**23-2405, OK15MASBx7 ARS 8-19-18-4_OK**
R (BU) = 1263, E (mm) = 123, W ($cm^2$) = 238
Rmax (BU) = 1638, Ratio = 10.3 at 90 min




**23-2406, OK16107123-19-9_OK**
R (BU) = 330, E (mm) = 146, W ($cm^2$) = 83
Rmax (BU) = 423, Ratio = 2.3 at 90 min




**23-2407, OK19225_OK**
R (BU) = 462, E (mm) = 146, W ($cm^2$) = 122
Rmax (BU) = 677, Ratio = 3.2 at 90 min

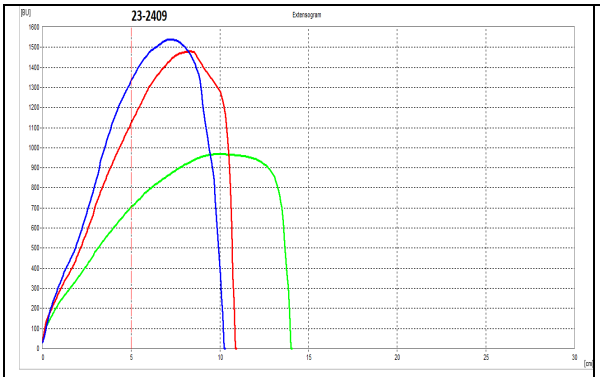



**23-2408, LCH19DH-152-6_LM**
R (BU) = 588, E (mm) = 141, W ($cm^2$) = 142
Rmax (BU) = 787, Ratio = 4.2 at 90 min

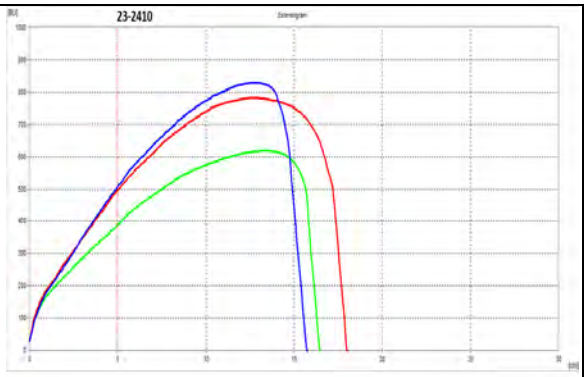
Notes: R (BU) = Resistance; E (mm) = Extensibility; W ($cm^2$) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

# Physical Dough Tests - Extensigrams

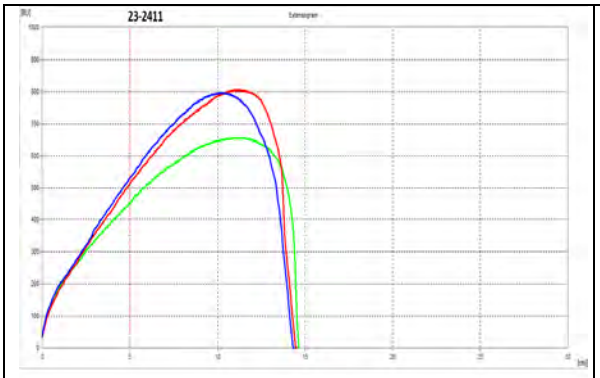
## 2023 (Small Scale) Samples – Southern Growout (Continued)



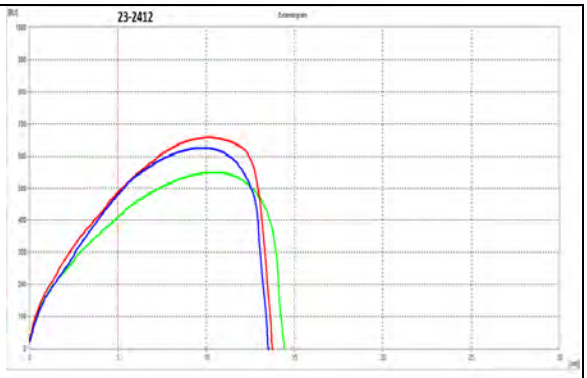

**23-2409, LCH16ACC421-64_LM**
R (BU) = 1132, E (mm) = 110, W ($cm^2$) = 189
Rmax (BU) = 1480, Ratio = 10.3 at 90 min




**23-2410, KS16DH0010-17_KM**
R (BU) = 499, E (mm) = 181, W ($cm^2$) = 181
Rmax (BU) = 782, Ratio = 2.75 at 90 min



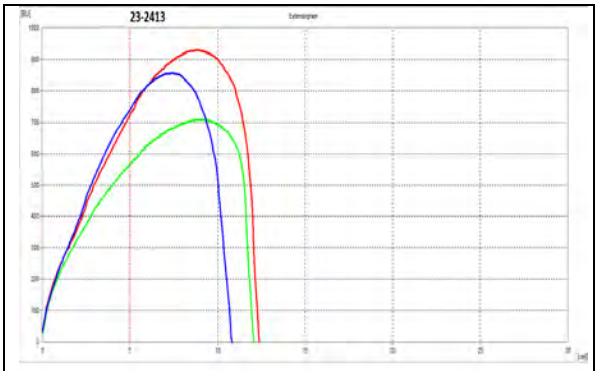

**23-2411, KS19H10_KH**
R (BU) = 513, E (mm) = 146, W ($cm^2$) = 139
Rmax (BU) = 803, Ratio = 3.5 at 90 min



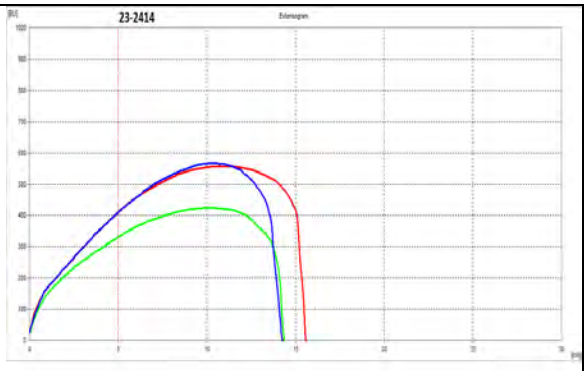

**23-2412, XF4412_WB**
R (BU) = 490, E (mm) = 139, W ($cm^2$) = 117
Rmax (BU) = 658, Ratio = 3.5 at 90 min

# Physical Dough Tests - Extensigrams

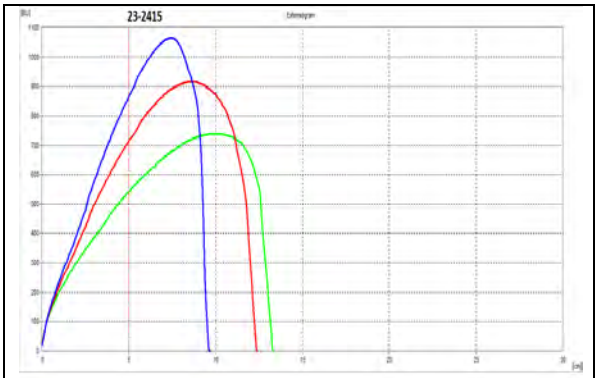
## 2023 (Small Scale) Samples – Southern Growout (Continued)



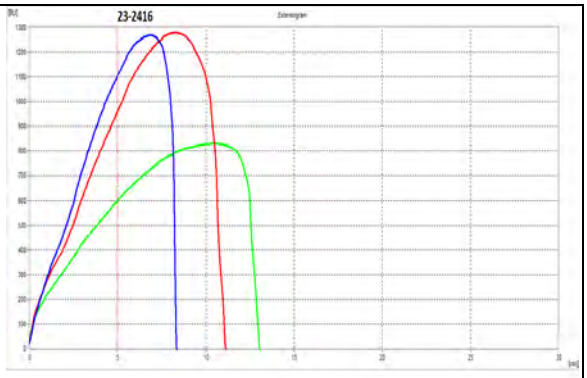

**23-2413, XF4402_WB**
R (BU) = 727, E (mm) = 124, W ($cm^2$) = 144
Rmax (BU) = 929, Ratio = 5.9 at 90 min




**23-2414, WB4422_WB**
R (BU) = 413, E (mm) = 157, W ($cm^2$) = 117
Rmax (BU) = 558, Ratio = 2.6 at 90 min

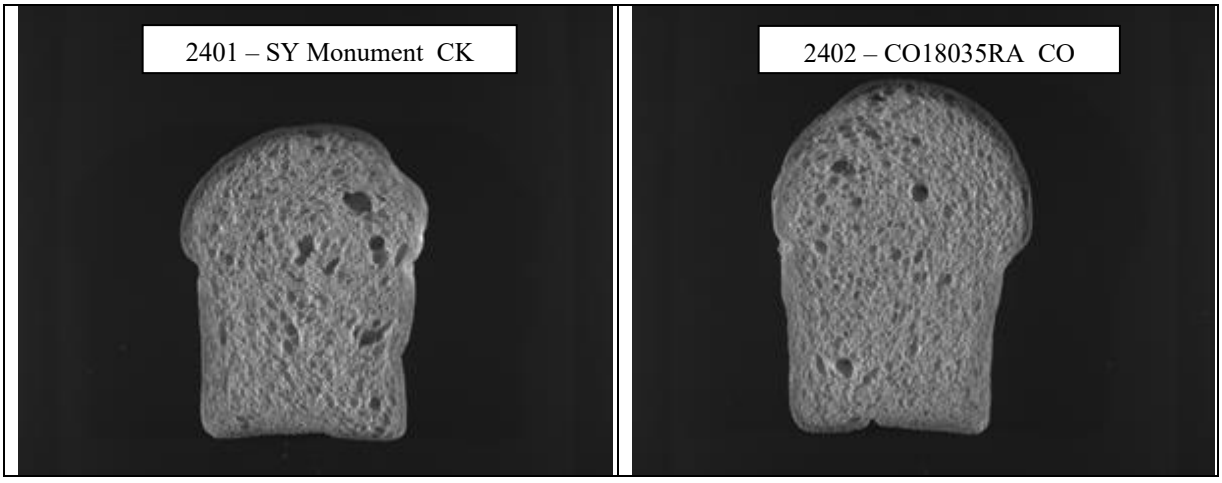



**23-2415, TX18A001119_TX**
R (BU) = 717, E (mm) = 125, W ($cm^2$) = 139
Rmax (BU) = 918, Ratio = 5.7 at 90 min

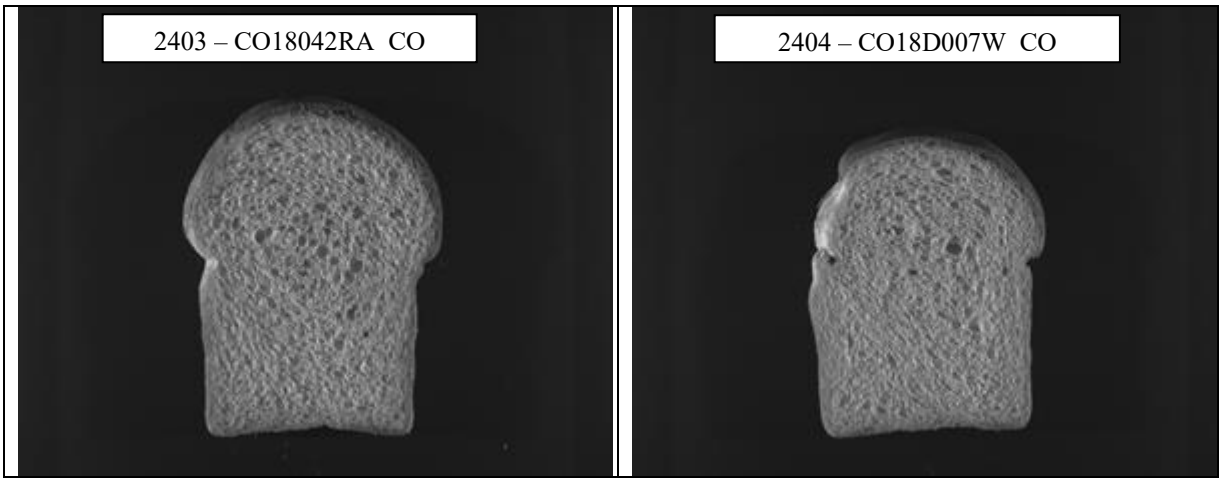



**23-2416, TX18A001132_TX**
R (BU) = 969, E (mm) = 113, W ($cm^2$) = 165
Rmax (BU) = 1280, Ratio = 8.6 at 90 min

# Southern Growout: C-Cell Bread Images and Analysis
# 2023 (Small-Scale) Samples

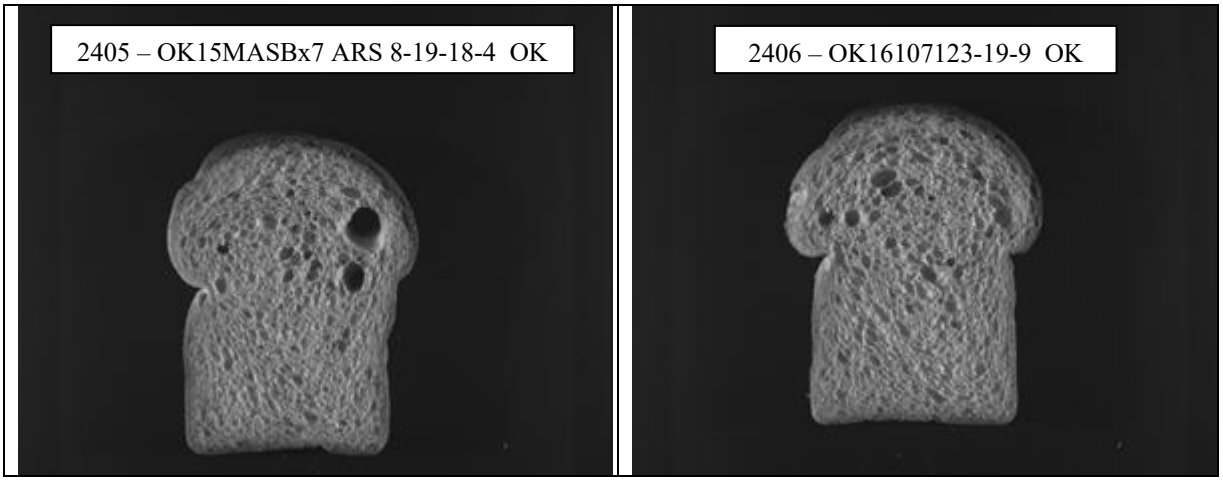



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2401** | 6237 | 113 | 3472 | 0.430 | 2.050 | 2.473 | 1.860 | 0.88 |
| **2402** | 6815 | 114 | 3845 | 0.425 | 2.033 | 0.808 | 1.835 | -0.38 |

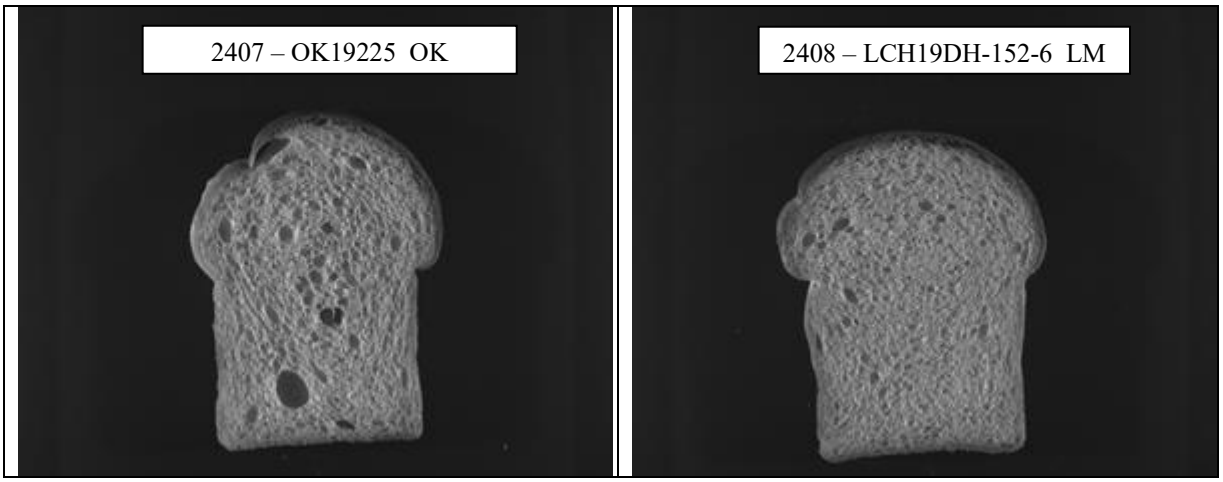



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2403** | 6808 | 113 | 3767 | 0.430 | 2.095 | 1.918 | 1.750 | -3.35 |
| **2404** | 6113 | 117 | 3657 | 0.420 | 1.893 | 3.298 | 1.768 | -3.95 |

# Southern Growout: C-Cell Bread Images and Analysis
# 2023 (Small-Scale) Samples (Continued)

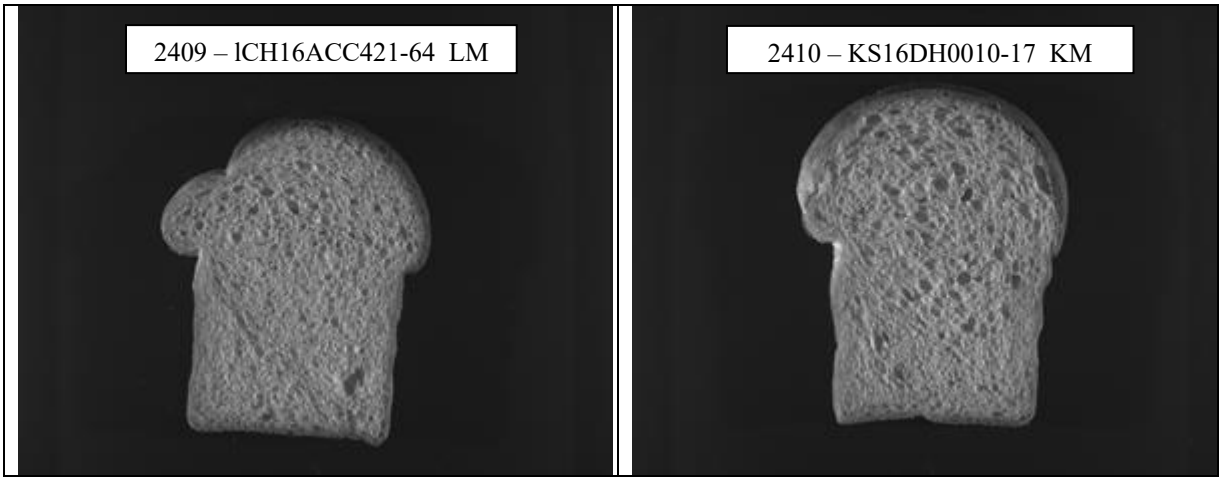



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2405** | 6437 | 111 | 3463 | 0.435 | 2.120 | 2.200 | 1.785 | -2.83 |
| **2406** | 6254 | 109 | 3280 | 0.440 | 2.255 | 6.740 | 1.635 | -5.50 |

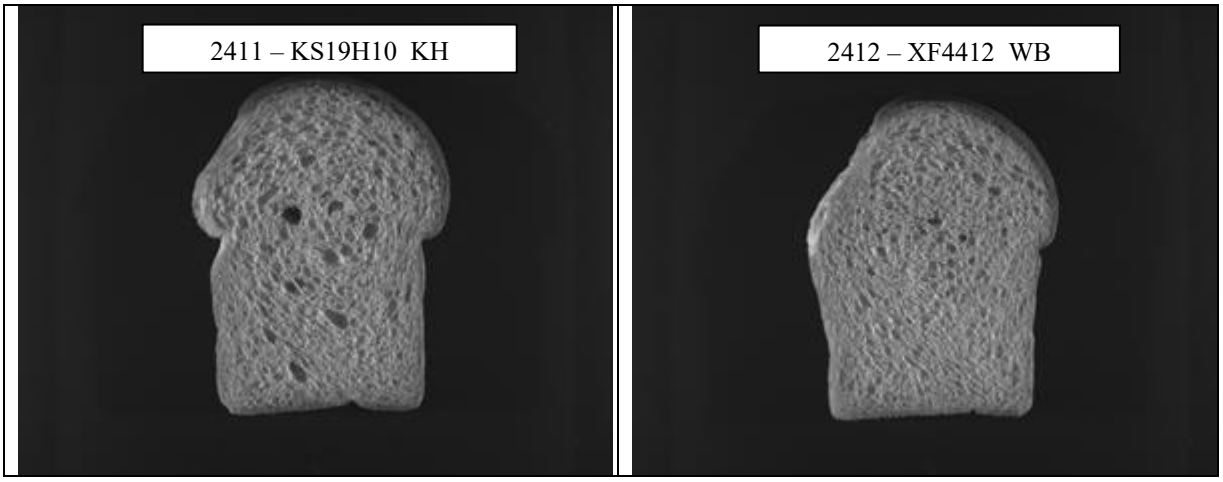



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2407** | 6424 | 116 | 3330 | 0.445 | 2.315 | 1.905 | 1.720 | -10.20 |
| **2408** | 6593 | 114 | 4038 | 0.415 | 1.890 | 0.983 | 1.778 | 4.13 |

# Southern Growout: C-Cell Bread Images and Analysis 2023 (Small-Scale) Samples (Continued)

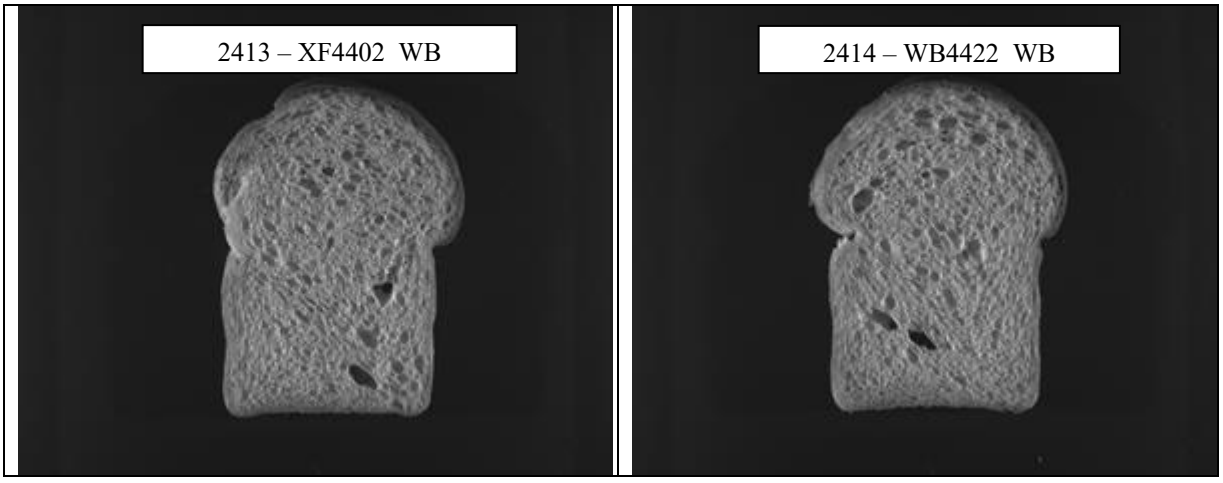



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2409** | 6885 | 114 | 4021 | 0.423 | 1.975 | 5.088 | 1.768 | -4.93 |
| **2410** | 7047 | 114 | 3976 | 0.430 | 2.080 | 2.255 | 1.745 | -9.65 |

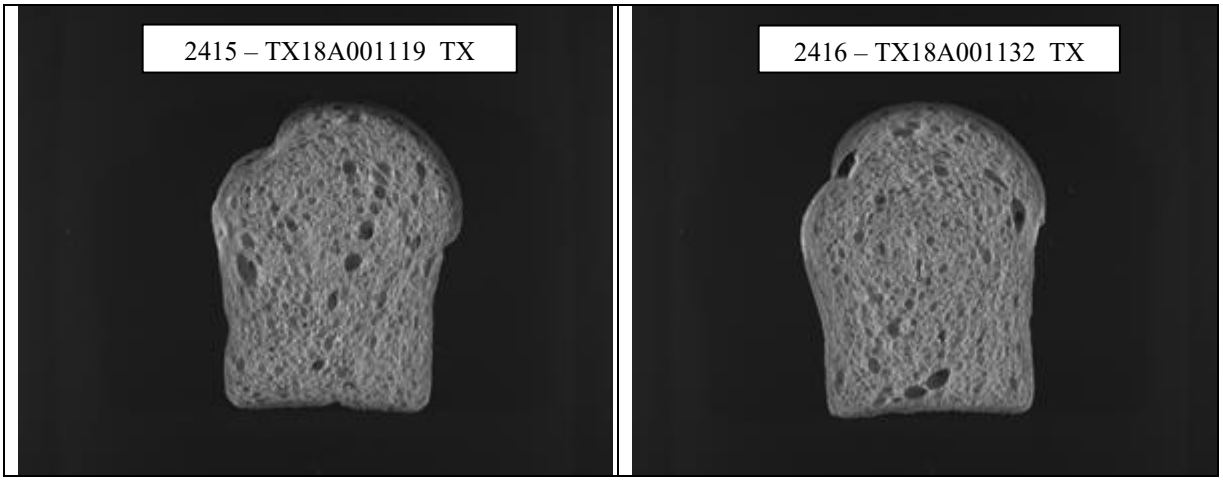



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2411** | 6612 | 112 | 3761 | 0.430 | 2.125 | 1.590 | 1.750 | -3.30 |
| **2412** | 6230 | 116 | 3955 | 0.410 | 1.895 | 1.535 | 1.720 | -9.60 |

# Southern Growout: C-Cell Bread Images and Analysis
# 2023 (Small-Scale) Samples (Continued)




| 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** | 6538 | 110 | 3766 | 0.430 | 2.065 | 7.255 | 1.700 | -8.70 |
| **2414** | 6549 | 111 | 3728 | 0.435 | 2.130 | 7.785 | 1.710 | -8.45 |

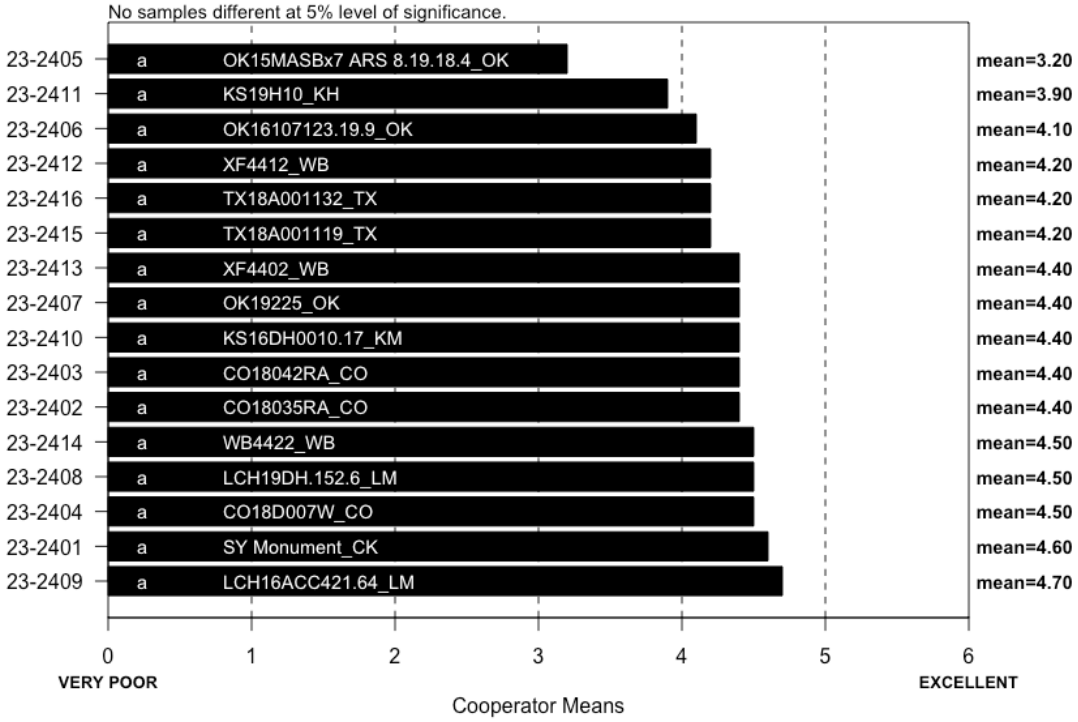



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2415** | 5943 | 110 | 3446 | 0.425 | 1.980 | 2.400 | 1.895 | 0.20 |
| **2416** | 6010 | 111 | 3702 | 0.420 | 1.885 | 1.415 | 1.860 | 0.95 |

## SPONGE CHARACTERISTICS
## (Uniform Growout) Southern

Cooperators = 5
ChiSqCalc = 7
ChiSqTab = 25
P Value = 0.957

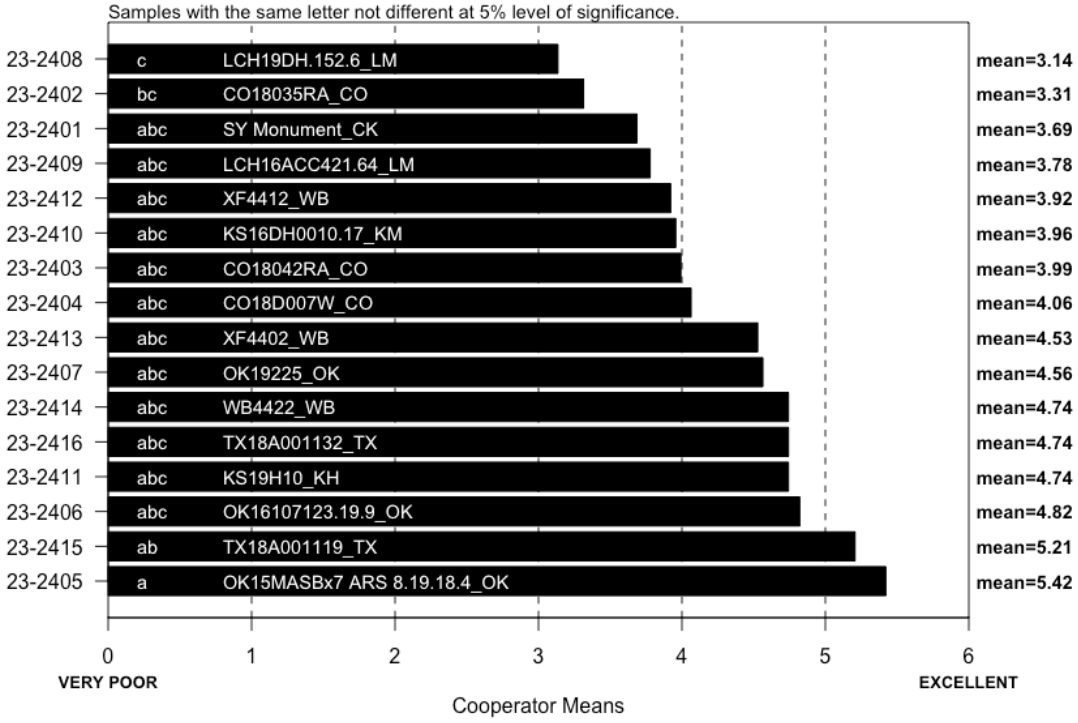
No samples different at 5% level of significance.




## BAKE ABSORPTION
## (Uniform Growout) Southern

Cooperators = 14
ChiSqCalc = 45.9
ChiSqTab = 25
P Value = <0.001

Samples with the same letter not different at 5% level of significance.

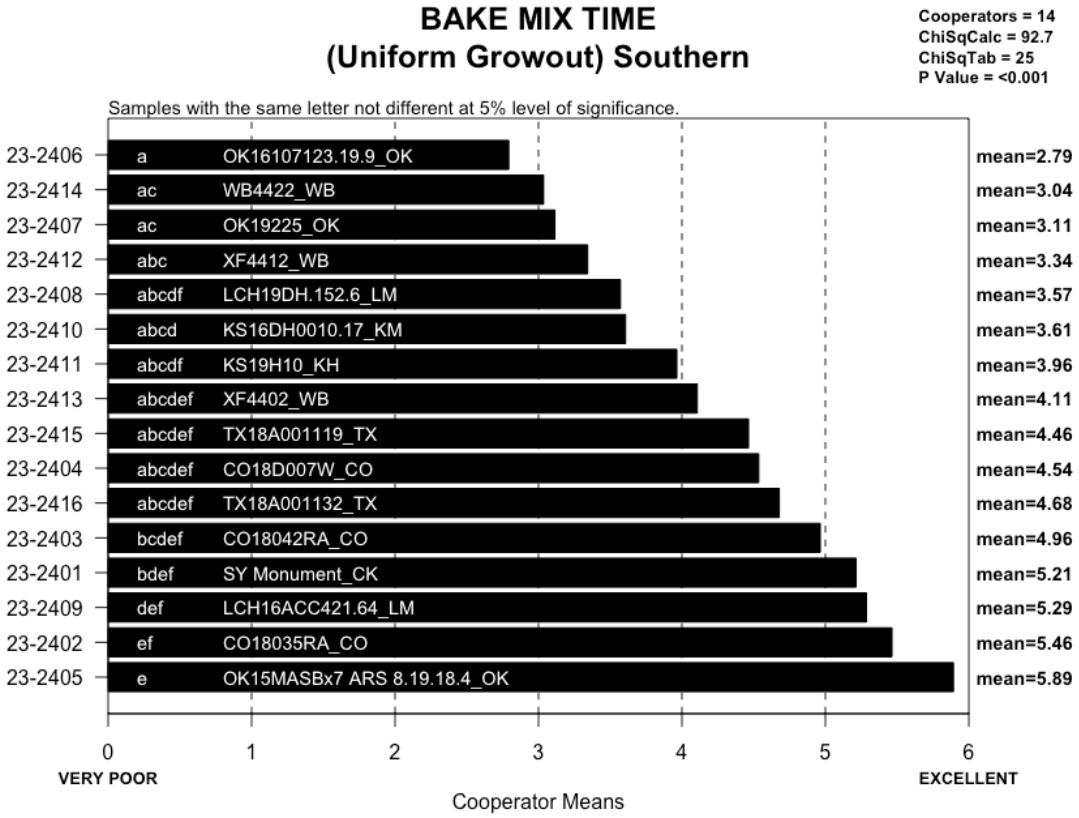


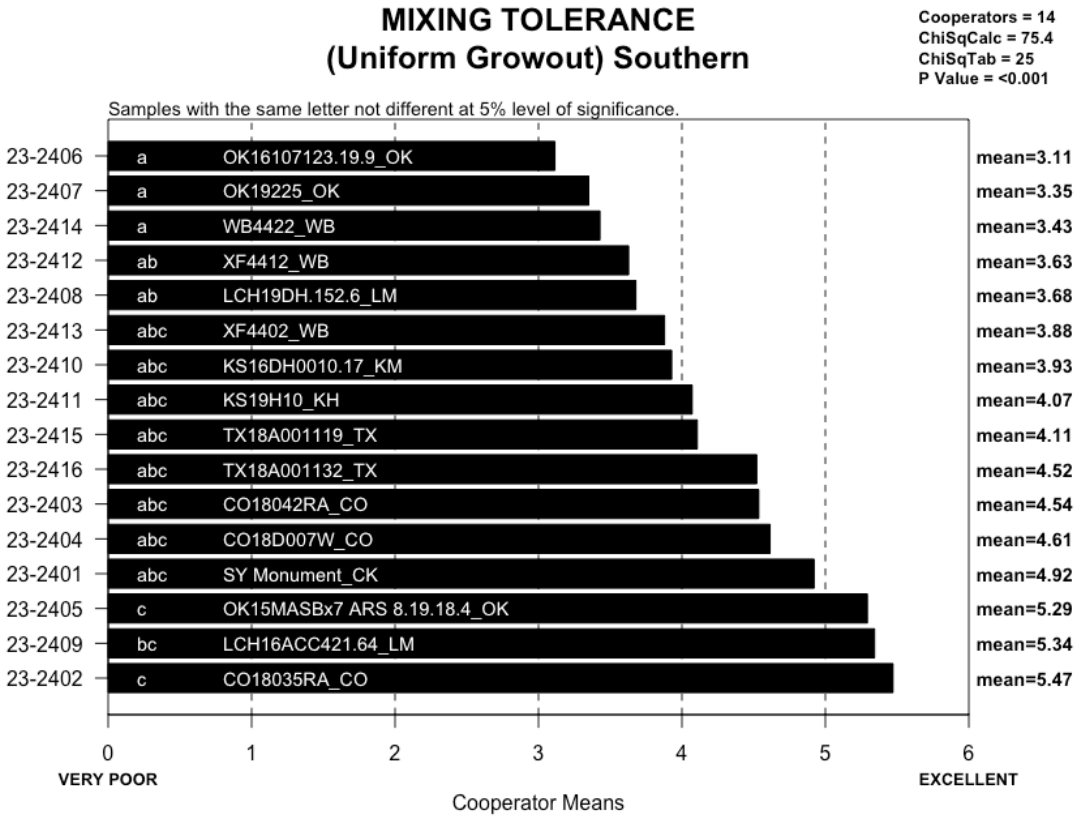
# BAKE ABSORPTION, ACTUAL (14% MB)
# (Uniform Growout) Southern
# Cooperators A – N

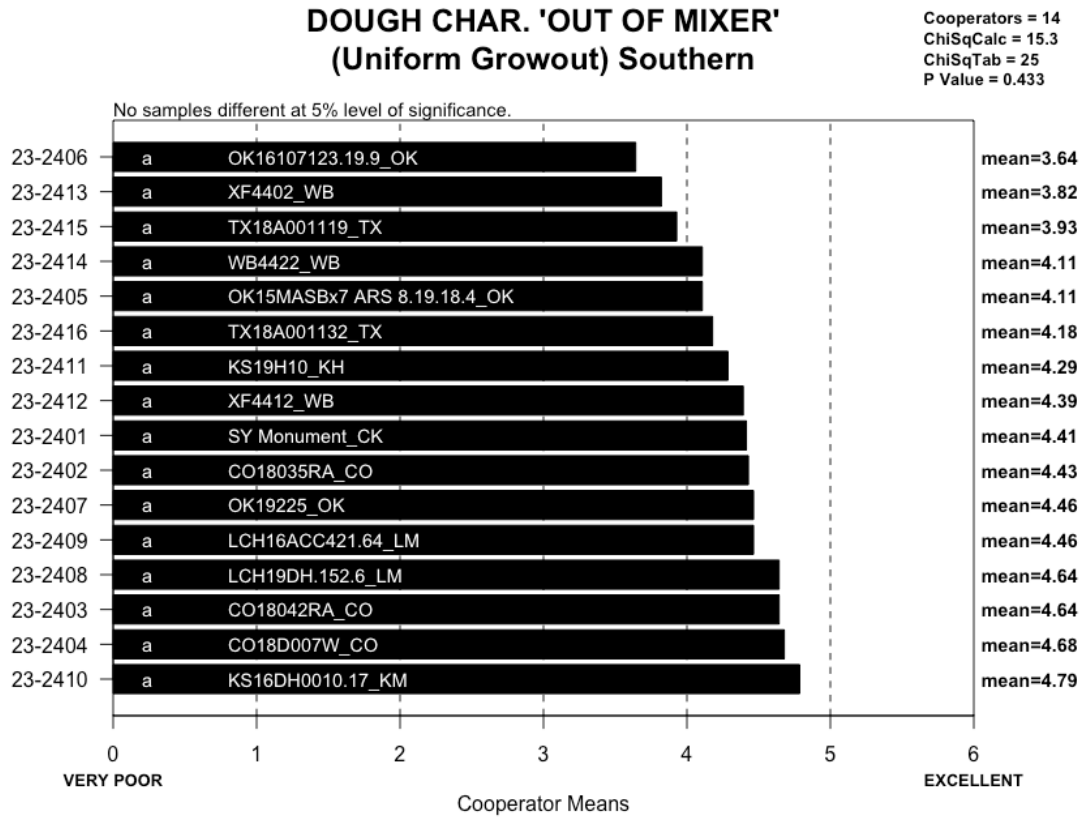
| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 66.9 | 62.8 | 59 | 64.6 | 66.1 | 63.6 | 64 | 66.7 | 59.1 | 62.2 | 64.7 | 66.1 | 64.2 | 65.1 |
| 23-2402 | CO18035RA_CO | 66.0 | 63.8 | 58 | 64.9 | 64.8 | 62.4 | 62 | 67.3 | 57.7 | 59.9 | 65.1 | 64.0 | 61.9 | 62.8 |
| 23-2403 | CO18042RA_CO | 66.9 | 63.0 | 59 | 66.0 | 65.6 | 63.9 | 64 | 67.8 | 59.0 | 62.1 | 66.0 | 67.0 | 64.1 | 64.8 |
| 23-2404 | CO18D007W_CO | 67.2 | 63.7 | 60 | 66.1 | 65.9 | 63.9 | 64 | 66.7 | 61.0 | 63.1 | 66.3 | 66.4 | 65.1 | 65.0 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 72.4 | 66.1 | 61 | 68.9 | 70.7 | 63.9 | 70 | 71.0 | 63.2 | 68.5 | 69.0 | 70.3 | 70.5 | 71.3 |
| 23-2406 | OK16107123.19.9_OK | 67.9 | 64.1 | 62 | 67.6 | 66.6 | 66.4 | 71 | 65.2 | 62.8 | 69.9 | 67.4 | 73.0 | 71.9 | 73.5 |
| 23-2407 | OK19225_OK | 67.7 | 65.2 | 61 | 67.2 | 67.0 | 63.9 | 67 | 66.8 | 62.8 | 65.7 | 67.0 | 68.9 | 67.7 | 66.7 |
| 23-2408 | LCH19DH.152.6_LM | 65.0 | 64.1 | 59 | 64.3 | 64.9 | 65.4 | 62 | 65.1 | 57.3 | 60.4 | 64.3 | 63.3 | 62.4 | 63.0 |
| 23-2409 | LCH16ACC421.64_LM | 66.4 | 64.0 | 59 | 65.8 | 67.0 | 64.9 | 62 | 66.2 | 58.9 | 61.0 | 65.9 | 63.3 | 63.0 | 63.1 |
| 23-2410 | KS16DH0010.17_KM | 66.5 | 64.4 | 60 | 66.3 | 66.5 | 63.9 | 64 | 66.2 | 60.6 | 62.7 | 66.2 | 65.4 | 64.7 | 63.0 |
| 23-2411 | KS19H10_KH | 66.9 | 63.6 | 61 | 66.2 | 68.0 | 64.4 | 69 | 67.7 | 62.4 | 67.8 | 66.4 | 70.1 | 69.8 | 70.5 |
| 23-2412 | XF4412_WB | 65.3 | 63.6 | 60 | 65.2 | 65.0 | 64.4 | 65 | 66.8 | 61.6 | 63.9 | 65.0 | 66.3 | 65.9 | 65.9 |
| 23-2413 | XF4402_WB | 68.2 | 62.6 | 61 | 65.8 | 67.8 | 63.9 | 70 | 67.4 | 62.8 | 68.6 | 66.0 | 71.6 | 70.6 | 71.5 |
| 23-2414 | WB4422_WB | 68.2 | 64.3 | 61 | 67.4 | 67.5 | 64.4 | 70 | 67.3 | 63.5 | 68.9 | 67.2 | 72.1 | 70.9 | 69.2 |
| 23-2415 | TX18A001119_TX | 69.6 | 65.5 | 61 | 67.7 | 68.5 | 64.9 | 72 | 68.6 | 61.5 | 71.8 | 67.5 | 74.0 | 73.8 | 74.5 |
| 23-2416 | TX18A001132_TX | 68.0 | 65.5 | 60 | 65.8 | 67.1 | 63.4 | 69 | 68.6 | 62.0 | 68.0 | 65.9 | 71.0 | 70.0 | 69.1 |

# 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 7.4 | 7.0 | 20 | 8.6 | 13.6 | 12.4 | 24 | 8.5 | 11 | 7 | 8.9 | 13 | 20 | 6.3 |
| 23-2402 | CO18035RA_CO | 9.6 | 10.0 | 20 | 11.3 | 18.5 | 17.2 | 25 | 10.0 | 14 | 6 | 10.6 | 17 | 20 | 6.0 |
| 23-2403 | CO18042RA_CO | 6.9 | 6.0 | 15 | 8.6 | 12.8 | 10.5 | 25 | 7.0 | 7 | 6 | 8.1 | 11 | 20 | 5.2 |
| 23-2404 | CO18D007W_CO | 5.8 | 6.0 | 15 | 6.7 | 9.6 | 9.8 | 16 | 6.3 | 7 | 13 | 6.6 | 7 | 16 | 4.8 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 11.8 | 8.5 | 20 | 12.4 | 21.0 | 19.5 | 50 | 11.8 | 20 | 41 | 10.1 | 30 | 20 | 8.8 |
| 23-2406 | OK16107123.19.9_OK | 3.5 | 3.8 | 8 | 3.8 | 4.4 | 4.1 | 8 | 3.5 | 4 | 6 | 3.3 | 7 | 8 | 4.5 |
| 23-2407 | OK19225_OK | 4.3 | 4.0 | 7 | 4.3 | 6.3 | 5.6 | 16 | 4.0 | 4 | 5 | 4.0 | 6 | 10 | 4.0 |
| 23-2408 | LCH19DH.152.6_LM | 3.8 | 4.8 | 10 | 5.2 | 7.1 | 6.2 | 16 | 4.8 | 6 | 5 | 5.1 | 6 | 14 | 4.3 |
| 23-2409 | LCH16ACC421.64_LM | 7.2 | 8.3 | 20 | 8.3 | 14.8 | 13.5 | 25 | 7.3 | 16 | 7 | 8.8 | 11 | 20 | 5.5 |
| 23-2410 | KS16DH0010.17_KM | 3.9 | 4.5 | 9 | 4.7 | 5.9 | 6.6 | 14 | 4.3 | 6 | 6 | 3.6 | 7 | 20 | 3.8 |
| 23-2411 | KS19H10_KH | 4.7 | 5.3 | 8 | 7.1 | 8.9 | 7.4 | 12 | 5.5 | 7 | 6 | 5.1 | 6 | 12 | 4.5 |
| 23-2412 | XF4412_WB | 4.2 | 5.0 | 7 | 4.8 | 6.0 | 4.8 | 7 | 4.0 | 6 | 6 | 3.3 | 6 | 10 | 4.0 |
| 23-2413 | XF4402_WB | 4.9 | 4.5 | 11 | 8.0 | 9.0 | 7.7 | 12 | 5.5 | 8 | 5 | 5.8 | 7 | 13 | 5.0 |
| 23-2414 | WB4422_WB | 3.4 | 3.3 | 5 | 4.0 | 4.6 | 4.0 | 8 | 3.8 | 6 | 8 | 3.5 | 7 | 10 | 4.5 |
| 23-2415 | TX18A001119_TX | 5.0 | 5.5 | 15 | 6.9 | 10.0 | 7.8 | 12 | 6.0 | 12 | 5 | 6.4 | 7 | 20 | 6.0 |
| 23-2416 | TX18A001132_TX | 6.0 | 6.5 | 15 | 8.5 | 12.8 | 10.5 | 16 | 7.3 | 12 | 5 | 6.5 | 7 | 20 | 6.0 |

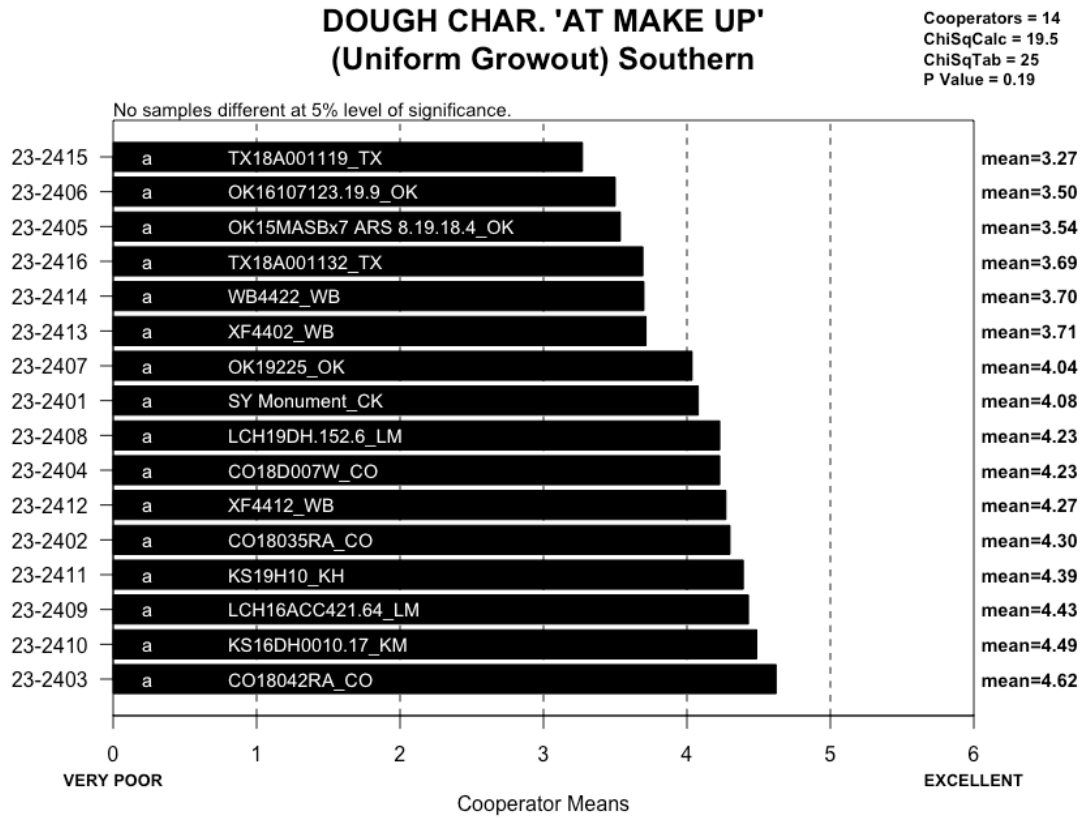

BAKE MIX TIME
(Uniform Growout) Southern
Cooperators = 14
ChiSqCalc = 92.7
ChiSqTab = 25
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
23-2406 a OK16107123.19.9_OK mean=2.79
23-2414 ac WB4422_WB mean=3.04
23-2407 ac OK19225_OK mean=3.11
23-2412 abc XF4412_WB mean=3.34
23-2408 abcdf LCH19DH.152.6_LM mean=3.57
23-2410 abcd KS16DH0010.17_KM mean=3.61
23-2411 abcdf KS19H10_KH mean=3.96
23-2413 abcdef XF4402_WB mean=4.11
23-2415 abcdef TX18A001119_TX mean=4.46
23-2404 abcdef CO18D007W_CO mean=4.54
23-2416 abcdef TX18A001132_TX mean=4.68
23-2403 bcdef CO18042RA_CO mean=4.96
23-2401 bdef SY Monument_CK mean=5.21
23-2409 def LCH16ACC421.64_LM mean=5.29
23-2402 ef CO18035RA_CO mean=5.46
23-2405 e OK15MASBx7 ARS 8.19.18.4_OK mean=5.89
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Uniform Growout) Southern
Cooperators = 14
ChiSqCalc = 75.4
ChiSqTab = 25
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
23-2406 a OK16107123.19.9_OK mean=3.11
23-2407 a OK19225_OK mean=3.35
23-2414 a WB4422_WB mean=3.43
23-2412 ab XF4412_WB mean=3.63
23-2408 ab LCH19DH.152.6_LM mean=3.68
23-2413 abc XF4402_WB mean=3.88
23-2410 abc KS16DH0010.17_KM mean=3.93
23-2411 abc KS19H10_KH mean=4.07
23-2415 abc TX18A001119_TX mean=4.11
23-2416 abc TX18A001132_TX mean=4.52
23-2403 abc CO18042RA_CO mean=4.54
23-2404 abc CO18D007W_CO mean=4.61
23-2401 abc SY Monument_CK mean=4.92
23-2405 c OK15MASBx7 ARS 8.19.18.4_OK mean=5.29
23-2409 bc LCH16ACC421.64_LM mean=5.34
23-2402 c CO18035RA_CO mean=5.47
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



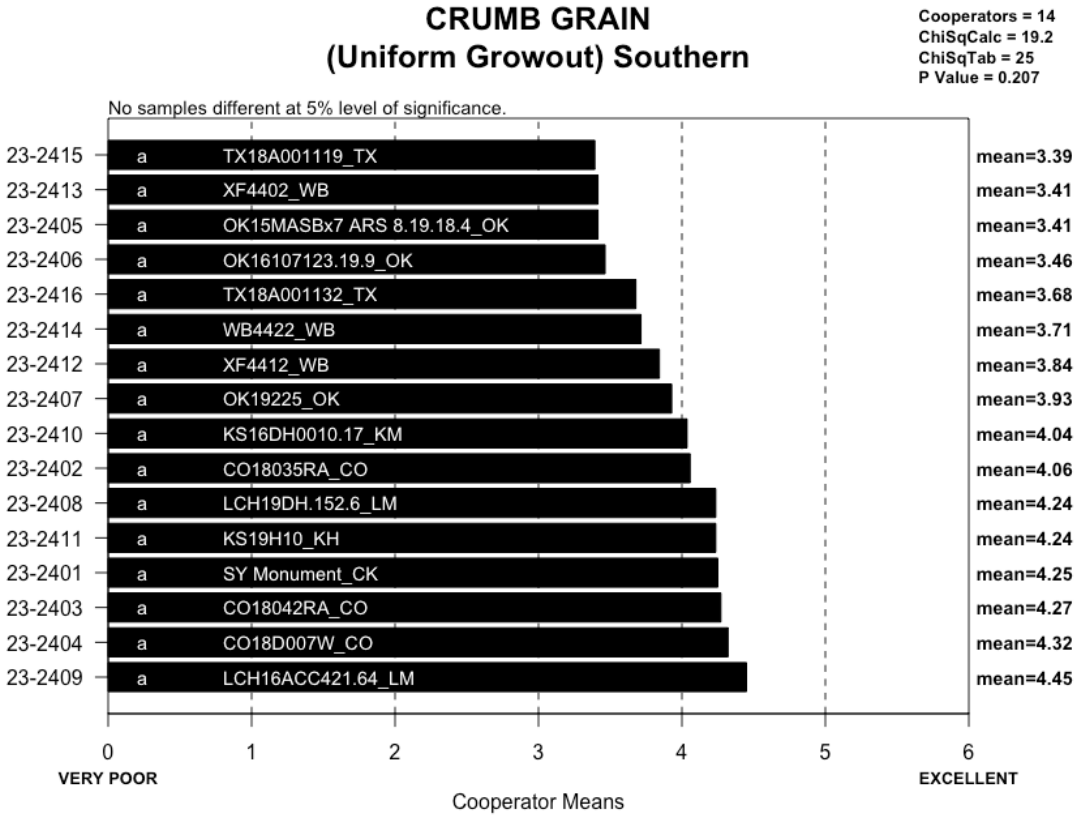

# DOUGH CHAR. 'OUT OF MIXER', DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 1 | 1 | 5 | 4 | 3 |
| 23-2402 | CO18035RA_CO | 1 | 0 | 4 | 7 | 2 |
| 23-2403 | CO18042RA_CO | 1 | 0 | 3 | 7 | 3 |
| 23-2404 | CO18D007W_CO | 2 | 0 | 1 | 7 | 4 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 0 | 0 | 8 | 6 | 0 |
| 23-2406 | OK16107123.19.9_OK | 5 | 1 | 3 | 3 | 2 |
| 23-2407 | OK19225_OK | 3 | 0 | 1 | 8 | 2 |
| 23-2408 | LCH19DH.152.6_LM | 2 | 0 | 0 | 9 | 3 |
| 23-2409 | LCH16ACC421.64_LM | 0 | 0 | 4 | 8 | 2 |
| 23-2410 | KS16DH0010.17_KM | 0 | 0 | 2 | 9 | 3 |
| 23-2411 | KS19H10_KH | 1 | 0 | 3 | 9 | 1 |
| 23-2412 | XF4412_WB | 3 | 0 | 2 | 8 | 1 |
| 23-2413 | XF4402_WB | 3 | 0 | 4 | 5 | 2 |
| 23-2414 | WB4422_WB | 4 | 0 | 2 | 7 | 1 |
| 23-2415 | TX18A001119_TX | 1 | 1 | 6 | 6 | 0 |
| 23-2416 | TX18A001132_TX | 1 | 0 | 5 | 7 | 1 |




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

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 1 | 1 | 7 | 4 | 1 |
| 23-2402 | CO18035RA_CO | 0 | 0 | 4 | 8 | 2 |
| 23-2403 | CO18042RA_CO | 1 | 0 | 2 | 9 | 2 |
| 23-2404 | CO18D007W_CO | 2 | 1 | 3 | 6 | 2 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 0 | 0 | 9 | 5 | 0 |
| 23-2406 | OK16107123.19.9_OK | 3 | 2 | 3 | 6 | 0 |
| 23-2407 | OK19225_OK | 3 | 0 | 2 | 7 | 2 |
| 23-2408 | LCH19DH.152.6_LM | 3 | 1 | 0 | 9 | 1 |
| 23-2409 | LCH16ACC421.64_LM | 0 | 0 | 4 | 7 | 3 |
| 23-2410 | KS16DH0010.17_KM | 1 | 0 | 2 | 9 | 2 |
| 23-2411 | KS19H10_KH | 1 | 1 | 2 | 8 | 2 |
| 23-2412 | XF4412_WB | 4 | 1 | 2 | 6 | 1 |
| 23-2413 | XF4402_WB | 2 | 0 | 5 | 6 | 1 |
| 23-2414 | WB4422_WB | 3 | 2 | 2 | 7 | 0 |
| 23-2415 | TX18A001119_TX | 2 | 1 | 8 | 3 | 0 |
| 23-2416 | TX18A001132_TX | 1 | 0 | 8 | 3 | 2 |

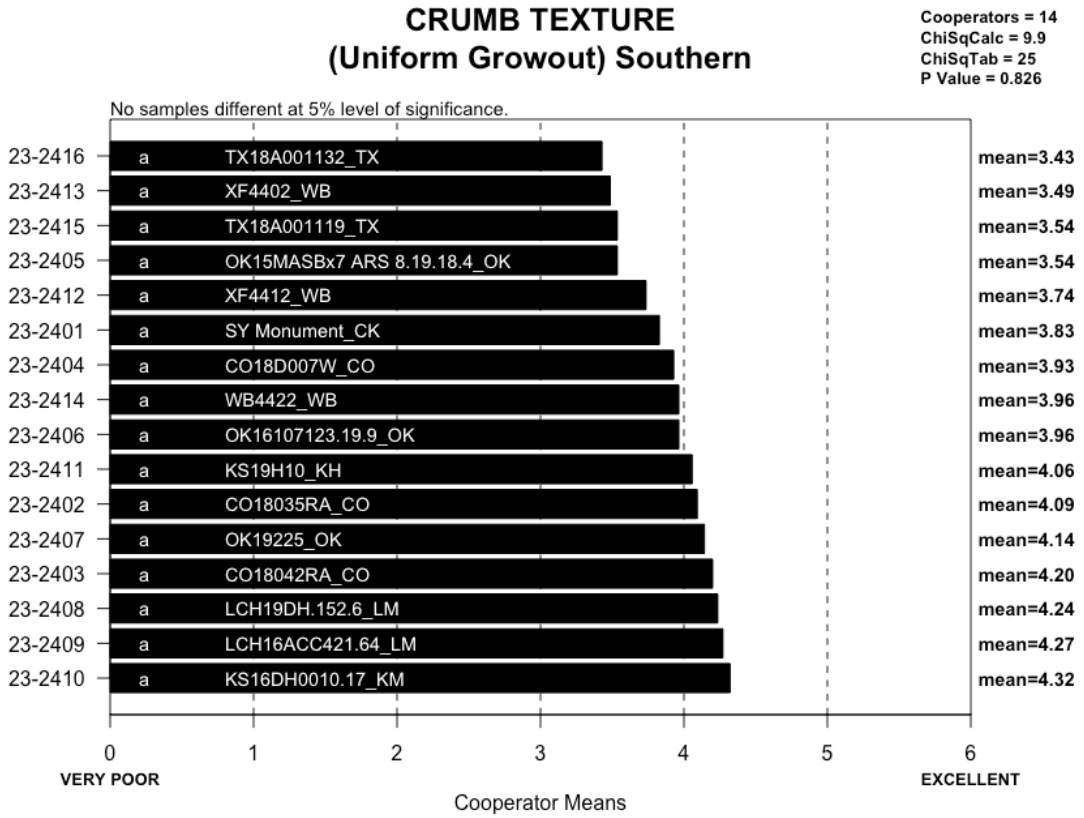



# CRUMB GRAIN, DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Open | Fine | Dense |
|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 4 | 7 | 3 |
| 23-2402 | CO18035RA_CO | 6 | 4 | 4 |
| 23-2403 | CO18042RA_CO | 4 | 8 | 2 |
| 23-2404 | CO18D007W_CO | 7 | 4 | 3 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 8 | 4 | 2 |
| 23-2406 | OK16107123.19.9_OK | 7 | 4 | 3 |
| 23-2407 | OK19225_OK | 9 | 3 | 2 |
| 23-2408 | LCH19DH.152.6_LM | 7 | 5 | 2 |
| 23-2409 | LCH16ACC421.64_LM | 8 | 3 | 3 |
| 23-2410 | KS16DH0010.17_KM | 9 | 2 | 3 |
| 23-2411 | KS19H10_KH | 6 | 6 | 2 |
| 23-2412 | XF4412_WB | 7 | 6 | 1 |
| 23-2413 | XF4402_WB | 11 | 1 | 2 |
| 23-2414 | WB4422_WB | 8 | 4 | 2 |
| 23-2415 | TX18A001119_TX | 10 | 2 | 2 |
| 23-2416 | TX18A001132_TX | 7 | 5 | 2 |

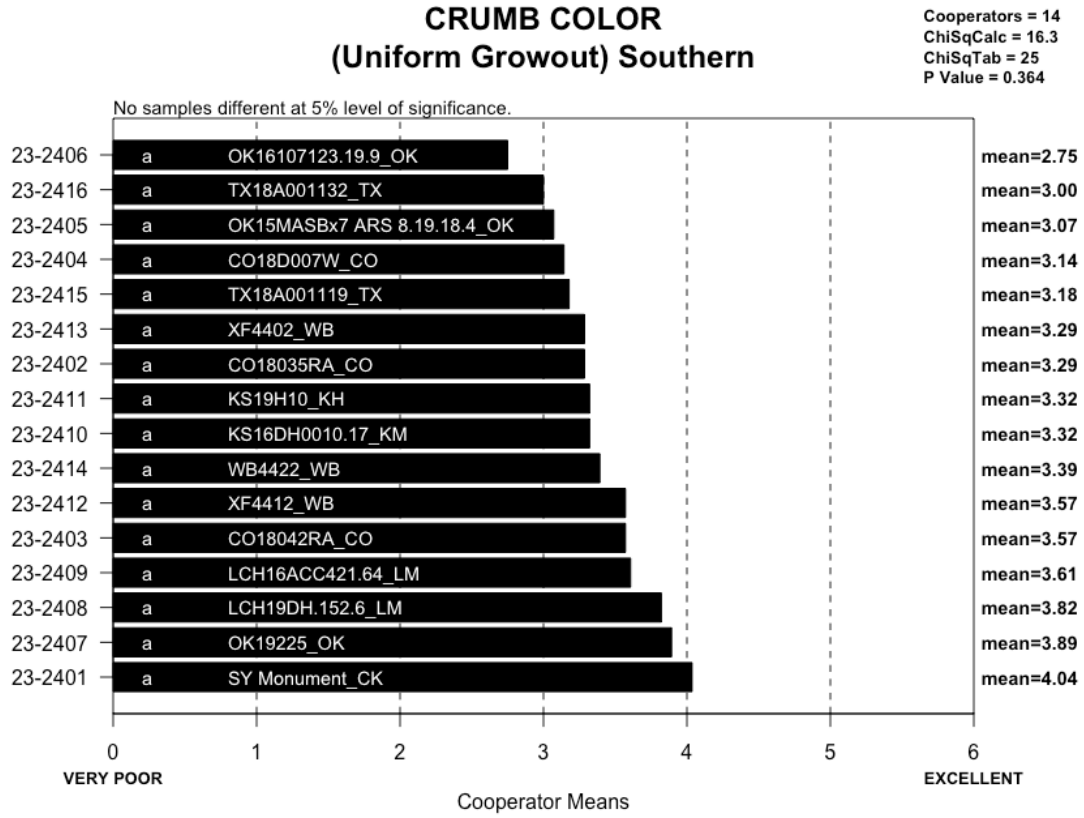
# CELL SHAPE, DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Round | Irregular | Elongated |
|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 4 | 5 | 5 |
| 23-2402 | CO18035RA_CO | 5 | 6 | 3 |
| 23-2403 | CO18042RA_CO | 7 | 4 | 3 |
| 23-2404 | CO18D007W_CO | 6 | 5 | 3 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 7 | 6 | 1 |
| 23-2406 | OK16107123.19.9_OK | 8 | 5 | 1 |
| 23-2407 | OK19225_OK | 7 | 6 | 1 |
| 23-2408 | LCH19DH.152.6_LM | 7 | 5 | 2 |
| 23-2409 | LCH16ACC421.64_LM | 5 | 5 | 4 |
| 23-2410 | KS16DH0010.17_KM | 5 | 6 | 3 |
| 23-2411 | KS19H10_KH | 6 | 5 | 3 |
| 23-2412 | XF4412_WB | 5 | 5 | 4 |
| 23-2413 | XF4402_WB | 8 | 4 | 2 |
| 23-2414 | WB4422_WB | 8 | 4 | 2 |
| 23-2415 | TX18A001119_TX | 8 | 4 | 2 |
| 23-2416 | TX18A001132_TX | 5 | 5 | 4 |




# CRUMB TEXTURE, DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Harsh | Smooth | Silky |
|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 3 | 9 | 2 |
| 23-2402 | CO18035RA_CO | 3 | 9 | 2 |
| 23-2403 | CO18042RA_CO | 1 | 9 | 4 |
| 23-2404 | CO18D007W_CO | 4 | 8 | 2 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 5 | 6 | 3 |
| 23-2406 | OK16107123.19.9_OK | 4 | 6 | 4 |
| 23-2407 | OK19225_OK | 4 | 7 | 3 |
| 23-2408 | LCH19DH.152.6_LM | 3 | 9 | 2 |
| 23-2409 | LCH16ACC421.64_LM | 1 | 11 | 2 |
| 23-2410 | KS16DH0010.17_KM | 2 | 9 | 3 |
| 23-2411 | KS19H10_KH | 1 | 11 | 2 |
| 23-2412 | XF4412_WB | 1 | 12 | 1 |
| 23-2413 | XF4402_WB | 4 | 8 | 2 |
| 23-2414 | WB4422_WB | 1 | 10 | 3 |
| 23-2415 | TX18A001119_TX | 4 | 9 | 1 |
| 23-2416 | TX18A001132_TX | 3 | 9 | 2 |




# CRUMB COLOR, DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Gray | Dark Yellow | Yellow | Dull | Creamy | White | Bright White |
|---|---|---|---|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 0 | 0 | 3 | 3 | 2 | 5 | 1 |
| 23-2402 | CO18035RA_CO | 0 | 0 | 5 | 1 | 6 | 2 | 0 |
| 23-2403 | CO18042RA_CO | 0 | 0 | 3 | 4 | 4 | 3 | 0 |
| 23-2404 | CO18D007W_CO | 0 | 2 | 2 | 3 | 7 | 0 | 0 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 2 | 0 | 3 | 2 | 6 | 1 | 0 |
| 23-2406 | OK16107123.19.9_OK | 0 | 3 | 2 | 5 | 4 | 0 | 0 |
| 23-2407 | OK19225_OK | 0 | 1 | 1 | 3 | 4 | 4 | 1 |
| 23-2408 | LCH19DH.152.6_LM | 0 | 0 | 3 | 2 | 5 | 4 | 0 |
| 23-2409 | LCH16ACC421.64_LM | 0 | 0 | 3 | 3 | 7 | 1 | 0 |
| 23-2410 | KS16DH0010.17_KM | 0 | 0 | 4 | 3 | 6 | 1 | 0 |
| 23-2411 | KS19H10_KH | 0 | 1 | 2 | 4 | 7 | 0 | 0 |
| 23-2412 | XF4412_WB | 1 | 0 | 2 | 4 | 5 | 2 | 0 |
| 23-2413 | XF4402_WB | 2 | 0 | 3 | 3 | 4 | 2 | 0 |
| 23-2414 | WB4422_WB | 0 | 0 | 3 | 4 | 6 | 1 | 0 |
| 23-2415 | TX18A001119_TX | 2 | 0 | 3 | 3 | 5 | 1 | 0 |
| 23-2416 | TX18A001132_TX | 0 | 1 | 3 | 3 | 7 | 0 | 0 |

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

| IDCODE | ID | A | B | C | D | E | F | H | I | J | K | L | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 143.8 | 154.2 | 407 | 139.6 | 151.5 | 140.7 | 143.7 | 481.9 | 467 | 141.3 | 446 | 126.8 |
| 23-2402 | CO18035RA_CO | 137.9 | 151.8 | 412 | 140.8 | 147.1 | 138.4 | 141.5 | 487.3 | 460 | 141.2 | 447 | 129.2 |
| 23-2403 | CO18042RA_CO | 140.5 | 150.1 | 411 | 139.1 | 148.4 | 137.3 | 143.7 | 479.7 | 457 | 140.5 | 445 | 131.0 |
| 23-2404 | CO18D007W_CO | 142.1 | 156.1 | 410 | 138.8 | 155.4 | 135.1 | 143.5 | 484.9 | 456 | 141.5 | 439 | 131.0 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 147.5 | 155.6 | 412 | 140.6 | 155.0 | 136.6 | 147.0 | 483.5 | 464 | 142.2 | 442 | 132.8 |
| 23-2406 | OK16107123.19.9_OK | 144.6 | 156.3 | 415 | 140.4 | 153.1 | 140.9 | 144.4 | 482.4 | 453 | 142.5 | 437 | 134.7 |
| 23-2407 | OK19225_OK | 142.4 | 158.0 | 410 | 140.2 | 153.6 | 142.7 | 144.9 | 480.0 | 458 | 141.4 | 437 | 134.9 |
| 23-2408 | LCH19DH.152.6_LM | 139.7 | 155.6 | 413 | 139.3 | 151.6 | 142.6 | 140.8 | 486.1 | 460 | 142.1 | 441 | 128.3 |
| 23-2409 | LCH16ACC421.64_LM | 140.7 | 153.0 | 416 | 139.9 | 152.8 | 138.3 | 141.0 | 484.7 | 466 | 140.8 | 442 | 132.5 |
| 23-2410 | KS16DH0010.17_KM | 141.9 | 153.9 | 413 | 139.6 | 150.8 | 140.5 | 143.4 | 482.2 | 461 | 140.9 | 443 | 132.8 |
| 23-2411 | KS19H10_KH | 142.8 | 156.3 | 410 | 140.6 | 152.6 | 140.6 | 144.7 | 477.1 | 458 | 142.5 | 439 | 135.7 |
| 23-2412 | XF4412_WB | 142.6 | 156.4 | 410 | 141.5 | 152.6 | 135.0 | 141.9 | 482.6 | 464 | 142.8 | 439 | 131.0 |
| 23-2413 | XF4402_WB | 143.7 | 155.5 | 410 | 140.5 | 153.6 | 137.2 | 142.3 | 477.5 | 477 | 141.5 | 438 | 137.2 |
| 23-2414 | WB4422_WB | 145.0 | 158.6 | 412 | 139.5 | 154.1 | 143.3 | 144.4 | 474.9 | 454 | 142.0 | 442 | 135.5 |
| 23-2415 | TX18A001119_TX | 146.8 | 161.5 | 414 | 141.0 | 154.0 | 143.4 | 146.2 | 472.1 | 459 | 140.3 | 443 | 136.7 |
| 23-2416 | TX18A001132_TX | 142.5 | 158.1 | 413 | 141.7 | 152.1 | 145.5 | 143.4 | 481.5 | 459 | 142.2 | 441 | 134.2 |

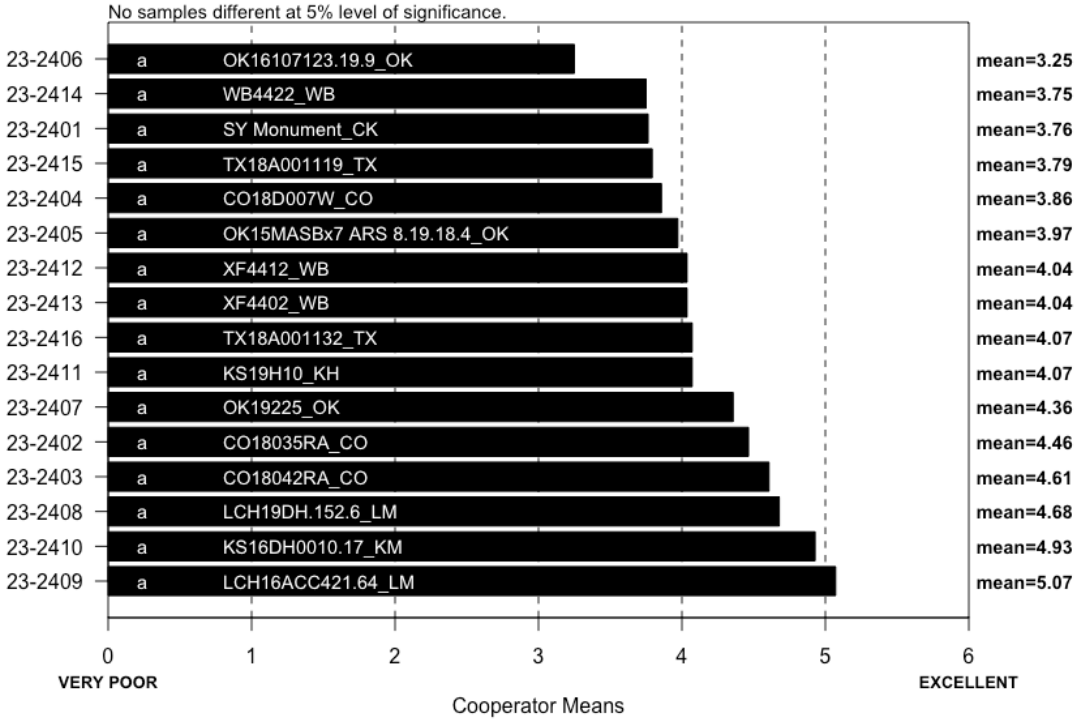
# LOAF VOLUME, ACTUAL
# (Uniform Growout) Southern
# Cooperators A – N

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2401 | SY Monument_CK | 935 | 798 | 2875 | 819 | 860 | 969 | 2941 | 960 | 2488 | 2271 | 815 | 2446 | 2600 | 880 |
| 23-2402 | CO18035RA_CO | 1035 | 842 | 2875 | 902 | 895 | 1000 | 3000 | 1115 | 2238 | 2328 | 835 | 2515 | 2700 | 940 |
| 23-2403 | CO18042RA_CO | 975 | 875 | 2925 | 882 | 925 | 1000 | 3044 | 1080 | 2363 | 2506 | 905 | 2539 | 2650 | 910 |
| 23-2404 | CO18D007W_CO | 930 | 830 | 2850 | 824 | 810 | 1000 | 2883 | 1025 | 2238 | 2494 | 800 | 2474 | 2500 | 950 |
| 23-2405 | OK15MASBx7 ARS 8.19.18.4_OK | 930 | 724 | 2825 | 812 | 855 | 958 | 2941 | 1025 | 2388 | 2494 | 750 | 2661 | 2475 | 900 |
| 23-2406 | OK16107123.19.9_OK | 820 | 759 | 2725 | 824 | 880 | 1000 | 2648 | 890 | 2350 | 2222 | 915 | 2448 | 2450 | 860 |
| 23-2407 | OK19225_OK | 955 | 863 | 2825 | 837 | 915 | 1000 | 2986 | 930 | 2550 | 2511 | 910 | 2502 | 2850 | 810 |
| 23-2408 | LCH19DH.152.6_LM | 985 | 856 | 2850 | 902 | 890 | 1000 | 3133 | 1045 | 2388 | 2577 | 940 | 2618 | 2900 | 895 |
| 23-2409 | LCH16ACC421.64_LM | 1055 | 879 | 2850 | 924 | 920 | 1000 | 3089 | 1130 | 2488 | 2560 | 885 | 2676 | 2900 | 965 |
| 23-2410 | KS16DH0010.17_KM | 955 | 904 | 2875 | 924 | 970 | 1000 | 3162 | 1065 | 2575 | 2639 | 970 | 2569 | 2900 | 875 |
| 23-2411 | KS19H10_KH | 905 | 751 | 2775 | 808 | 925 | 1000 | 2986 | 1025 | 2513 | 2426 | 880 | 2496 | 2825 | 830 |
| 23-2412 | XF4412_WB | 895 | 750 | 2750 | 789 | 865 | 1000 | 2927 | 1040 | 2575 | 2475 | 870 | 2581 | 2700 | 820 |
| 23-2413 | XF4402_WB | 895 | 715 | 2925 | 735 | 905 | 895 | 2986 | 1020 | 2838 | 2043 | 775 | 2663 | 2900 | 845 |
| 23-2414 | WB4422_WB | 860 | 796 | 2725 | 788 | 920 | 898 | 3015 | 940 | 2500 | 2395 | 885 | 2500 | 2625 | 865 |
| 23-2415 | TX18A001119_TX | 900 | 655 | 2825 | 723 | 795 | 908 | 3000 | 1005 | 2738 | 2339 | 800 | 2462 | 2900 | 880 |
| 23-2416 | TX18A001132_TX | 930 | 728 | 2925 | 768 | 790 | 945 | 3162 | 1020 | 2675 | 2477 | 770 | 2509 | 2900 | 880 |

## LOAF VOLUME
## (Uniform Growout) Southern

Cooperators = 14
ChiSqCalc = 23.1
ChiSqTab = 25
P Value = 0.083

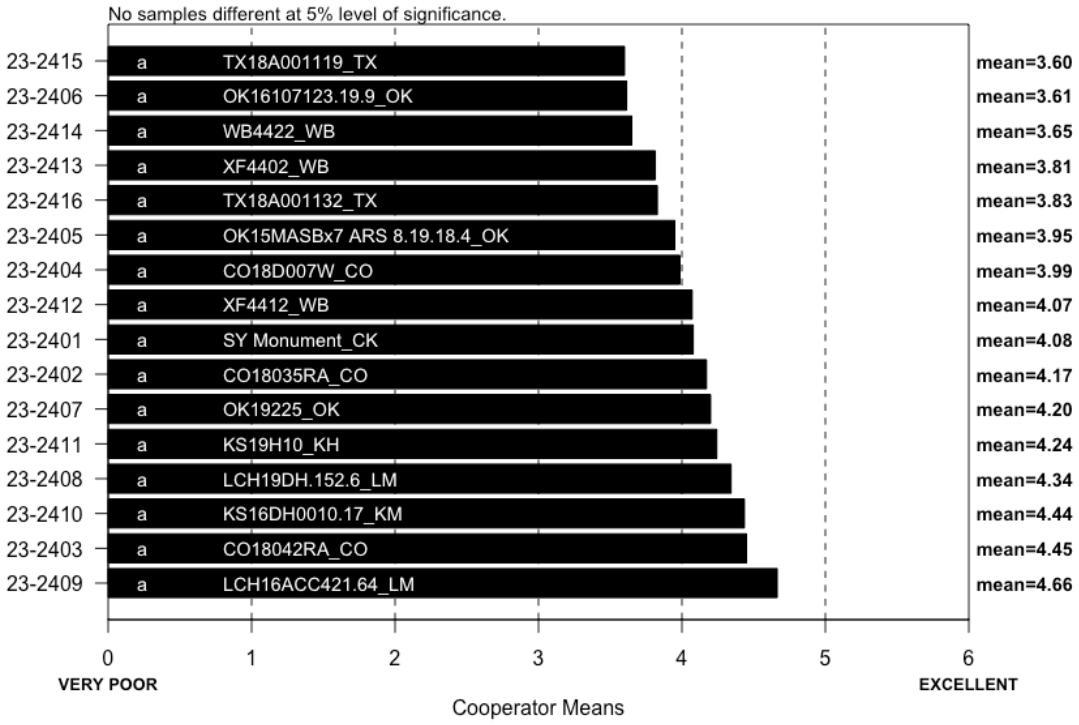
No samples different at 5% level of significance.




## OVERALL BAKING QUALITY
## (Uniform Growout) Southern

Cooperators = 14
ChiSqCalc = 17.8
ChiSqTab = 25
P Value = 0.275

No samples different at 5% level of significance.



# COOPERATOR'S COMMENTS
# (Uniform Growout) Southern
# Cooperators A – N

**23-2401 SY Monument_CK**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Long mix  Good volume |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume and excellent mixing tolerance |
| F | High Water Abs, Extremely Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | nice loaf externals |
| I | Low absorption, sticky dough, average grain, lower volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein, absorption and volume. Strong dough feels. Good mix tolerance. |
| N | No comment. |

**23-2402 CO18035RA_CO**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Long mix  Tough dough  Good volume |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume and excellent mixing tolerance |
| F | High Water Abs, Extremely Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume w KH, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | long time to pick up, excellent externals |
| I | Very low absoprtion, tough dough, very low volume, very good mixing tolerance. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein and absorption. Strong dough feels. Good volume and mix tolerance. |
| N | No comment. |

**23-2403 CO18042RA_CO**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Excellent volume Open grain  Strong dough |
| D | No comment. |
| E | Long mix time, avg absorption and grain, good volume, excellent mixing tolerance |
| F | High Water Abs, Extremely Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume w KH, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | long time to pick up, excellent externals |
| I | Low absorption, sticky dough, average grain, low volume. |
| J | Best bread of day 1 bakes |
| K | No comment. |
| L | No comment. |
| M | Fair protein and volume. Good absorption and mix tolerance. Strong dough feels. |
| N | No comment. |

**23-2404 CO18D007W_CO**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Strong dough Good volume Nice interior |
| D | No comment. |
| E | Long mix time, avg absorption, dense grain, low volume. |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Open Elongate Cells, Good Resilient & Slightly Harsh Texture |
| G | Target absorption, good stability / mix,  good volume |
| H | nice externals |
| I | Avg absorption and mix time, tough dough throughout, below average dark yellow crumb grain, very low volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein, dough feels and mix tolerance. Good absorption. Low volume. High stability. |
| N | No comment. |

**23-2405 OK15MASBx7 ARS 8-19-18-4_OK**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Tough dough Long mix Very open grain |
| D | No comment. |
| E | Long mix time, open crumb grain, very high absorption, excellent mixing tolerance. |
| F | High Water Abs, Extremely Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Dull Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Silky Smooth Texture |
| G | Sponge seemed dry, excessive absorption and mix time, good dough handling (slightly tight), excellent volume |
| H | long time to pick up, bx7OE? |
| I | High absorption, longest mix time, tough dough throughout, fine nice grain, low volume, highest mix tolerance. |
| J | mixed so long, dough was dry throughout the make up process |
| K | No comment. |
| L | No comment. |
| M | Good protein, absorption, and mix tolerance. Strong dough feels. Low volume. High stability. |
| N | Long long long mix time |

**23-2406 OK16107123-19-9_OK**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Short mix for protein Average volume Sl soft out of mixer |
| D | No comment. |
| E | Avg mix time, absorption and volume, and open crumb with dark yellow color. |
| F | Extremely High Water Abs, Medium MT, Slight Sticky & Strong Dough, Very High Loaf Volume w KH, Yellow Crumb Grain, Open Round Cells, Soft Resilient & Slight Harsh Texture |
| G | Sponge weak / collapsed, excessive absorption, over absorbed- sticky dough, lower stability mix than others, average / marginal volume. Noted Highest protein of Southern Group |
| H | dry? |
| I | High absorption, very short mix time, sticky dough throughout, below average dense grain, dark yellow crumb color, low volume and lowest mix tolerance. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | High protein. Good absorption. Low mix tolerance and volume. Do not recommend. |
| N | No comment. |

**23-2407 OK19225_OK**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Short mix for protein  Average volume  Sl soft out of mixer |
| D | No comment. |
| E | Long mix time, avg absorption and grain, good volume. |
| F | High Water Abs, Normal MT, Slight Sticky & Strong Dough, Very High Loaf Volume w KH, Yellow Crumb Grain, Open Round Cells, Soft Resilient & Slight Harsh Texture |
| G | Excessive absorption, good mix time,  seemed over-absorbed (sticky handling), excellent volume |
| H | cap |
| I | High absorption, very short mix time, surprisingly good dough, dense, dark yellow poor crumb grain, average volume and low mix tolerance. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein, absorption and volume. Fair dough feels and mix tolerance. |
| N | No comment. |

**23-2408 LCH19DH-152-6_LM**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume. |
| F | High Water Abs,  a Little Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Open Elongate Cells, Soft Resilient & Slight Harsh Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | excellent externals |
| I | Avg absorption and mixing time, below avg open grain, low volume. Surprisingly good dough. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein and volume. Fair absorption, dough feels and mix tolerance. |
| N | No comment. |

**23-2409 LCH16ACC421-64_LM**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Long mix Good volume |
| D | No comment. |
| E | Long mix time, avg absorption and grain, good mixing tolerance, dough characteristics and volume. |
| F | High Water Abs, Extremely Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | long time to pick up, excellent externals |
| I | Low absorption, tough dough, average grain, lower volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein, absorption, and mix tolerance. High volume. Strong dough feels. |
| N | No comment. |

**23-2410 KS16DH0010-17_KM**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Shorter mix Good volume |
| D | No comment. |
| E | Long mix time, avg absorption and grain, excellent volume. |
| F | High Water Abs, a Little Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Slight Open Elongate Cells, Good Resilient & Smooth Texture |
| G | Target absorption, mix, excellent volume |
| H | excellent externals |
| I | Avg absorption, mix time & tolerance, crumb grain and volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein, absorption, dough feels, and mix tolerance. High volume. |
| N | No comment. |

**23-2411 KS19H10_KH**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | High absorption, open crumb with dark yellow color, good volume. |
| F | High Water Abs, a Little Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Open Elongate Cells, Good Resilient & Smooth Texture |
| G | Sponge seemed dry, excessive absorption, good mix time, excellent volume |
| H | cap |
| I | Avg absorption, slightly above avg mix tolerance and time, avg crumb grain & volume. Wet dough. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein and mixing tolerance. High absorption. Good dough feels and volume. |
| N | No comment. |

**23-2412 XF4412_WB**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume. |
| F | High Water Abs, Medium MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Slight Open Elongate Cells, Good Resilient & Smooth Texture |
| G | Lower stability / mix time, seemed over-absorbed (sticky handling), good volume |
| H | nice externals |
| I | Avg absorption, mix time & tolerance, crumb grain and volume. Sticky dough throughout. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein. Good absorption, dough feels, mix tolerance and volume. |
| N | No comment. |

**23-2413 XF4402_WB**

| | |
|---|---|
| A | No comment. |
| B | Dough was extremely tough and very difficult to work with |
| C | No comment. |
| D | No comment. |
| E | Long mix time, high absorption, lower mixing tolerance, open grain. |
| F | High Water Abs, a Little Long MT, Slight Sticky & Strong Dough, High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Excessive absorption, good mix time, seemed over-absorbed (sticky handling), good volume |
| H | bucky, right side break |
| I | Avg absorption, mix time & tolerance, avg crumb grain. Highest volume, Tough dough throughout. |
| J | tough bite |
| K | No comment. |
| L | No comment. |
| M | Fair protein and mixing tolerance. Good absorption, dough feels and volume. |
| N | No comment. |

**23-2414 WB4422_WB**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Shortest mix |
| D | No comment. |
| E | Avg mix time, absorption and volume, and open crumb. |
| F | High Water Abs, Medium MT, Slight Sticky & Strong Dough, High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Lower stability / mix time, excessive absorption, seemed over-absorbed (sticky handling), good volume |
| H | cap |
| I | Highest absorption, avg mix time, crumb grain, and volume. Slightly above avg mix tolerance. Wet dough. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein and absorption. Low mixing tolerance. Fair dough feels and volume. |
| N | No comment. |

**23-2415 TX18A001119_TX**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Tough lifeless dough with no gas retention, open grain, poor volume. Long mix time and bake absorption. |
| F | High Water Abs, a Little Long MT, Slight Sticky & Strong Dough, High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Silky Smooth Texture |
| G | Sponge seemed dry, excessive absorption, good mix time, seemed over-absorpbed (sticky handling), good volume |
| H | rough break |
| I | High absorption, long mix time avg crumb grain. Above average volume. Tough dough throughout. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein, mixing tolerance, dough feels and volume. High absorption. Dough mixing not consistent with stability. |
| N | No comment. |

**23-2416 TX18A001132_TX**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Tough lifeless dough with no gas retention, open grain with dark yellow color, poor volume. Avg absorption. |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Excessive absorption, good mix time, seemed over-absorpbed (sticky handling), good volume. Note Lowest protein of Southern Group. |
| H | dry?, rough break |
| I | High absorption, long mix time, high mix tolerance, avg crumb grain, above average volume. Tough dough throughout. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein. Good absorption, dough feels, mixing tolerance and volume. |
| N | No comment. |

Sponge and dough bake tests: C, G, I, L, and M.

# SOUTHERN MICRO-QUALITY ANALYSIS

| Entry_Code | Entry_ID | Entry_No | Breeding Programs | Locations* |
|---|---|---|---|---|
| 23-UM2401 | SY Monument | 2401 | Check | UM |
| 23-UM2402 | CO18035RA | 2402 | Colorado | UM |
| 23-UM2403 | CO18042RA | 2403 | Colorado | UM |
| 23-UM2404 | CO18D007W | 2404 | Colorado | UM |
| 23-UM2405 | OK15MASBx7 ARS 8-19-18-4 | 2405 | Oklahoma | UM |
| 23-UM2406 | OK16107123-19-9 | 2406 | Oklahoma | UM |
| 23-UM2407 | OK19225 | 2407 | Oklahoma | UM |
| 23-UM2408 | LCH19DH-152-6 | 2408 | Limagrain | UM |
| 23-UM2409 | LCH16ACC421-64 | 2409 | Limagrain | UM |
| 23-UM2410 | KS16DH0010-17 | 2410 | Kansas-Manhattan | UM |
| 23-UM2411 | KS19H10 | 2411 | KS-Hays | UM |
| 23-UM2412 | XF4412 | 2412 | Bayer/WestBred | UM |
| 23-UM2413 | XF4402 | 2413 | Bayer/WestBred | UM |
| 23-UM2414 | WB4422 | 2414 | Bayer/WestBred | UM |
| 23-UM2415 | TX18A001119 | 2415 | Texas A&M | UM |
| 23-UM2416 | TX18A001132 | 2416 | Texas A&M | UM |
| 23-LM2401 | SY Monument | 2401 | Check | LM |
| 23-LM2402 | CO18035RA | 2402 | Colorado | LM |
| 23-LM2403 | CO18042RA | 2403 | Colorado | LM |
| 23-LM2404 | CO18D007W | 2404 | Colorado | LM |
| 23-LM2405 | OK15MASBx7 ARS 8-19-18-4 | 2405 | Oklahoma | LM |
| 23-LM2406 | OK16107123-19-9 | 2406 | Oklahoma | LM |
| 23-LM2407 | OK19225 | 2407 | Oklahoma | LM |
| 23-LM2408 | LCH19DH-152-6 | 2408 | Limagrain | LM |
| 23-LM2409 | LCH16ACC421-64 | 2409 | Limagrain | LM |
| 23-LM2410 | KS16DH0010-17 | 2410 | Kansas-Manhattan | LM |
| 23-LM2411 | KS19H10 | 2411 | KS-Hays | LM |
| 23-LM2412 | XF4412 | 2412 | Bayer/WestBred | LM |
| 23-LM2413 | XF4402 | 2413 | Bayer/WestBred | LM |
| 23-LM2414 | WB4422 | 2414 | Bayer/WestBred | LM |
| 23-LM2415 | TX18A001119 | 2415 | Texas A&M | LM |
| 23-LM2416 | TX18A001132 | 2416 | Texas A&M | LM |
| 23-OK2401 | SY Monument | 2401 | Check | OK |
| 23-OK2402 | CO18035RA | 2402 | Colorado | OK |
| 23-OK2403 | CO18042RA | 2403 | Colorado | OK |
| 23-OK2404 | CO18D007W | 2404 | Colorado | OK |
| 23-OK2405 | OK15MASBx7 ARS 8-19-18-4 | 2405 | Oklahoma | OK |
| 23-OK2406 | OK16107123-19-9 | 2406 | Oklahoma | OK |
| 23-OK2407 | OK19225 | 2407 | Oklahoma | OK |
| 23-OK2408 | LCH19DH-152-6 | 2408 | Limagrain | OK |

| | | | | |
|---|---|---|---|---|
| 23-OK2409 | LCH16ACC421-64 | 2409 | Limagrain | OK |
| 23-OK2410 | KS16DH0010-17 | 2410 | Kansas-Manhattan | OK |
| 23-OK2411 | KS19H10 | 2411 | KS-Hays | OK |
| 23-OK2412 | XF4412 | 2412 | Bayer/WestBred | OK |
| 23-OK2413 | XF4402 | 2413 | Bayer/WestBred | OK |
| 23-OK2414 | WB4422 | 2414 | Bayer/WestBred | OK |
| 23-OK2415 | TX18A001119 | 2415 | Texas A&M | OK |
| 23-OK2416 | TX18A001132 | 2416 | Texas A&M | OK |
| 23-TB2401 | SY Monument | 2401 | Check | TB |
| 23-TB2402 | CO18035RA | 2402 | Colorado | TB |
| 23-TB2403 | CO18042RA | 2403 | Colorado | TB |
| 23-TB2404 | CO18D007W | 2404 | Colorado | TB |
| 23-TB2405 | OK15MASBx7 ARS 8-19-18-4 | 2405 | Oklahoma | TB |
| 23-TB2406 | OK16107123-19-9 | 2406 | Oklahoma | TB |
| 23-TB2407 | OK19225 | 2407 | Oklahoma | TB |
| 23-TB2408 | LCH19DH-152-6 | 2408 | Limagrain | TB |
| 23-TB2409 | LCH16ACC421-64 | 2409 | Limagrain | TB |
| 23-TB2410 | KS16DH0010-17 | 2410 | Kansas-Manhattan | TB |
| 23-TB2411 | KS19H10 | 2411 | KS-Hays | TB |
| 23-TB2412 | XF4412 | 2412 | Bayer/WestBred | TB |
| 23-TB2413 | XF4402 | 2413 | Bayer/WestBred | TB |
| 23-TB2414 | WB4422 | 2414 | Bayer/WestBred | TB |
| 23-TB2415 | TX18A001119 | 2415 | Texas A&M | TB |
| 23-TB2416 | TX18A001132 | 2416 | Texas A&M | TB |
| 23-AP2401 | SY Monument | 2401 | Check | AP |
| 23-AP2402 | CO18035RA | 2402 | Colorado | AP |
| 23-AP2403 | CO18042RA | 2403 | Colorado | AP |
| 23-AP2404 | CO18D007W | 2404 | Colorado | AP |
| 23-AP2405 | OK15MASBx7 ARS 8-19-18-4 | 2405 | Oklahoma | AP |
| 23-AP2406 | OK16107123-19-9 | 2406 | Oklahoma | AP |
| 23-AP2407 | OK19225 | 2407 | Oklahoma | AP |
| 23-AP2408 | LCH19DH-152-6 | 2408 | Limagrain | AP |
| 23-AP2409 | LCH16ACC421-64 | 2409 | Limagrain | AP |
| 23-AP2410 | KS16DH0010-17 | 2410 | Kansas-Manhattan | AP |
| 23-AP2411 | KS19H10 | 2411 | KS-Hays | AP |
| 23-AP2412 | XF4412 | 2412 | Bayer/WestBred | AP |
| 23-AP2413 | XF4402 | 2413 | Bayer/WestBred | AP |
| 23-AP2414 | WB4422 | 2414 | Bayer/WestBred | AP |
| 23-AP2415 | TX18A001119 | 2415 | Texas A&M | AP |
| 23-AP2416 | TX18A001132 | 2416 | Texas A&M | AP |

*AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU;
TB=Texas A&M Bushland.

## 1. LOCATIONS AND ENTRIES

A. There are 5 locations:

USDA-Manhattan = UM;

Limagrain = LM;

Oklahoma = OK;

Texas A&M Bushland = TB;

Agripro = AP

B. There are 16 entries from 7 breeding programs grown in each of locations:

SY Monument (Check) = 2401

CO18035RA = 2402

CO18042RA = 2403

CO18D007W = 2404

OK15MASBx7 ARS 8-19-18-4 = 2405

OK16107123-19-9 = 2406

OK19225 = 2407

LCH19DH-152-6 = 2408

LCH16ACC421-64 = 2409

KS16DH0010-17 = 2410

KS19H10 = 2411

XF4412 = 2412

XF4402 = 2413

WB4422 = 2424

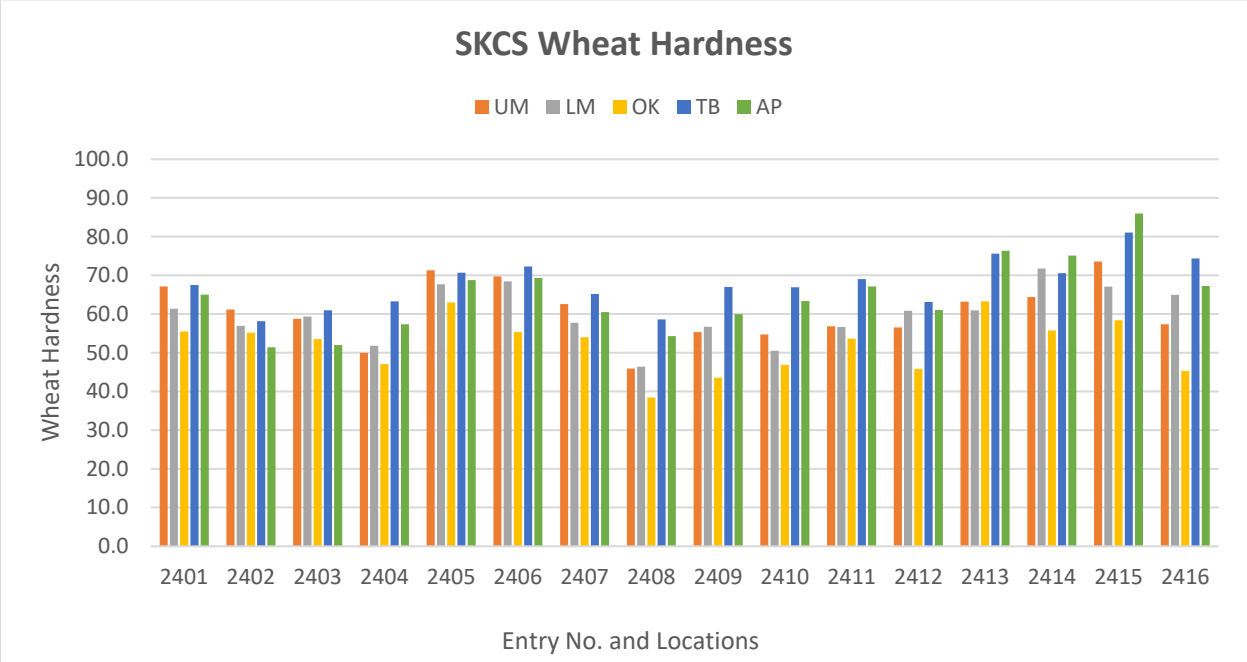
TX18A001119 = 2415

TX18A001132 = 2416.

## 2. SKCS SINGLE KERNEL INFORMATION

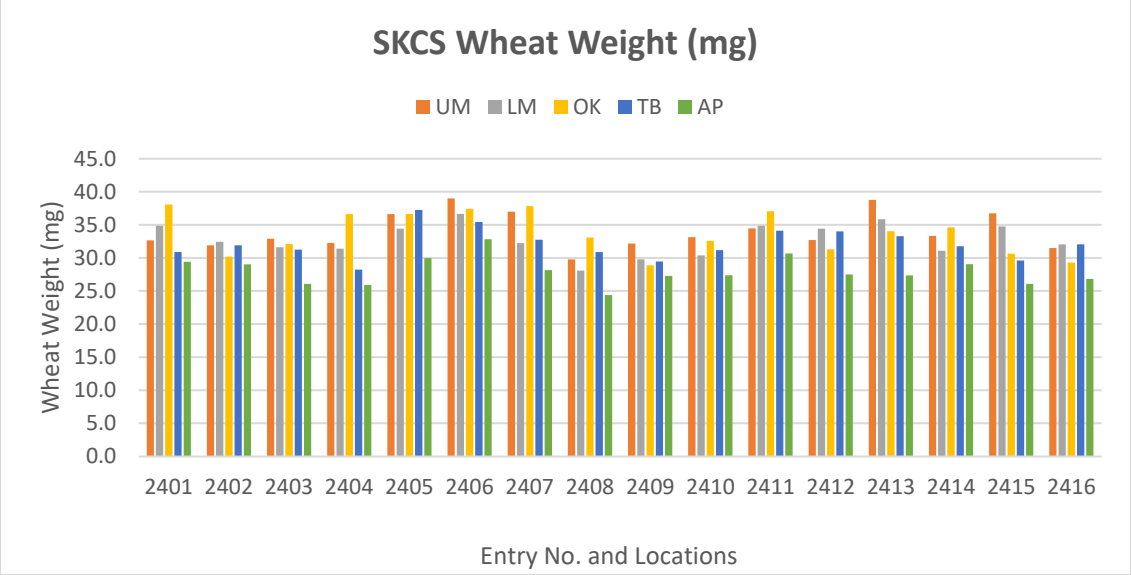
### A. Kernel Hardness

| SKCS Wheat Kernel Hardness | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 67.1 | 61.3 | 55.5 | 67.5 | 65.0 | 63.3 | 5.00 |
| 2402 | 61.1 | 57.0 | 55.2 | 58.1 | 51.4 | 56.6 | 3.61 |
| 2403 | 58.8 | 59.3 | 53.5 | 61.0 | 52.0 | 56.9 | 3.93 |
| 2404 | 49.9 | 51.8 | 47.1 | 63.3 | 57.4 | 53.9 | 6.44 |
| 2405 | 71.3 | 67.7 | 63.0 | 70.7 | 68.8 | 68.3 | 3.29 |
| 2406 | 69.7 | 68.4 | 55.3 | 72.3 | 69.3 | 67.0 | 6.68 |
| 2407 | 62.6 | 57.7 | 54.0 | 65.2 | 60.5 | 60.0 | 4.33 |
| 2408 | 45.9 | 46.4 | 38.4 | 58.6 | 54.3 | 48.7 | 7.87 |
| 2409 | 55.3 | 56.7 | 43.5 | 67.0 | 60.0 | 56.5 | 8.54 |
| 2410 | 54.7 | 50.5 | 46.9 | 66.9 | 63.3 | 56.5 | 8.48 |
| 2411 | 56.8 | 56.6 | 53.6 | 69.0 | 67.1 | 60.6 | 6.93 |
| 2412 | 56.5 | 60.8 | 45.8 | 63.1 | 61.0 | 57.5 | 6.94 |
| 2413 | 63.2 | 60.9 | 63.3 | 75.6 | 76.3 | 67.9 | 7.45 |
| 2414 | 64.4 | 71.8 | 55.7 | 70.5 | 75.1 | 67.5 | 7.63 |
| 2415 | 73.6 | 67.1 | 58.4 | 81.1 | 86.0 | 73.2 | 10.98 |
| 2416 | 57.3 | 65.0 | 45.3 | 74.3 | 67.2 | 61.8 | 11.06 |
| Avg. | 60.5 | 59.9 | 52.2 | 67.8 | 64.7 | | |
| Std | 7.62 | 6.96 | 7.00 | 6.28 | 9.31 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland | | | | | | | |



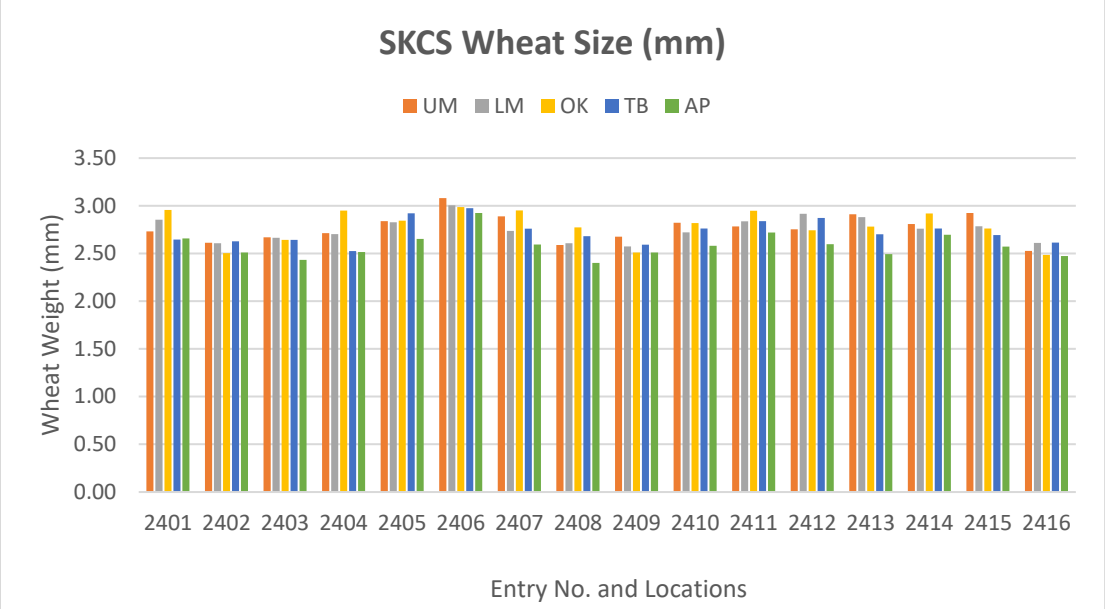
B. Kernel Weight (mg)

| SKCS Wheat Kernel Weight (mg) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 32.6 | 34.8 | 38.1 | 30.9 | 29.4 | 33.2 | 3.41 |
| 2402 | 31.9 | 32.4 | 30.2 | 31.9 | 29.0 | 31.1 | 1.43 |
| 2403 | 32.9 | 31.6 | 32.1 | 31.3 | 26.1 | 30.8 | 2.71 |
| 2404 | 32.3 | 31.4 | 36.6 | 28.2 | 25.9 | 30.9 | 4.09 |
| 2405 | 36.6 | 34.4 | 36.6 | 37.2 | 30.0 | 35.0 | 3.00 |
| 2406 | 39.0 | 36.7 | 37.4 | 35.4 | 32.8 | 36.3 | 2.31 |
| 2407 | 37.0 | 32.2 | 37.8 | 32.7 | 28.2 | 33.6 | 3.92 |
| 2408 | 29.8 | 28.1 | 33.1 | 30.9 | 24.4 | 29.2 | 3.26 |
| 2409 | 32.2 | 29.8 | 28.9 | 29.5 | 27.3 | 29.5 | 1.77 |
| 2410 | 33.1 | 30.4 | 32.6 | 31.2 | 27.4 | 30.9 | 2.27 |
| 2411 | 34.5 | 34.9 | 37.1 | 34.1 | 30.7 | 34.2 | 2.30 |
| 2412 | 32.7 | 34.4 | 31.3 | 34.0 | 27.5 | 32.0 | 2.79 |
| 2413 | 38.8 | 35.8 | 34.0 | 33.3 | 27.4 | 33.9 | 4.20 |
| 2414 | 33.3 | 31.1 | 34.6 | 31.8 | 29.1 | 32.0 | 2.13 |
| 2415 | 36.7 | 34.8 | 30.7 | 29.6 | 26.1 | 31.6 | 4.24 |
| 2416 | 31.5 | 32.1 | 29.3 | 32.0 | 26.8 | 30.3 | 2.27 |
| Avg. | 34.1 | 32.8 | 33.8 | 32.1 | 28.0 | | |
| Std | 2.73 | 2.40 | 3.20 | 2.31 | 2.10 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland | | | | | | | |



C. Kernel Size

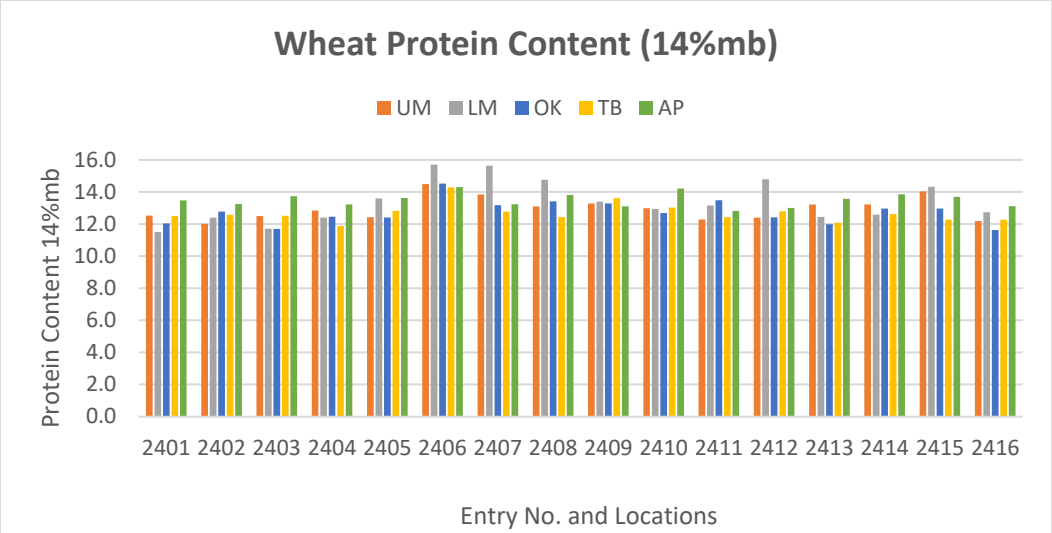
| SKCS Wheat Kernel Size (mm) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 2.73 | 2.85 | 2.96 | 2.64 | 2.66 | 2.77 | 0.13 |
| 2402 | 2.61 | 2.61 | 2.50 | 2.63 | 2.51 | 2.57 | 0.06 |
| 2403 | 2.67 | 2.66 | 2.64 | 2.64 | 2.43 | 2.61 | 0.10 |
| 2404 | 2.71 | 2.70 | 2.95 | 2.53 | 2.51 | 2.68 | 0.18 |
| 2405 | 2.84 | 2.83 | 2.84 | 2.92 | 2.65 | 2.82 | 0.10 |
| 2406 | 3.08 | 3.00 | 2.99 | 2.97 | 2.92 | 2.99 | 0.06 |
| 2407 | 2.89 | 2.74 | 2.95 | 2.76 | 2.59 | 2.79 | 0.14 |
| 2408 | 2.59 | 2.61 | 2.77 | 2.68 | 2.40 | 2.61 | 0.14 |
| 2409 | 2.68 | 2.57 | 2.51 | 2.59 | 2.51 | 2.57 | 0.07 |
| 2410 | 2.82 | 2.72 | 2.82 | 2.76 | 2.58 | 2.74 | 0.10 |
| 2411 | 2.78 | 2.84 | 2.95 | 2.84 | 2.72 | 2.82 | 0.08 |
| 2412 | 2.75 | 2.92 | 2.74 | 2.87 | 2.60 | 2.78 | 0.12 |
| 2413 | 2.91 | 2.88 | 2.78 | 2.70 | 2.49 | 2.75 | 0.17 |
| 2414 | 2.81 | 2.76 | 2.92 | 2.76 | 2.70 | 2.79 | 0.08 |
| 2415 | 2.92 | 2.78 | 2.76 | 2.69 | 2.57 | 2.75 | 0.13 |
| 2416 | 2.53 | 2.61 | 2.48 | 2.61 | 2.47 | 2.54 | 0.07 |
| Avg. | 2.77 | 2.76 | 2.79 | 2.73 | 2.58 | | |
| Std | 0.14 | 0.13 | 0.17 | 0.13 | 0.13 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland | | | | | | | |



## 3. PROTEN CONTENT

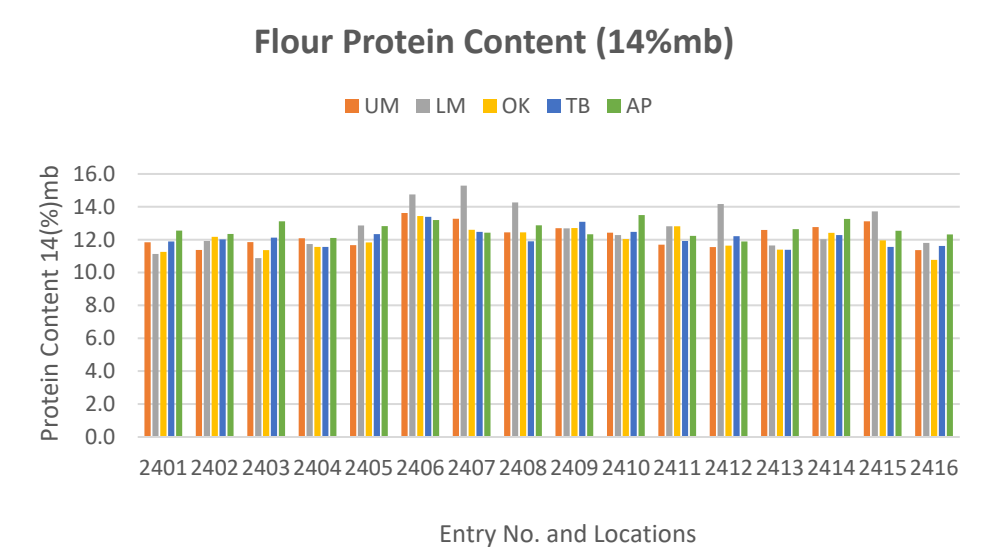
A. Wheat Protein

| Wheat Protein Content (14%mb) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 12.5 | 11.5 | 12.0 | 12.5 | 13.5 | 12.4 | 0.73 |
| 2402 | 12.0 | 12.4 | 12.8 | 12.6 | 13.2 | 12.6 | 0.46 |
| 2403 | 12.5 | 11.7 | 11.7 | 12.5 | 13.7 | 12.4 | 0.83 |
| 2404 | 12.8 | 12.4 | 12.4 | 11.9 | 13.2 | 12.6 | 0.51 |
| 2405 | 12.4 | 13.6 | 12.4 | 12.8 | 13.6 | 13.0 | 0.60 |
| 2406 | 14.5 | 15.7 | 14.5 | 14.3 | 14.3 | 14.7 | 0.60 |
| 2407 | 13.8 | 15.6 | 13.2 | 12.8 | 13.2 | 13.7 | 1.13 |
| 2408 | 13.1 | 14.8 | 13.4 | 12.4 | 13.8 | 13.5 | 0.86 |
| 2409 | 13.3 | 13.4 | 13.3 | 13.6 | 13.1 | 13.3 | 0.19 |
| 2410 | 13.0 | 12.9 | 12.7 | 13.0 | 14.2 | 13.2 | 0.60 |
| 2411 | 12.3 | 13.2 | 13.5 | 12.4 | 12.8 | 12.8 | 0.50 |
| 2412 | 12.4 | 14.8 | 12.4 | 12.8 | 13.0 | 13.1 | 0.99 |
| 2413 | 13.2 | 12.4 | 12.0 | 12.1 | 13.6 | 12.7 | 0.70 |
| 2414 | 13.2 | 12.6 | 13.0 | 12.6 | 13.9 | 13.0 | 0.52 |
| 2415 | 14.0 | 14.3 | 13.0 | 12.3 | 13.7 | 13.5 | 0.83 |
| 2416 | 12.2 | 12.7 | 11.6 | 12.3 | 13.1 | 12.4 | 0.57 |
| Avg. | 13.0 | 13.4 | 12.7 | 12.7 | 13.5 | | |
| Std | 0.71 | 1.31 | 0.75 | 0.58 | 0.43 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland. | | | | | | | |



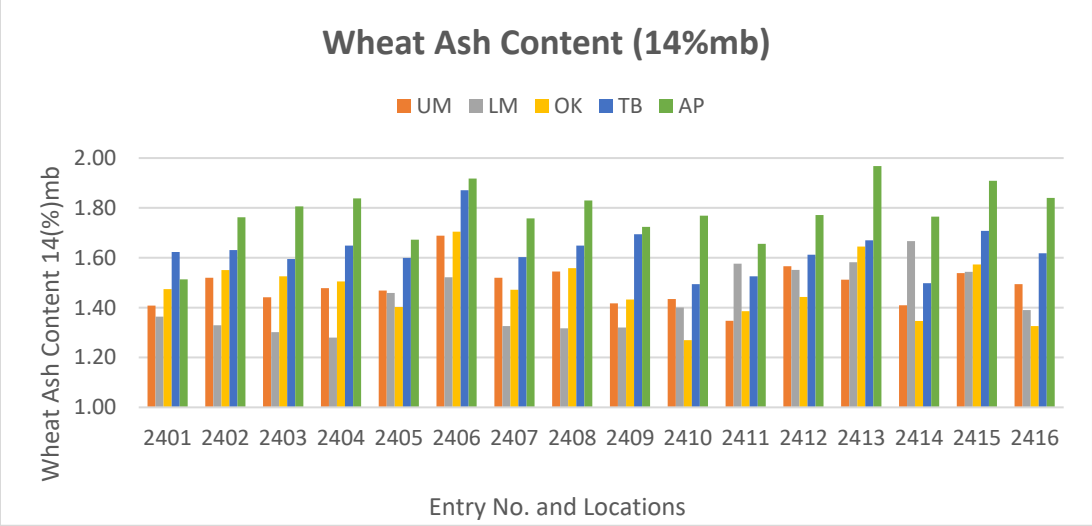
B. Flour Protein

| Flour Protein Content (14%) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 11.8 | 11.1 | 11.3 | 11.9 | 12.5 | 11.7 | 0.57 |
| 2402 | 11.4 | 11.9 | 12.2 | 12.0 | 12.3 | 12.0 | 0.37 |
| 2403 | 11.9 | 10.9 | 11.4 | 12.1 | 13.1 | 11.9 | 0.85 |
| 2404 | 12.1 | 11.7 | 11.6 | 11.6 | 12.1 | 11.8 | 0.27 |
| 2405 | 11.7 | 12.9 | 11.8 | 12.3 | 12.8 | 12.3 | 0.55 |
| 2406 | 13.6 | 14.7 | 13.4 | 13.4 | 13.2 | 13.7 | 0.62 |
| 2407 | 13.3 | 15.3 | 12.6 | 12.5 | 12.4 | 13.2 | 1.21 |
| 2408 | 12.4 | 14.3 | 12.4 | 11.9 | 12.9 | 12.8 | 0.90 |
| 2409 | 12.7 | 12.7 | 12.7 | 13.1 | 12.3 | 12.7 | 0.27 |
| 2410 | 12.4 | 12.3 | 12.0 | 12.5 | 13.5 | 12.5 | 0.56 |
| 2411 | 11.7 | 12.8 | 12.8 | 11.9 | 12.2 | 12.3 | 0.51 |
| 2412 | 11.5 | 14.2 | 11.6 | 12.2 | 11.9 | 12.3 | 1.08 |
| 2413 | 12.6 | 11.6 | 11.4 | 11.4 | 12.6 | 11.9 | 0.63 |
| 2414 | 12.8 | 12.0 | 12.4 | 12.3 | 13.3 | 12.5 | 0.48 |
| 2415 | 13.1 | 13.7 | 12.0 | 11.6 | 12.5 | 12.6 | 0.87 |
| 2416 | 11.4 | 11.8 | 10.8 | 11.6 | 12.3 | 11.6 | 0.57 |
| Avg. | 12.3 | 12.7 | 12.0 | 12.1 | 12.6 | | |
| Std | 0.70 | 1.33 | 0.69 | 0.54 | 0.46 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland. | | | | | | | |



## 4. Wheat Ash

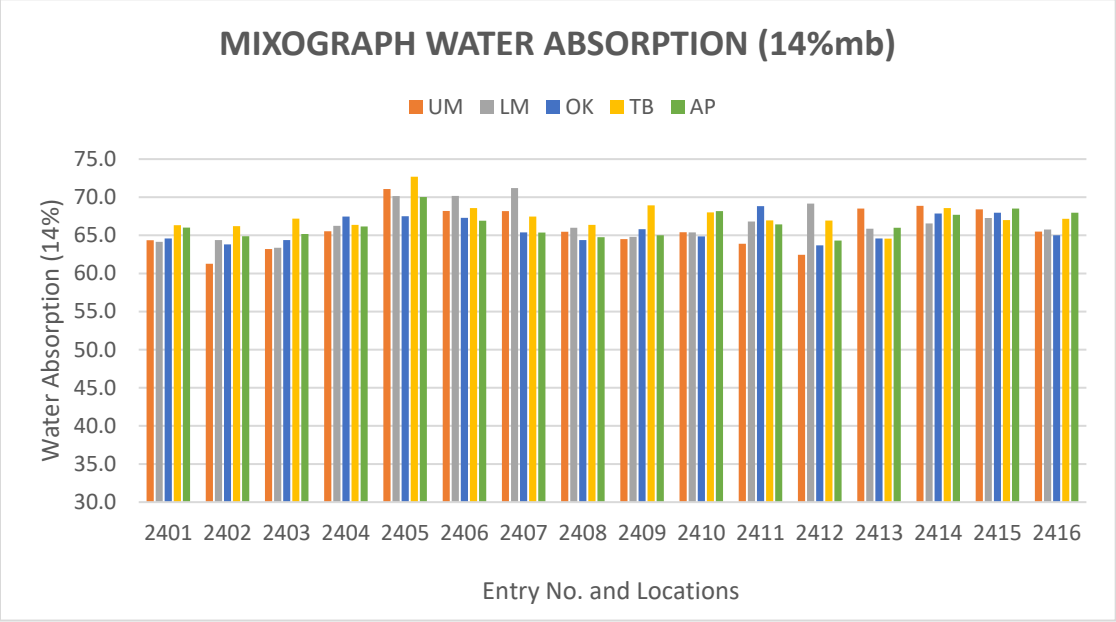
| Wheat Ash Content (14%) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 1.41 | 1.36 | 1.47 | 1.62 | 1.51 | 1.48 | 0.10 |
| 2402 | 1.52 | 1.33 | 1.55 | 1.63 | 1.76 | 1.56 | 0.16 |
| 2403 | 1.44 | 1.30 | 1.53 | 1.60 | 1.81 | 1.53 | 0.19 |
| 2404 | 1.48 | 1.28 | 1.50 | 1.65 | 1.84 | 1.55 | 0.21 |
| 2405 | 1.47 | 1.46 | 1.40 | 1.60 | 1.67 | 1.52 | 0.11 |
| 2406 | 1.69 | 1.52 | 1.70 | 1.87 | 1.92 | 1.74 | 0.16 |
| 2407 | 1.52 | 1.33 | 1.47 | 1.60 | 1.76 | 1.54 | 0.16 |
| 2408 | 1.54 | 1.32 | 1.56 | 1.65 | 1.83 | 1.58 | 0.19 |
| 2409 | 1.42 | 1.32 | 1.43 | 1.69 | 1.72 | 1.52 | 0.18 |
| 2410 | 1.43 | 1.40 | 1.27 | 1.49 | 1.77 | 1.47 | 0.18 |
| 2411 | 1.35 | 1.58 | 1.39 | 1.53 | 1.66 | 1.50 | 0.13 |
| 2412 | 1.57 | 1.55 | 1.44 | 1.61 | 1.77 | 1.59 | 0.12 |
| 2413 | 1.51 | 1.58 | 1.64 | 1.67 | 1.97 | 1.68 | 0.17 |
| 2414 | 1.41 | 1.67 | 1.35 | 1.50 | 1.76 | 1.54 | 0.18 |
| 2415 | 1.54 | 1.54 | 1.57 | 1.71 | 1.91 | 1.65 | 0.16 |
| 2416 | 1.49 | 1.39 | 1.33 | 1.62 | 1.84 | 1.53 | 0.20 |
| Avg. | 1.49 | 1.43 | 1.48 | 1.63 | 1.78 | | |
| Std | 0.08 | 0.12 | 0.12 | 0.09 | 0.11 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland. | | | | | | | |



## 5. MIXOGRAPH TEST RESULTS

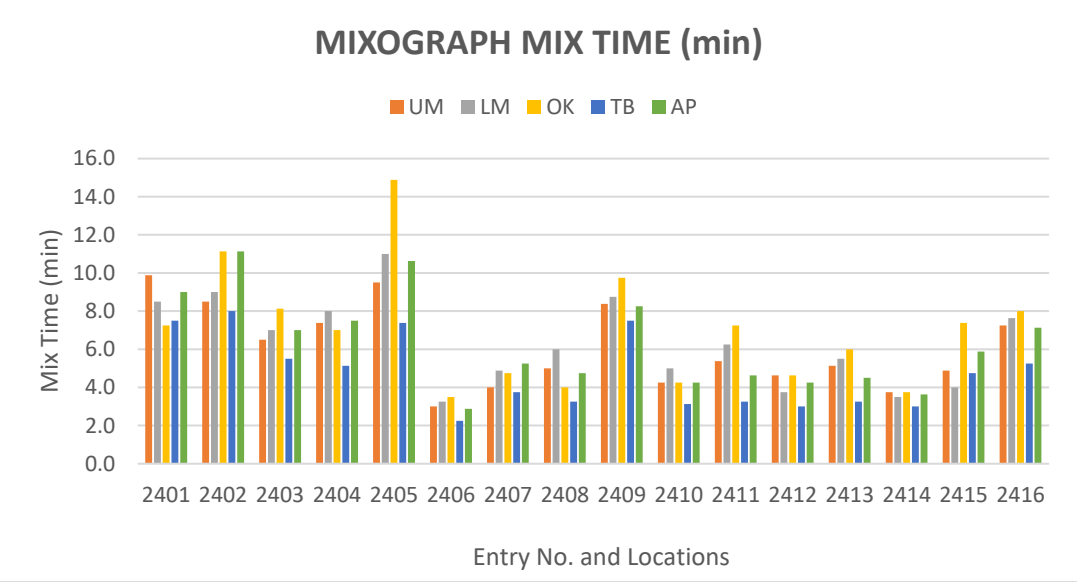
### A. Mixograph Water Absorption

| Mixograph Water Absorption (14%mb) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 64.3 | 64.2 | 64.6 | 66.3 | 66.0 | 65.1 | 1.01 |
| 2402 | 61.3 | 64.4 | 63.8 | 66.2 | 64.9 | 64.1 | 1.81 |
| 2403 | 63.2 | 63.4 | 64.4 | 67.2 | 65.2 | 64.7 | 1.62 |
| 2404 | 65.5 | 66.2 | 67.5 | 66.4 | 66.2 | 66.4 | 0.70 |
| 2405 | 71.1 | 70.1 | 67.5 | 72.7 | 70.0 | 70.3 | 1.88 |
| 2406 | 68.2 | 70.2 | 67.3 | 68.6 | 66.9 | 68.2 | 1.27 |
| 2407 | 68.2 | 71.2 | 65.4 | 67.5 | 65.4 | 67.5 | 2.41 |
| 2408 | 65.5 | 66.0 | 64.4 | 66.4 | 64.8 | 65.4 | 0.82 |
| 2409 | 64.5 | 64.8 | 65.8 | 68.9 | 65.0 | 65.8 | 1.81 |
| 2410 | 65.4 | 65.4 | 64.9 | 68.0 | 68.2 | 66.4 | 1.60 |
| 2411 | 63.9 | 66.8 | 68.8 | 67.0 | 66.4 | 66.6 | 1.77 |
| 2412 | 62.4 | 69.2 | 63.7 | 66.9 | 64.3 | 65.3 | 2.70 |
| 2413 | 68.5 | 65.9 | 64.6 | 64.6 | 66.0 | 65.9 | 1.61 |
| 2414 | 68.9 | 66.6 | 67.9 | 68.6 | 67.7 | 67.9 | 0.90 |
| 2415 | 68.4 | 67.3 | 68.0 | 67.0 | 68.5 | 67.8 | 0.68 |
| 2416 | 65.5 | 65.8 | 65.0 | 67.2 | 68.0 | 66.3 | 1.24 |
| Avg. | 65.9 | 66.7 | 65.8 | 67.5 | 66.5 | | |
| Std | 2.69 | 2.33 | 1.70 | 1.77 | 1.62 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland | | | | | | | |



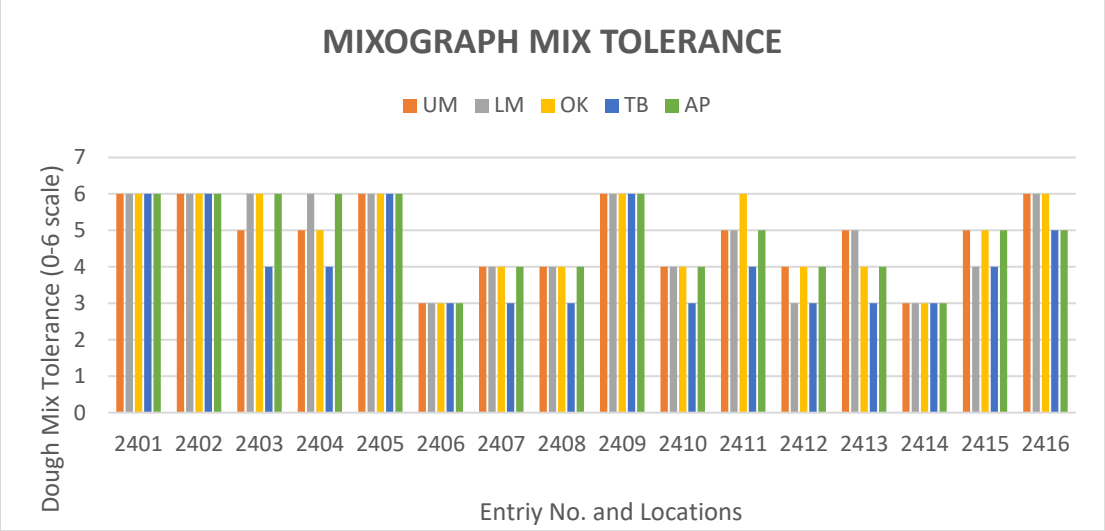
B. Mixograph Mix Time

| Mixograph Mix Time (min) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 9.9 | 8.5 | 7.3 | 7.5 | 9.0 | 8.4 | 1.08 |
| 2402 | 8.5 | 9.0 | 11.1 | 8.0 | 11.1 | 9.6 | 1.48 |
| 2403 | 6.5 | 7.0 | 8.1 | 5.5 | 7.0 | 6.8 | 0.95 |
| 2404 | 7.4 | 8.0 | 7.0 | 5.1 | 7.5 | 7.0 | 1.11 |
| 2405 | 9.5 | 11.0 | 14.9 | 7.4 | 10.6 | 10.7 | 2.74 |
| 2406 | 3.0 | 3.3 | 3.5 | 2.3 | 2.9 | 3.0 | 0.47 |
| 2407 | 4.0 | 4.9 | 4.8 | 3.8 | 5.3 | 4.5 | 0.63 |
| 2408 | 5.0 | 6.0 | 4.0 | 3.3 | 4.8 | 4.6 | 1.04 |
| 2409 | 8.4 | 8.8 | 9.8 | 7.5 | 8.3 | 8.5 | 0.82 |
| 2410 | 4.3 | 5.0 | 4.3 | 3.1 | 4.3 | 4.2 | 0.67 |
| 2411 | 5.4 | 6.3 | 7.3 | 3.3 | 4.6 | 5.4 | 1.53 |
| 2412 | 4.6 | 3.8 | 4.6 | 3.0 | 4.3 | 4.1 | 0.69 |
| 2413 | 5.1 | 5.5 | 6.0 | 3.3 | 4.5 | 4.9 | 1.06 |
| 2414 | 3.8 | 3.5 | 3.8 | 3.0 | 3.6 | 3.5 | 0.31 |
| 2415 | 4.9 | 4.0 | 7.4 | 4.8 | 5.9 | 5.4 | 1.30 |
| 2416 | 7.3 | 7.6 | 8.0 | 5.3 | 7.1 | 7.1 | 1.06 |
| Avg. | 6.1 | 6.4 | 7.0 | 4.7 | 6.3 | | |
| Std | 2.15 | 2.29 | 3.06 | 1.94 | 2.49 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland | | | | | | | |



C. Mixograph Mix Tolerance

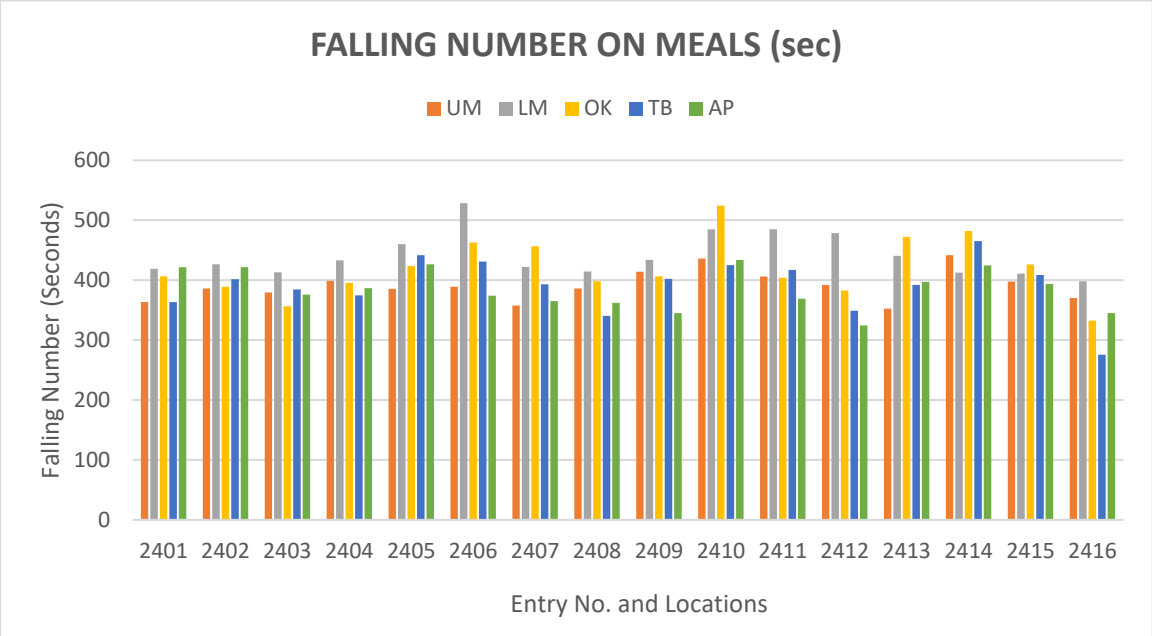
| Mixograph Mix Tolerance | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 6 | 6 | 6 | 6 | 6 | 6.0 | 0.0 |
| 2402 | 6 | 6 | 6 | 6 | 6 | 6.0 | 0.0 |
| 2403 | 5 | 6 | 6 | 4 | 6 | 5.4 | 0.9 |
| 2404 | 5 | 6 | 5 | 4 | 6 | 5.2 | 0.8 |
| 2405 | 6 | 6 | 6 | 6 | 6 | 6.0 | 0.0 |
| 2406 | 3 | 3 | 3 | 3 | 3 | 3.0 | 0.0 |
| 2407 | 4 | 4 | 4 | 3 | 4 | 3.8 | 0.4 |
| 2408 | 4 | 4 | 4 | 3 | 4 | 3.8 | 0.4 |
| 2409 | 6 | 6 | 6 | 6 | 6 | 6.0 | 0.0 |
| 2410 | 4 | 4 | 4 | 3 | 4 | 3.8 | 0.4 |
| 2411 | 5 | 5 | 6 | 4 | 5 | 5.0 | 0.7 |
| 2412 | 4 | 3 | 4 | 3 | 4 | 3.6 | 0.5 |
| 2413 | 5 | 5 | 4 | 3 | 4 | 4.2 | 0.8 |
| 2414 | 3 | 3 | 3 | 3 | 3 | 3.0 | 0.0 |
| 2415 | 5 | 4 | 5 | 4 | 5 | 4.6 | 0.5 |
| 2416 | 6 | 6 | 6 | 5 | 5 | 5.6 | 0.5 |
| Avg. | 4.8 | 4.8 | 4.9 | 4.1 | 4.8 | | |
| Std | 1.05 | 1.22 | 1.15 | 1.26 | 1.11 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland | | | | | | | |



## 6. FALLING NUMBER TEST

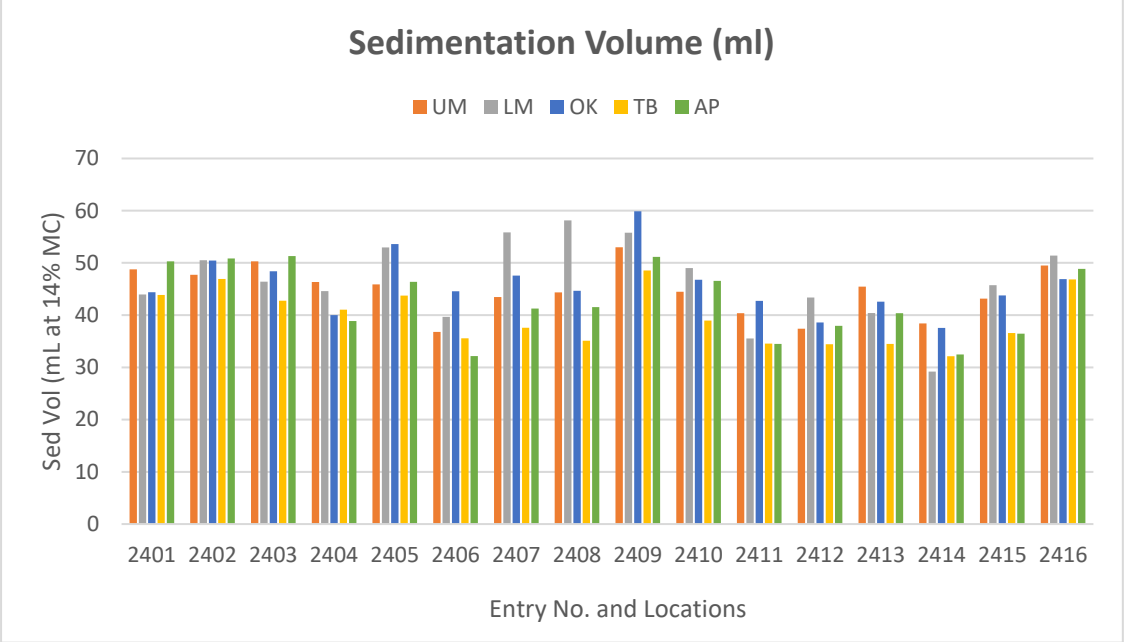
| Falling Number on Meals (sec) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 364 | 419 | 407 | 364 | 422 | 395 | 29 |
| 2402 | 386 | 427 | 389 | 402 | 422 | 405 | 18 |
| 2403 | 380 | 413 | 357 | 385 | 376 | 382 | 20 |
| 2404 | 399 | 433 | 396 | 375 | 387 | 398 | 22 |
| 2405 | 386 | 460 | 424 | 442 | 427 | 427 | 28 |
| 2406 | 389 | 529 | 463 | 431 | 374 | 437 | 62 |
| 2407 | 358 | 422 | 457 | 393 | 365 | 399 | 41 |
| 2408 | 386 | 415 | 398 | 341 | 362 | 380 | 29 |
| 2409 | 414 | 434 | 407 | 402 | 345 | 400 | 33 |
| 2410 | 436 | 485 | 525 | 425 | 434 | 461 | 43 |
| 2411 | 406 | 485 | 404 | 417 | 369 | 416 | 42 |
| 2412 | 392 | 479 | 383 | 349 | 325 | 385 | 59 |
| 2413 | 353 | 441 | 472 | 392 | 397 | 411 | 46 |
| 2414 | 442 | 413 | 482 | 465 | 425 | 445 | 29 |
| 2415 | 398 | 411 | 426 | 409 | 394 | 407 | 13 |
| 2416 | 370 | 398 | 333 | 276 | 345 | 344 | 46 |
| Avg. | 391 | 441 | 420 | 392 | 385 | | |
| Std | 25 | 36 | 49 | 45 | 33 | | |

AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland



## 7. SEDIMENTATION TEST

| Sedimentation Volume (ml) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | |
| Entry No. | UM | LM | OK | TB | AP | Avg | Std |
| 2401 | 48.8 | 44.0 | 44.4 | 43.9 | 50.3 | 46.3 | 3.05 |
| 2402 | 47.7 | 50.5 | 50.5 | 46.9 | 50.8 | 49.3 | 1.82 |
| 2403 | 50.3 | 46.4 | 48.4 | 42.8 | 51.3 | 47.8 | 3.40 |
| 2404 | 46.3 | 44.6 | 40.0 | 41.1 | 38.9 | 42.2 | 3.17 |
| 2405 | 45.9 | 53.0 | 53.6 | 43.7 | 46.4 | 48.5 | 4.47 |
| 2406 | 36.8 | 39.7 | 44.6 | 35.6 | 32.2 | 37.7 | 4.67 |
| 2407 | 43.5 | 55.8 | 47.6 | 37.6 | 41.3 | 45.1 | 6.99 |
| 2408 | 44.3 | 58.1 | 44.7 | 35.1 | 41.5 | 44.8 | 8.41 |
| 2409 | 53.0 | 55.8 | 59.9 | 48.5 | 51.2 | 53.7 | 4.36 |
| 2410 | 44.5 | 49.0 | 46.8 | 39.0 | 46.5 | 45.2 | 3.81 |
| 2411 | 40.4 | 35.5 | 42.7 | 34.6 | 34.5 | 37.5 | 3.78 |
| 2412 | 37.4 | 43.4 | 38.6 | 34.4 | 38.0 | 38.3 | 3.23 |
| 2413 | 45.5 | 40.4 | 42.6 | 34.5 | 40.4 | 40.7 | 4.03 |
| 2414 | 38.4 | 29.2 | 37.5 | 32.1 | 32.5 | 33.9 | 3.90 |
| 2415 | 43.1 | 45.7 | 43.8 | 36.6 | 36.4 | 41.1 | 4.32 |
| 2416 | 49.5 | 51.4 | 46.9 | 46.8 | 48.9 | 48.7 | 1.92 |
| Avg. | 44.7 | 46.4 | 45.8 | 39.6 | 42.6 | | |
| Std | 4.70 | 7.83 | 5.63 | 5.28 | 6.85 | | |
| AP=Agripro; UM=USDA-Manhattan; LM=Limagrain; OK=OSU; TB=Texas A&M Bushland | | | | | | | |



# NORTHERN GROWOUT

| | |
|---|---|
| 23-2417 | SY Mounment_CK |
| 23-2418 | 21Nord-160_ND |
| 23-2419 | XF4102_WB |
| 23-2420 | SD18B072-2_SD |
| 23-2421 | SD19B033-2_SD |
| 23-2422 | NE16562_NE |
| 23-2423 | NW15443_NE |

CK=Check; ND=North Dakota; SD=South Dakota; WB =Westbred (Bayer); NE=Nebraska.

# Description of Test Plots and Breeder Entries

## Northern Growout:

There are 7 composited entries including one control and 6 breeding lines from 4 breeding programs (ND, SD, NE and AP). The Northern growout consisted of 4 locations (ND, SD, NE, and AP), but 3 locations (ND, SD, and AP) submitted the entries for the composites used for end-use quality testing.

## NORTH DAKOTA by Francois Marais and Bradley Bisek

### Growing Location & Conditions

The NDSU WQC grow-outs were located at the NDSU Agronomy Seed Farm (ASF) in Casselton, ND, approximately 20 miles west of Fargo. The grow-out strips (4' x 120') were seeded on Sept. 20th, 2022, into un-tilled field pea stubble. The fall was extremely dry, and lead to uneven germination and establishment of winter wheat plants. However, good snow amounts presented good cover to protect what plants were able to establish before the winter months and provided adequate moisture for growing plants in the spring melt. The WQC Grow-outs did not see any significant winter kill, but uneven stands were common within the strips due to compaction issues (tire tracks) and late germination of seeds. The spring months were dry and hot at times leading to overall concerns of stressed young plants, which most likely reduced yield amounts in the area. However, timely rains with accompanying moderate temperatures later in the season provided a more favorable environment for the winter wheat plants to rebound and mature appropriately. Urea was applied at a rate of 260 lbs/A (120 lbs N) by the ASF in the fall on November 8th, 2022. The pesticide Wolverine Advanced was sprayed on May 30$^{th}$ at the wheat jointing stage, to control weed growth. The WQC strips were harvested on July 31$^{31}$, 2023. Seed quality appeared to be adequate among the entries. Below are the yields for the harvested strips at Casselton.

| Entry Name | Yield (lbs) |
|---|---|
| | |
| **SY Monument** | 54.9 |
| **21NORD-160** | 61.2 |
| **XF4102** | 41.4 |
| **SD18B072-2** | 59.8 |
| **SD19B033-2** | 53.5 |
| **NE16562** | 47.5 |
| **NW15443** | 52.8 |
| | |
| **Jagalene - excluded** | 52.9 |
| **20NORD-138 - excluded** | 59 |
| **21NORD-154 - excluded** | 57.4 |
| **SD19B019-2 - excluded** | 56.3 |
| **NHH19651 - excluded** | 54.8 |

### 21NORD-160

21NORD-160 is an NDSU experimental line derived from a winter wheat project cross (16K474, Pedigree: RWG21/Jerry//Accipiter/14RGON-273). 21NORD-160 is shorter than the cultivar Jerry, and has shown to have generally good standability. 21NORD-160 has good winter survival ratings, and has performed adequately in grain yield in North Dakota. In the NDSU winter wheat project disease screenings, 21NORD-160 has shown to have adequate resistance to leaf rest, while containing excellent resistance to stem rust races prevalent in North Dakota. *Lr46* and *Sr24* are among confirmed DNA markers possessed by 21NORD-160. In 2024, 21NORD-160 will be included in regional variety trials in ND, SD, & MN, as well as a first-year entry to the NRPN trial.

## SOUTH DAKOTA by Sunish Sehgal

### Growing Location and Conditions

A total of 10 entries with two checks (Jagalene and SY Monument) were evaluated under the 2023 Northern Wheat Quality Council (WQC) grow-outs. At Brookings (SD), all entries were timely planted on September 20, 2022, as 200' long and 5' wide strips (7-rows) in oat stubble (no-till). A starter fertilizer 10-34-0 (10 gallons/ac) was applied at seeding. All entries had good emergence, but growth was limited going into winter due to dry fall. In spring 2023 no visible winter kill was observed, 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. Even with dry spring the winter wheat entries showed good tillering and the grain harvested per strip ranged from 99 lbs to 122 lbs. The grow-outs

were harvested on July 23, 2023. The grain protein content ranged from 13.2% to 14.9% and the test weight ranged from 58.8 lb/bu to 63.3 lb/bu among the 12 entries.

**SD18B072-2**

SD18B072-2 was developed from the cross Alice/SY Wolf and it has medium height and early maturity (one day later than Expedition). It has good straw strength and good winter hardiness. SD18B072-2 has been evaluated in 23 environments over two years in South Dakota Crop Performance Trials. Overall, SD18B072-2 ranked 6$^{th}$ in eastern, 21$^{st}$ in central, and 14$^{th}$ in western SD locations among 30 entries, demonstrating a good yield potential. It has an average test weight and average grain protein concentration. SD18B072-2 was resistant to most of the prevalent leaf rust races and likely carries *Lr24, Lr26,* and unknown genes. SD18B072-2 was rated overall good milling and baking quality. Across multiple trial locations (2022), its milling quality parameters (average flour yield 66.6 %), mixograph mix time (mins) of 5.2, and mix tolerance of 4.0 and baking quality parameters (average loaf volume 1037 cm$^3$ and specific volume 6.8 cc/g) were comparable to SY Monument (average flour yield 65.8%, mix time 10 and mix tolerance 6.0, average loaf volume 1000 cm$^3$, and specific volume 6.7 cc/g).

**SD19B033-2**

SD19B033-2 was developed from the cross SD07W083-7/NE09499. It is medium-tall height (*Rht-B1b*) with late maturity. It is a high-yielding line with good test weight and excellent grain protein content. SD19B033-2 has been evaluated for 46-year location trials to date**.** In SDSU Elite yield trials in 2021, SD19B033-2 ranked 6$^{th}$ overall among 36 entries across 8 locations. Owing to good yield performance, resistance to stem rust, and good quality SD19B033-2 was entered in SD CPT trials in 2022. Overall, in the last 2 years, SD19B033-2 ranked 7$^{th}$ in eastern SD, 7$^{th}$ in central SD, and 23$^{rd}$ in western SD. It showed good resistance to Bacterial Leaf Streak and Stem rust in 2023. SD19B033-2 has shown very good milling and baking characteristics in USDA and SDSU evaluations. Across multiple trial locations (2022), its milling quality parameters (average flour yield 67.7 %), mixograph mix time of 6.0 and mix tolerance of 5.0 and baking quality parameters (average loaf volume 1015 cm$^3$ and specific volume 6.7 cc/g) were comparable to SY Monument (average flour yield 65.8%, mix time 10 and mix tolerance 6.0, average loaf volume 1000 cm$^3$, and specific volume 6.7 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 and central South Dakota, 2022 and 2023).

| | 2023 | | | 2 year | | | | 2023 | | | 2 year | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variety | Yield (bu/ac) | Test Wt (lb/bu) | Protein (%) | Yield (bu/ac) | Test Wt (lb/bu) | Protein (%) | Variety | Yield (bu/ac) | Test Wt (lb/bu) | Protein (%) | Yield (bu/ac) | Test Wt (lb/bu) | Protein (%) |
| SD18B025-8 | 74.7 | 60.0 | 13.9 | 69.1 | 59.4 | 13.9 | WB4422 | 56.4 | 61.4 | 13.6 | 67.1 | 60.7 | 14.3 |
| WB4422 | 68.2 | 59.5 | 14.4 | 65.5 | 59.1 | 14.3 | SD18B025-8 | 60.8 | 61.7 | 13.8 | 67.0 | 60.3 | 14.2 |
| SD Andes | 71.8 | 60.4 | 13.3 | 65.3 | 59.2 | 13.4 | SD Andes | 57.3 | 61.7 | 13.5 | 65.2 | 60.7 | 13.7 |
| LCS Steel AX | 73.9 | 59.7 | 13.3 | 65.1 | 58.4 | 13.1 | SY Wolverine | 54.6 | 60.1 | 13.2 | 64.6 | 59.8 | 13.7 |
| SD Midland | 68.2 | 58.8 | 13.2 | 64.6 | 58.7 | 13.5 | SD Midland | 59.8 | 61.0 | 13.1 | 64.2 | 60.1 | 13.7 |
| **SD18B072-2** | **66.7** | **57.6** | **13.7** | **64.2** | **58.1** | **13.7** | CP7017AX | 53.2 | 60.1 | 13.4 | 64.1 | 59.5 | 13.2 |
| **SD19B033-2** | **72.0** | **59.5** | **14.1** | **64.0** | **59.0** | **14.0** | **SD19B033-2** | **57.7** | **61.4** | **13.7** | **63.9** | **60.1** | **14.1** |
| Winner | 69.0 | 58.6 | 13.8 | 63.9 | 58.2 | 13.8 | LCS Steel AX | 56.3 | 60.6 | 13.3 | 63.8 | 59.4 | 13.2 |
| SD19B019-2 | 64.3 | 60.5 | 13.8 | 63.4 | 59.7 | 13.8 | WB4309 | 54.5 | 59.4 | 13.4 | 63.5 | 58.8 | 13.9 |
| CP7017AX | 63.8 | 57.8 | 13.1 | 63.3 | 57.6 | 13.0 | Draper | 54.5 | 60.1 | 13.9 | 62.6 | 59.0 | 14.1 |
| SD15035-2 | 66.8 | 60.3 | 13.7 | 63.2 | 59.2 | 14.0 | LCS Helix AX | 51.5 | 60.8 | 13.4 | 62.3 | 60.4 | 13.5 |
| WB4309 | 67.6 | 57.1 | 14.1 | 62.6 | 57.5 | 13.8 | Redfield | 55.6 | 61.2 | 14.1 | 62.1 | 59.4 | 14.4 |
| Byrd CL Plus | 67.5 | 59.3 | 13.1 | 62.3 | 57.7 | 13.2 | CP7909 | 51.0 | 60.0 | 13.2 | 61.8 | 59.3 | 13.4 |
| Draper | 65.1 | 58.4 | 13.7 | 62.3 | 57.7 | 13.8 | AP Clair | 49.6 | 60.2 | 13.8 | 61.7 | 59.7 | 13.9 |
| AP Clair | 64.5 | 58.3 | 13.9 | 62.2 | 58.3 | 13.9 | MS Maverick | 57.1 | 61.2 | 13.7 | 61.7 | 59.6 | 14.1 |
| SY Wolverine | 64.7 | 58.4 | 13.6 | 62.1 | 58.1 | 13.6 | Ideal | 57.9 | 61.5 | 13.4 | 61.4 | 60.2 | 13.8 |
| Redfield | 67.1 | 59.2 | 13.5 | 61.9 | 58.3 | 14.1 | Byrd CL Plus | 53.4 | 60.3 | 13.3 | 61.3 | 58.8 | 13.3 |
| CP7909 | 65.9 | 58.4 | 13.3 | 61.8 | 58.9 | 13.3 | Winner | 56.1 | 60.6 | 13.2 | 61.3 | 59.8 | 14.2 |
| LCS Helix AX | 62.1 | 59.2 | 13.2 | 61.2 | 58.6 | 13.2 | AP 18AX | 53.0 | 59.6 | 13.8 | 61.1 | 59.1 | 13.6 |
| CP7869 | 62.8 | 57.7 | 13.5 | 61.0 | 58.0 | 13.3 | SD15035-2 | 56.1 | 62.1 | 13.8 | 61.1 | 60.8 | 14.1 |
| MS Maverick | 66.6 | 59.2 | 13.7 | 60.8 | 58.1 | 13.9 | **SD18B072-2** | **52.3** | **59.8** | **13.5** | **61.0** | **59.0** | **13.9** |
| Ideal | 63.0 | 58.6 | 13.4 | 60.7 | 58.6 | 13.8 | AP Bigfoot | 50.1 | 59.9 | 13.7 | 61.0 | 59.2 | 13.8 |
| WB4510CLP | 69.8 | 60.7 | 13.0 | 60.4 | 58.9 | 13.4 | SD19B019-2 | 52.8 | 62.2 | 13.9 | 61.0 | 61.1 | 14.3 |
| AP Bigfoot | 58.1 | 57.8 | 13.7 | 60.1 | 57.7 | 13.6 | Kivari AX | 53.7 | 61.0 | 12.9 | 60.8 | 59.4 | 12.6 |
| AP 18AX | 61.8 | 57.2 | 14.0 | 59.7 | 57.1 | 13.8 | Crescent AX | 48.5 | 60.3 | 13.4 | 60.5 | 59.7 | 13.5 |
| Crescent AX | 60.9 | 57.9 | 13.6 | 59.4 | 58.2 | 13.5 | LCS Chrome | 54.5 | 61.1 | 14.2 | 60.3 | 59.3 | 14.6 |
| Kivari AX | 65.9 | 58.6 | 12.9 | 59.2 | 57.2 | 12.7 | CP7869 | 53.3 | 60.6 | 13.4 | 59.8 | 59.7 | 13.7 |
| CP7266AX | 63.2 | 58.2 | 13.9 | 57.8 | 57.7 | 13.7 | CP7266AX | 50.0 | 60.3 | 13.7 | 57.6 | 59.1 | 13.5 |
| LCS Chrome | 60.9 | 58.7 | 14.3 | 57.2 | 58.1 | 14.5 | Expedition | 48.8 | 61.4 | 14.2 | 57.4 | 60.0 | 14.5 |
| Expedition | 56.5 | 58.3 | 14.1 | 57.1 | 58.3 | 14.4 | WB4510CLP | 55.0 | 63.0 | 13.1 | 57.1 | 61.0 | 13.9 |
| Trial Average | 66 | 58.9 | 13.7 | 62.1 | 58.4 | 13.7 | Trial Average | 54.1 | 60.9 | 13.6 | 61.9 | 59.8 | 13.8 |
| LSD | 4 | 1.1 | 0.3 | 1.9 | 0.5 | 0.2 | LSD | 3.6 | 0.5 | 0.3 | 2.2 | 0.4 | 0.2 |
| CV | 7.6 | | | 6.1 | | | CV | 9.6 | | | 8.3 | | |

## SYNGENTA by Josh Coltrain

Northern and Southern uniform growout increase strips were planted on 10/5/22 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. Timely rains created excellent growing conditions at the site which was unique for most of the growing region. The increase strips were harvested on June 29, 2023 with very high yield levels.

## NEBRASKA by Katherine Frels

The 2022-2023 test site in Lincoln, NE was subjected to exceptional drought conditions from planting to maturity and was not submitted for analysis.

**NE16562**

NE16562 (HV9W02-942R/Camelot) is a hard red winter wheat with broad adaptation across Nebraska with highest yield potential in high rainfall regions with intensive management practices. It out-yields LCS Valiant in breeding program and Nebraska state variety trials with slightly lower testweight. NE16562 has medium plant height comparable to LCS Valiant and is early maturing. Grain size averages 34 mg per seed with average protein content. This line has had good water absorption and good mixing and baking characteristics in UNL quality tests. It is moderately susceptible to stripe, stem, and leaf rust and susceptible to FHB. It is a hollow stem variety susceptible to wheat stem sawfly and Hessian fly. It is a variety release candidate in 2023 pending seed increase success.

**NW15443**

NW15443 (OR 2060108/NW03681//NW03666) is a hard white winter wheat targeted toward west-central and south western Nebraska. Lower test weight It is a medium tall, comparable in height to the drought tolerant variety Robidoux. It has medium-late maturity and has escaped several late freezes while in yield testing. Large grain size (36mg) comparable to LCS Valiant. Med-tall plant height comparable to the variety Robidoux. NW15443 has excellent protein content, good water absorption and mixing characteristics, but has had lower loaf volume and bake scores in UNL quality tests. It is MR/MS to stripe and stem rust and susceptible to leaf rust. It is moderately susceptible to FHB. It is a hollow stem variety susceptible to wheat stem sawfly and Hessian fly.

## BAYER (WESTBRED) by Adam Bray

## XF4102 (2444102 Out-license)

XF4102 is a medium maturity hard red winter wheat with great straw strength, improved test weight and protein over Keldin. It has good winterhardiness and is well adapted to Montana with comparable yields to Keldin. It has improved Wheat Streak Mosaic Virus tolerance compared to Keldin. It is moderately resistant to FHB and Leaf Rust, and moderately susceptible to Stripe Rust. Internal quality testing indicates above average protein with good functionality. 2444102 was offered for Out-licensing in 2023 due to its yield stability and improvements over Keldin across Montana and the Northern Plains.

# Northern Growout: 2023 (Small-Scale) Samples

| Test entry number | 23-2417 | 23-2418 | 23-2419 | 23-2420 |
|---|---|---|---|---|
| **Sample identification** | **SY Monument_CK** | **21Nord-160_ND** | **XF4102_WB** | **SD18B072-2_SD** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 2 HRW | 2 HRW | 2 HDWH | 2 HRW |
| **Test weight (lb/bu)** | 59.0 | 58.9 | 59.9 | 59.4 |
| **Hectoliter weight (kg/hl)** | 77.6 | 77.5 | 78.8 | 78.2 |
| **1000 kernel weight (gm)** | 27.2 | 25.6 | 29.8 | 30.5 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 68.8 | 52.7 | 65.5 | 72.5 |
| Over 9 wire (%) | 30.6 | 45.7 | 33.9 | 27.2 |
| Through 9 wire (%) | 0.7 | 1.7 | 0.7 | 0.4 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 70.0/16.9 | 27.3/18.7 | 61.3/16.9 | 53.7/14.9 |
| Weight (mg) (avg/s.d) | 28.8/9.6 | 28.9/10.5 | 31.6/10.6 | 31.2/9.5 |
| Diameter (mm)(avg/s.d) | 2.56/0.40 | 2.43/0.39 | 2.64/0.42 | 2.66/0.40 |
| Moisture (%) (avg/s.d) | 12.2/0.8 | 12.3/0.6 | 12.0/0.6 | 11.7/0.6 |
| SKCS distribution | 02-05-20-73-01 | 67-17-09-07-04 | 06-13-25-56-01 | 09-20-35-36-01 |
| Classification | Hard | Soft | Hard | Hard |
| **Wheat protein (12% mb)** | 12.9 | 13.6 | 14.2 | 12.9 |
| **Wheat ash (12% mb)** | 1.60 | 1.78 | 1.67 | 1.56 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 76.5 | 70.4 | 74.4 | 76.9 |
| Quadrumat Sr. Mill | 67.9 | 61.5 | 66.4 | 70.0 |
| **Flour moisture (%)** | 12.5 | 12.0 | 12.4 | 12.9 |
| **Flour protein (14% mb)** | 11.6 | 11.9 | 12.9 | 12.0 |
| **Flour ash (14% mb)** | 0.61 | 0.52 | 0.58 | 0.51 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 5.9 | 5.9 | 6.1 | 6.0 |
| Peak viscosity (RVU) | 178.6 | 179.8 | 178.3 | 180.3 |
| Breakdown (RVU) | 72.3 | 72.0 | 70.9 | 67.9 |
| Final viscosity at 13 min (RVU) | 204.8 | 210.7 | 202.6 | 215.2 |
| **Minolta color meter** | | | | |
| L* | 90.39 | 91.77 | 90.66 | 91.18 |
| a* | -0.90 | -0.90 | -0.89 | -0.90 |
| b* | 9.00 | 7.20 | 8.70 | 7.86 |
| **PPO** | 0.255 | 0.397 | 0.422 | 0.564 |
| **Falling number (sec)** | 417 | 356 | 407 | 396 |
| **Damaged Starch** | | | | |
| (AI%) | 96.8 | 95.1 | 97.1 | 97.0 |
| (AACC76-31) | 6.9 | 5.6 | 7.2 | 7.0 |

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

# Northern Growout: 2023 (Small-Scale) Samples (continued)

| Test entry number | 23-2421 | 23-2422 | 23-2423 |
|---|---|---|---|
| **Sample identification** | **SD19B033-2_SD** | **BF NE16562_NE** | **NW15443_NE** |
| **Wheat Data** | | | |
| **GIPSA classification** | 1 HRW | 2 HRW | 2 XWHT* |
| **Test weight (lb/bu)** | 60.5 | 59.8 | 59.8 |
| **Hectoliter weight (kg/hl)** | 79.6 | 78.7 | 78.7 |
| **1000 kernel weight (gm)** | 28.8 | 28.8 | 35.2 |
| **Wheat kernel size (Rotap)** | | | |
| Over 7 wire (%) | 61.7 | 62.7 | 78.6 |
| Over 9 wire (%) | 38.0 | 37.1 | 21.2 |
| Through 9 wire (%) | 0.3 | 0.3 | 0.3 |
| **Single kernel (skcs)[a]** | | | |
| Hardness (avg /s.d) | 70.1/14.3 | 66.3/16.2 | 59.7/14.9 |
| Weight (mg) (avg/s.d) | 31.3/8.7 | 30.4/8.5 | 35.6/11.5 |
| Diameter (mm)(avg/s.d) | 2.62/0.35 | 2.66/0.36 | 2.78/0.44 |
| Moisture (%) (avg/s.d) | 12.3/0.5 | 12.3/0.6 | 12.1/0.5 |
| SKCS distribution | 01-05-17-77-01 | 03-08-19-70-01 | 05-13-31-51-01 |
| Classification | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 13.8 | 12.9 | 13.5 |
| **Wheat ash (12% mb)** | 1.61 | 1.70 | 1.70 |
| **Milling and Flour Quality Data** | | | |
| **Flour yield (%, str. grade)** | | | |
| Miag Multomat Mill | 76.8 | 75.2 | 74.6 |
| Quadrumat Sr. Mill | 69.0 | 66.4 | 67.1 |
| **Flour moisture (%)** | 13.2 | 13.1 | 12.6 |
| **Flour protein (14% mb)** | 12.3 | 11.9 | 11.9 |
| **Flour ash (14% mb)** | 0.56 | 0.64 | 0.56 |
| **Rapid Visco-Analyser** | | | |
| Peak time (min) | 5.9 | 6.0 | 5.9 |
| Peak viscosity (RVU) | 180.9 | 159.8 | 157.0 |
| Breakdown (RVU) | 81.7 | 61.9 | 68.2 |
| Final viscosity at 13 min (RVU) | 185.6 | 186.9 | 176.3 |
| **Minolta color meter** | | | |
| L* | 90.56 | 90.87 | 91.15 |
| a* | -0.70 | -0.79 | -1.08 |
| b* | 8.35 | 7.79 | 8.87 |
| **PPO** | 0.574 | 0.551 | 0.194 |
| **Falling number (sec)** | 385 | 375 | 383 |
| **Damaged Starch** | | | |
| (AI%) | 97.1 | 97.1 | 97.0 |
| (AACC76-31) | 7.1 | 7.2 | 7.1 |

[a]s.d. = standard deviation; skcs = Single Kernel Characterization System 4100. *89%HDWH11%HRW

# Northern Growout: Physical Dough Tests and Gluten Analysis 2023 (Small-Scale) Samples

| Test Entry Number | 23-2417 | 23-2418 | 23-2419 | 23-2420 |
|---|---|---|---|---|
| Sample Identification | SY Monument_CK | 21Nord-160_ND | XF4102_WB | SD18B072-2_SD |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 66.6 | 65.7 | 67.1 | 65.9 |
| Flour Abs (14% mb) | 65.1 | 63.7 | 65.7 | 64.8 |
| Mix Time (min) | 6.6 | 3.5 | 3.8 | 5.6 |
| Mix tolerance (0-6) | 5 | 3 | 4 | 5 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 63.8 | 59.6 | 66.7 | 63.7 |
| Flour Abs (14% mb) | 62.3 | 57.5 | 65.3 | 62.5 |
| Peak time (min) | 4.5 | 3.5 | 6.2 | 4.3 |
| Mix stability (min) | 10.3 | 9.0 | 10.2 | 11.7 |
| Mix Tolerance Index (FU) | 28 | 21 | 32 | 22 |
| Breakdown time (min) | 10.6 | 9.6 | 11.1 | 10.8 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 135 | 90 | 136 | 120 |
| L(mm): Extensibility | 59 | 97 | 84 | 99 |
| G(mm): Swelling index | 17.1 | 21.9 | 20.3 | 22.1 |
| W($10^{-4}$ J): strength (curve area) | 334 | 296 | 395 | 433 |
| P/L: curve configuration ratio | 2.29 | 0.93 | 1.62 | 1.21 |
| Ie($P_{200}$/P): elasticity index | 64.0 | 58.5 | 57.9 | 63.7 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 607/743/868 | 424/469/472 | 385/396/434 | 489/594/637 |
| Extensibility (mm at 45/90/135 min) | 151/130/133 | 158/154/152 | 155/167/159 | 159/149/145 |
| Energy ($cm^2$ at 45/90/135 min) | 174/165/199 | 126/129/128 | 109/120/129 | 151/164/179 |
| Resist $_{max}$ (BU at 45/90/135min) | 922/1069/1264 | 614/647/657 | 542/547/654 | 749/912/1029 |
| Ratio (at 45/90/135 min) | 4.0/5.7/6.6 | 2.7/3.0/3.1 | 2.5/2.4/2.7 | 3.1/4.0/4.4 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 1, 7+9, 5+10 | 1, 7+8, 5+10 | 1/2*, 7+9, 5+10 | 2*, 7+9, 5+10 |
| TPP/TMP | 0.92 | 1.12 | 0.81 | 0.82 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 66.5 | 60.7 | 66.0 | 69.2 |

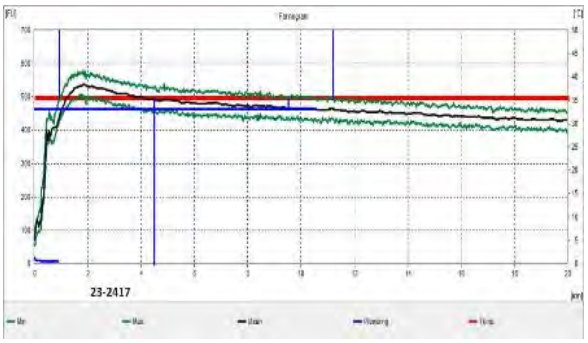
# Northern Growout: Physical Dough Tests and Gluten Analysis 2023 (Small-Scale) Samples (continued)

| Test Entry Number | 23-2421 | 23-2422 | 23-2423 |
|---|---|---|---|
| Sample Identification | SD19B033-2_SD | NE16562_NE | NW15443-NE |
| **MIXOGRAPH** | | | |
| Flour Abs (% as-is) | 68.0 | 65.3 | 67.9 |
| Flour Abs (14% mb) | 67.2 | 64.6 | 66.7 |
| Mix Time (min) | 6.0 | 4.3 | 6.0 |
| Mix tolerance (0-6) | 5 | 4 | 4 |
| **FARINOGRAPH** | | | |
| Flour Abs (% as-is) | 63.7 | 64.6 | 65.6 |
| Flour Abs (14% mb) | 62.9 | 63.9 | 64.4 |
| Peak time (min) | 5.5 | 7.7 | 4.9 |
| Mix stability (min) | 13.5 | 12.3 | 12.3 |
| Mix Tolerance Index (FU) | 14 | 24 | 20 |
| Breakdown time (min) | 13.2 | 13.0 | 11.8 |
| **ALVEOGRAPH** | | | |
| P(mm): Tenacity | 134 | 147 | 152 |
| L(mm): Extensibility | 80 | 55 | 68 |
| G(mm): Swelling index | 19.9 | 16.5 | 18.3 |
| W($10^{-4}$ J): strength (curve area) | 416 | 325 | 407 |
| P/L: curve configuration ratio | 1.68 | 2.67 | 2.24 |
| Ie($P_{200}$/P): elasticity index | 65.1 | 57.7 | 62.4 |
| **EXTENSIGRAPH** | | | |
| Resist (BU at 45/90/135 min) | 512/764/846 | 396/449/474 | 505/564/650 |
| Extensibility (mm at 45/90/135 min) | 138/137/173 | 140/139/140 | 149/149/133 |
| Energy ($cm^2$ at 45/90/135 min) | 126/187/173 | 96/108/114 | 137/156/155 |
| Resist $_{max}$ (BU at 45/90/135min) | 702/1108/1136 | 525/609/644 | 726/866/977 |
| Ratio (at 45/90/135 min) | 3.7/5.6/6.6 | 2.8/3.2/3.4 | 3.4/3.8/4.9 |
| **PROTEIN ANALYSIS** | | | |
| HMW-GS Composition | 2*, 17+18, 5+10 | null, 7+9, 2+12 | 2*, 7+9, 5+10 |
| TPP/TMP | 0.71 | 0.75 | 0.80 |
| **SEDIMENTATION TEST** | | | |
| Volume (ml) | 65.5 | 50.6 | 62.7 |

# Physical Dough Tests – Farino and Mixo

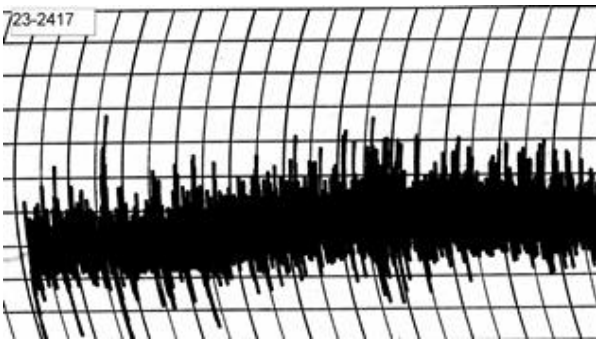
## 2023 (Small Scale) Samples – Northern Growout

### Farinograms



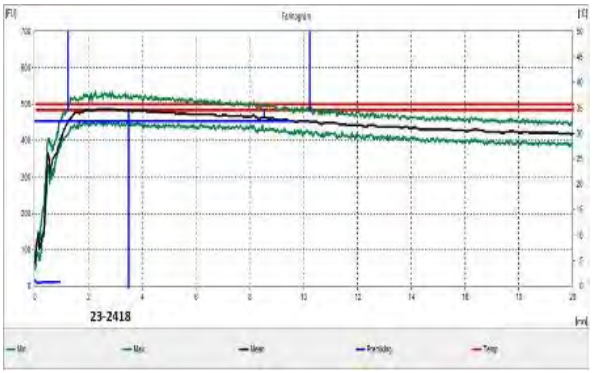

Water abs = 62.3%, Peak time = 4.5 min,
Mix stab = 10.3 min, MTI = 28 FU

### Mixograms

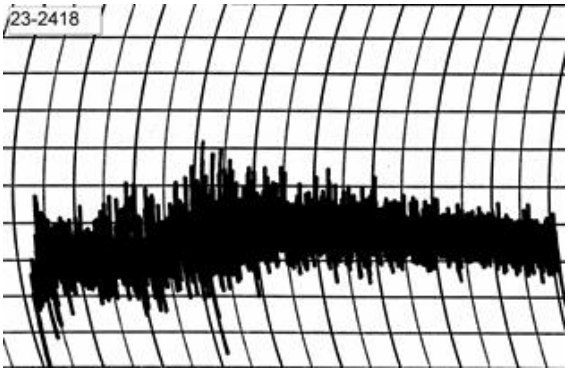



Water abs = 65.1%
Mix time = 6.6 min

### 23-2417, SY Mounment_CK




Water abs = 57.5%, Peak time = 3.5 min,
Mix stab = 9.0 min, MTI = 21 FU



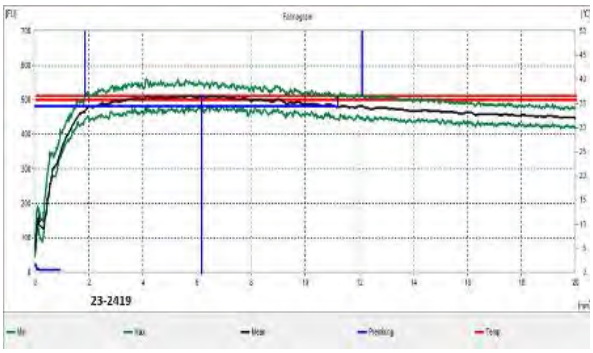

Water abs = 63.7%
Mix time = 3.5 min

### 23-2418, 21Nord-160_ND

# Physical Dough Tests – Farino and Mixo

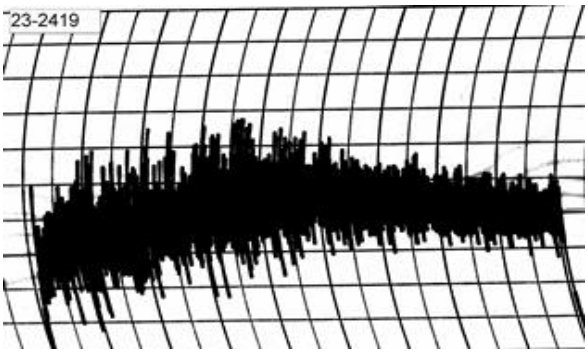
## 2023 (Small Scale) Samples – Northern Growout (Continued)

### Farinograms




Water abs = 65.3%, Peak time = 6.2 min,
Mix stab = 10.2 min, MTI = 32 FU

### Mixograms



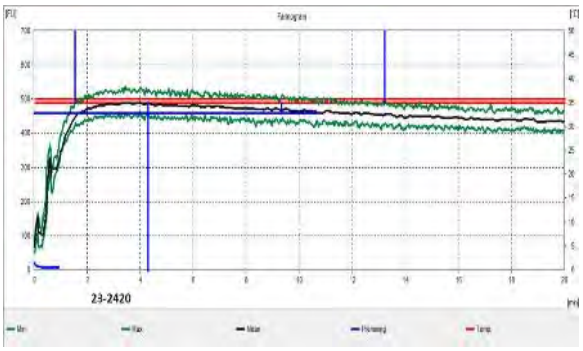

Water abs = 65.7%
Mix time = 3.8 min

**23-2419, XF4102_WB**

# Physical Dough Tests - Farino and Mixo

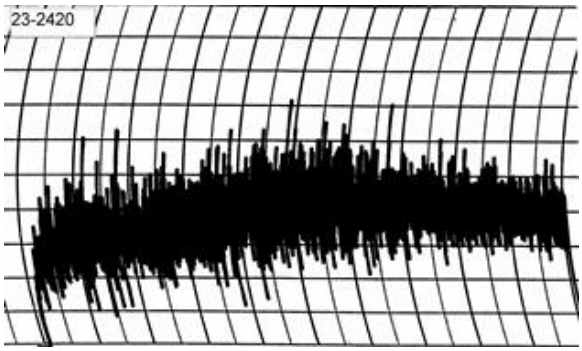
## 2023 (Small Scale) Samples – Northern Growout (Continued)

### Farinograms



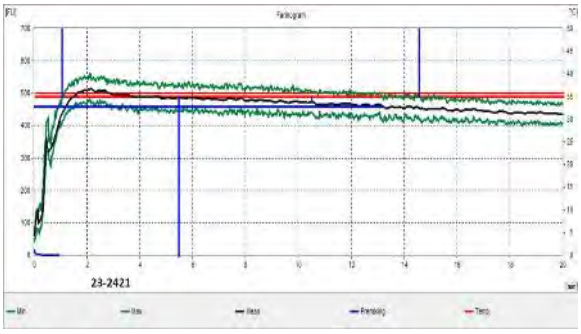

Water abs = 62.5%, Peak time = 4.3 min,
Mix stab = 11.7 min, MTI = 22 FU

### Mixograms

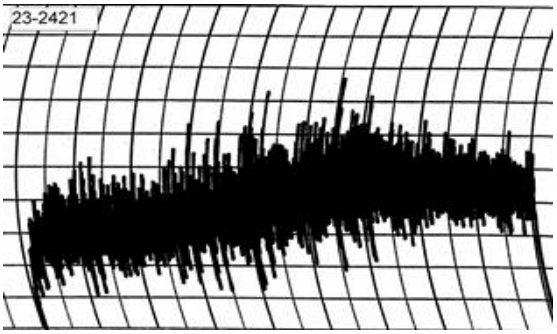



Water abs = 64.8%
Mix time = 5.6 min

## 23-2420, SD18B072-2_SD




Water abs = 62.9%, Peak time = 5.5 min,
Mix stab = 13.5 min, MTI = 14 FU



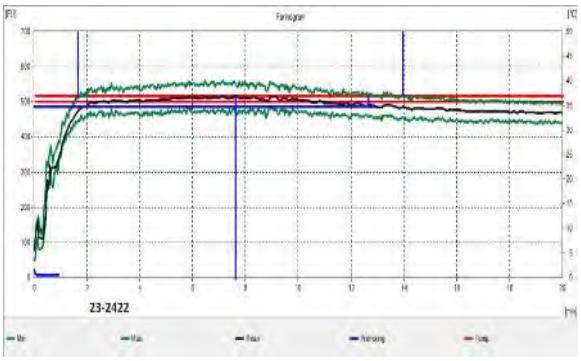

Water abs = 67.2%
Mix time = 6.0 min

## 23-2421, SD19B033-2_SD

# Physical Dough Tests- Farino and Mixo

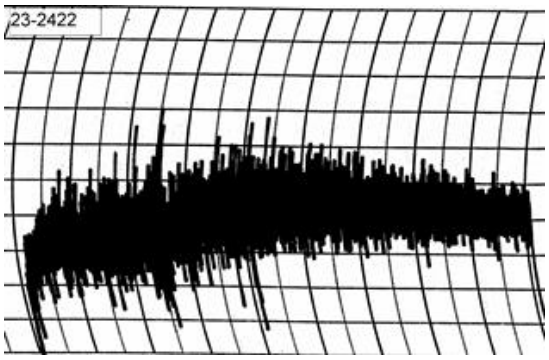
## 2023 (Small Scale) Samples – Northern Growout (Continued)

### Farinograms



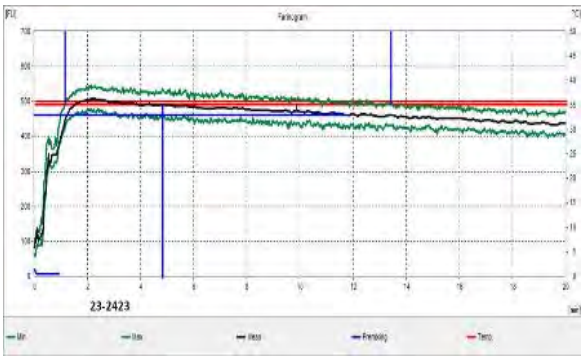

Water abs = 63.9%, Peak time = 7.7 min,
Mix stab = 12.3 min, MTI = 24 FU

### Mixograms

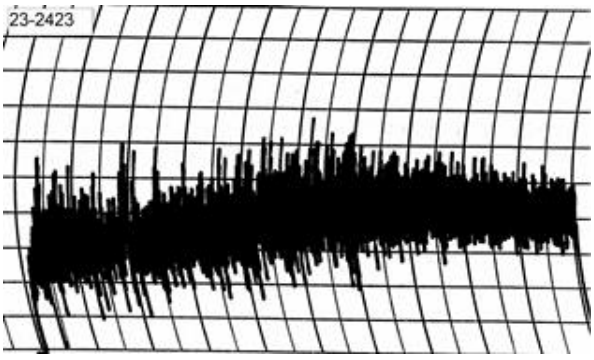



Water abs = 64.6%
Mix time = 4.3 min

### 23-2422, NE16562_NE




Water abs = 64.5%, Peak time = 4.9 min,
Mix stab = 12.3 min, MTI = 20 FU

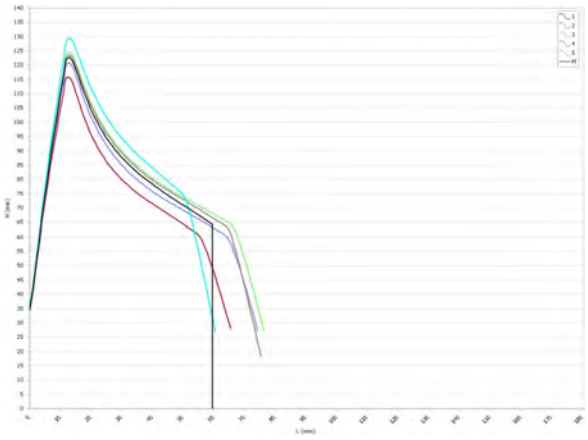



Water abs = 66.7%
Mix time = 6.0 min

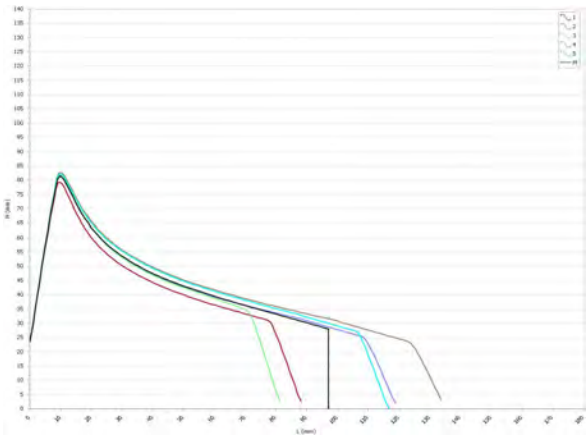
### 23-2423, NW15443_NE

# Physical Dough Tests - Alveograms

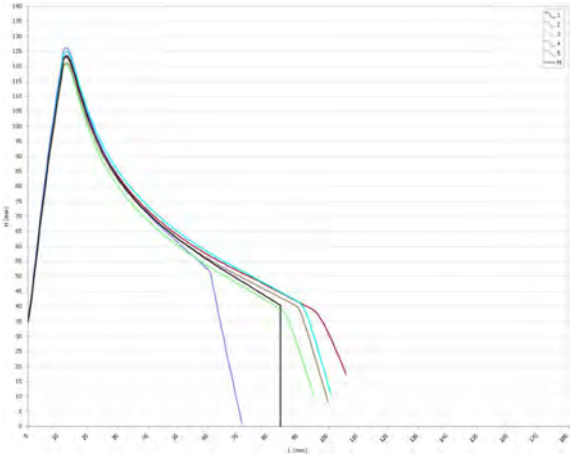
## 2023 (Small Scale) Samples – Northern Growout



**23-2417, SY Monument_CK**
P(mm $H_20$) = 135, L(mm) = 59, W($10E^{-4}$ J) = 334



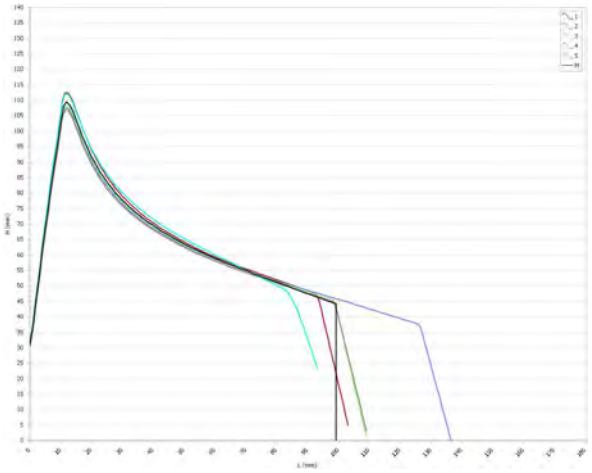
**23-2418, 21Nord-160_ND**
P(mm $H_20$) = 90, L(mm) = 97, W($10E^{-4}$ J) = 296



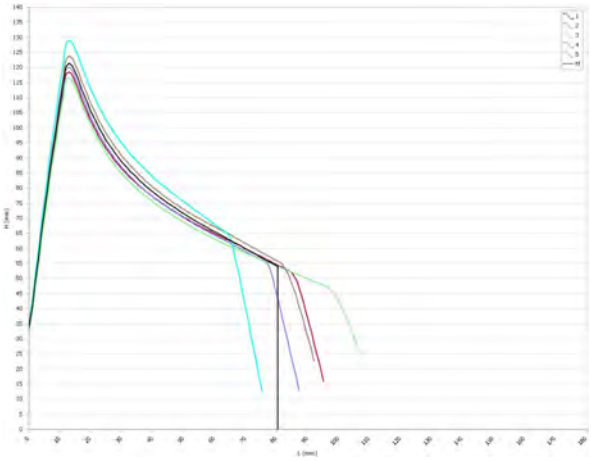
**23-2419, XF4102_WB**
P(mm $H_20$) = 136, L(mm) = 84, W($10E^{-4}$ J) = 395

# Physical Dough Tests - Alveograms

## 2023 (Small Scale) Samples – Northern Growout (Continued)

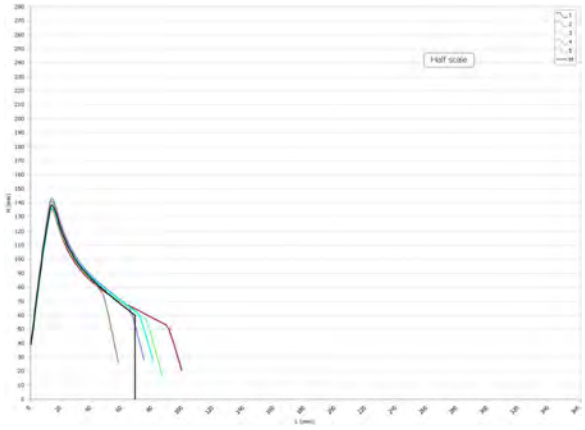


**23-2420, SD18B072-2_SD**
P(mm $H_20$) = 120, L(mm) = 99, W($10E^{-4}$ J) = 433



**23-2421, SD19B033-2_SD**
P(mm $H_20$) = 134, L(mm) = 80, W($10E^{-4}$ J) = 416

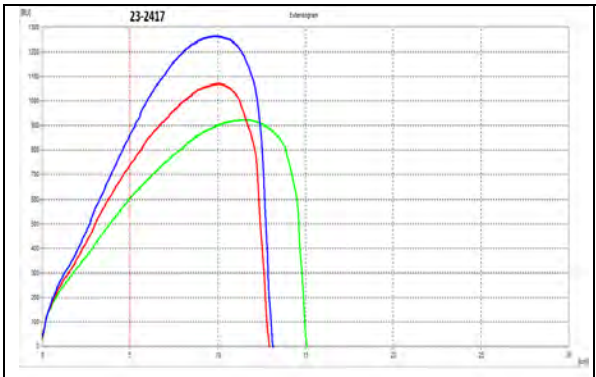
**23-2422, NE19562_NE**
P(mm $H_20$) = 147, L(mm) = 55, W($10E^{-4}$ J) = 325



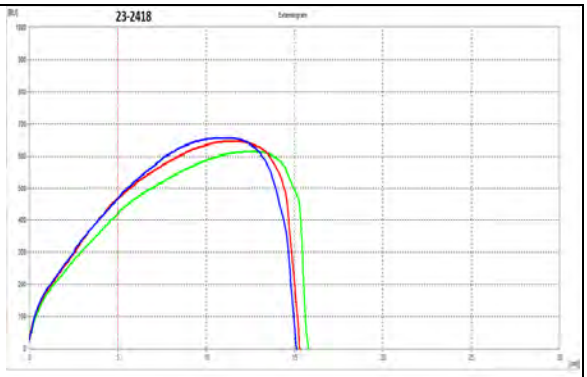
**23-2423, NW15443_NE**
P(mm $H_20$) = 152, L(mm) = 68, W($10E^{-4}$ J) = 407

# Physical Dough Tests - Extensigrams

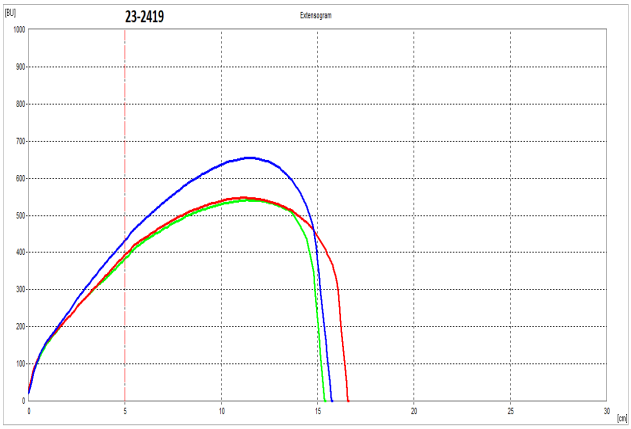
## 2023 (Small Scale) Samples – Northern Growout




**23-2417, SY Monument_CK**
R (BU) =743, E (mm) = 130, W ($cm^2$) = 165
Rmax (BU) = 1069, Ratio = 5.7 at 90 min




**23-2418, 21Nord-160_ND**
R (BU) = 469, E (mm) = 154, W ($cm^2$) = 129
Rmax (BU) = 647, Ratio = 3.0 at 90 min

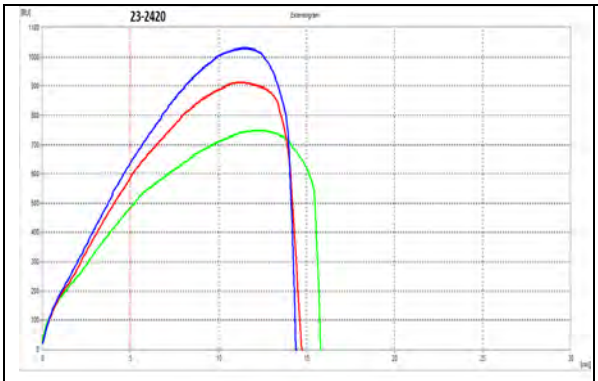



**23-2419, XF4102_WB**
R (BU) = 396, E (mm) = 167, W ($cm^2$) = 120
Rmax (BU) = 547, Ratio = 2.4 at 90 min

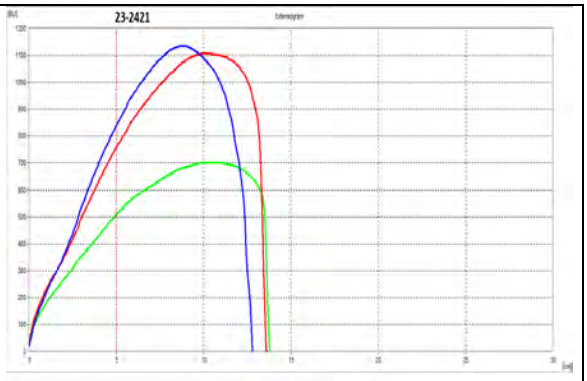
Notes: R (BU) = Resistance; E (mm) = Extensibility; W ($cm^2$) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

# Physical Dough Tests - Extensigrams

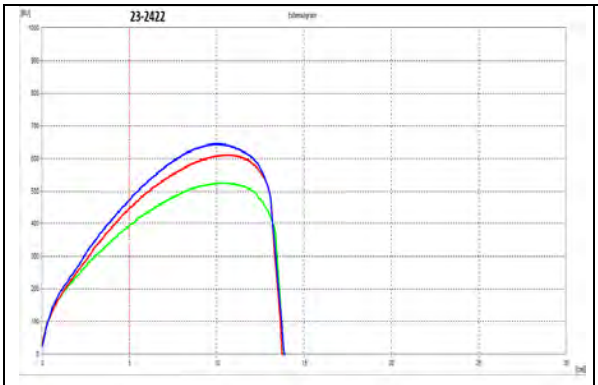
## 2023 (Small Scale) Samples – Northern Growout (Continued)



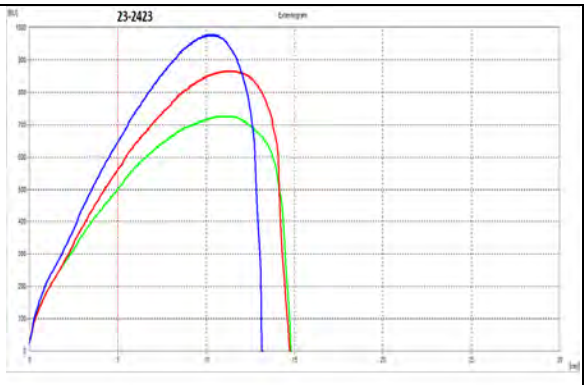

**23-2420, SD18B072-2_ND**
R (BU) = 594, E (mm) = 149, W ($cm^2$) = 164
Rmax (BU) = 912, Ratio = 4.0 at 90 min




**23-2421, SD19B033-2_SD**
R (BU) = 764, E (mm) = 137, W ($cm^2$) = 186
Rmax (BU) = 1108, Ratio = 5.6 at 90 min



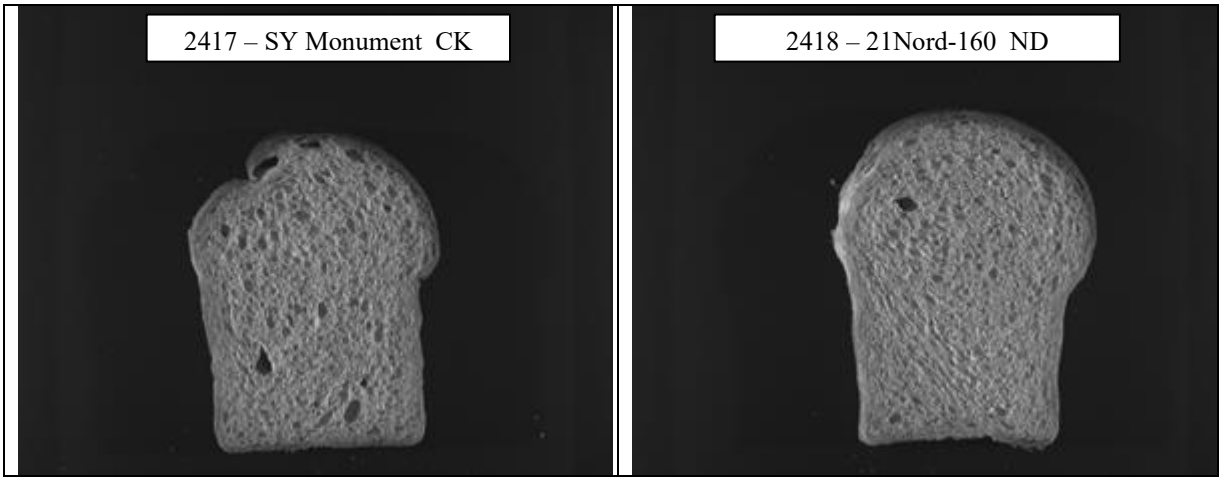

**23-2422, NE16562_NE**
R (BU) = 449, E (mm) = 139, W ($cm^2$) = 108
Rmax (BU) = 609, Ratio = 3.2 at 90 min



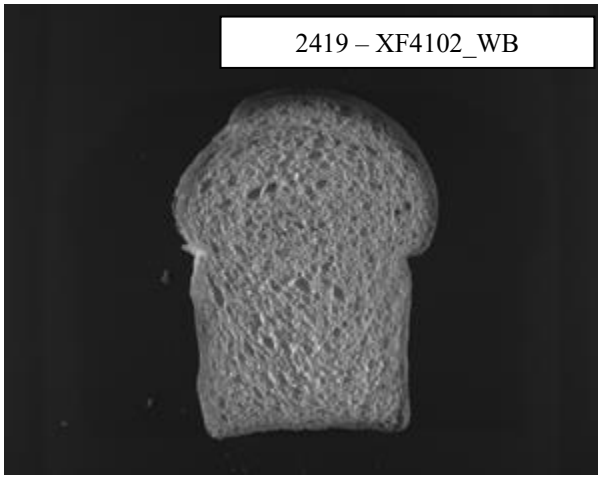

**23-2423, NW15443_NE**
R (BU) = 564, E (mm) = 149, W ($cm^2$) = 156
Rmax (BU) = 866, Ratio = 3.8 at 90 min

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

# Northern Growout: C-Cell Bread Images and Analysis
# 2023 (Small-Scale) Samples

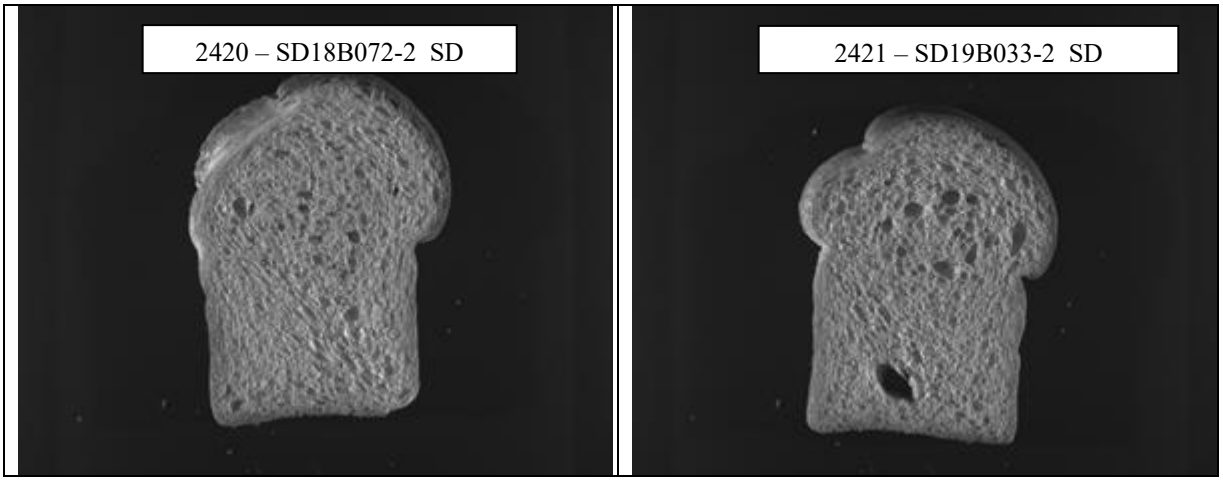



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2417** | 6271 | 109 | 3478 | 0.433 | 2.045 | 2.418 | 1.788 | -2.78 |
| **2418** | 6780 | 114 | 4095 | 0.420 | 1.930 | 0.775 | 1.740 | -8.25 |

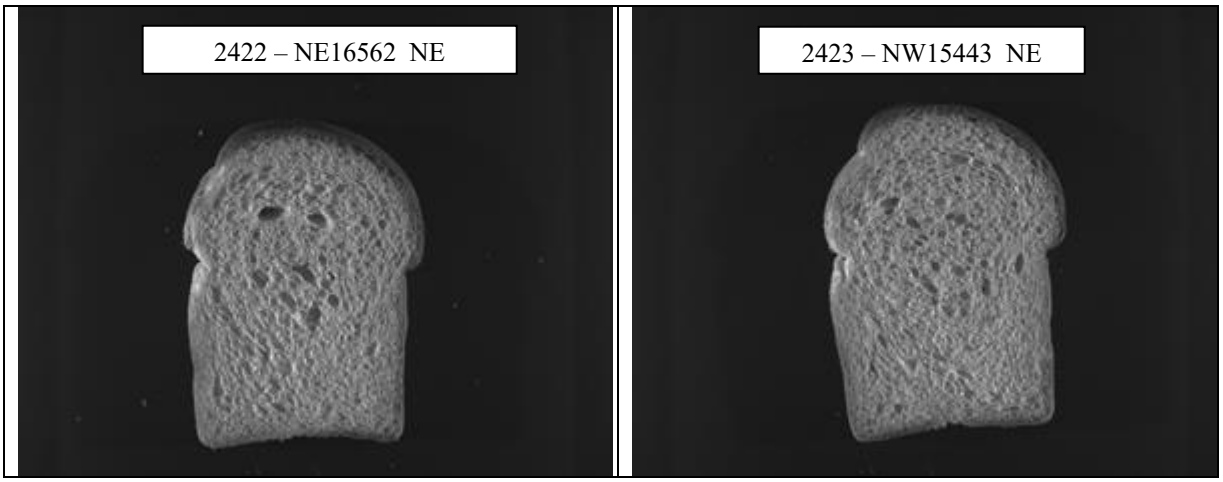



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2419** | 6995 | 111 | 3952 | 0.430 | 2.105 | 2.900 | 1.710 | -4.30 |

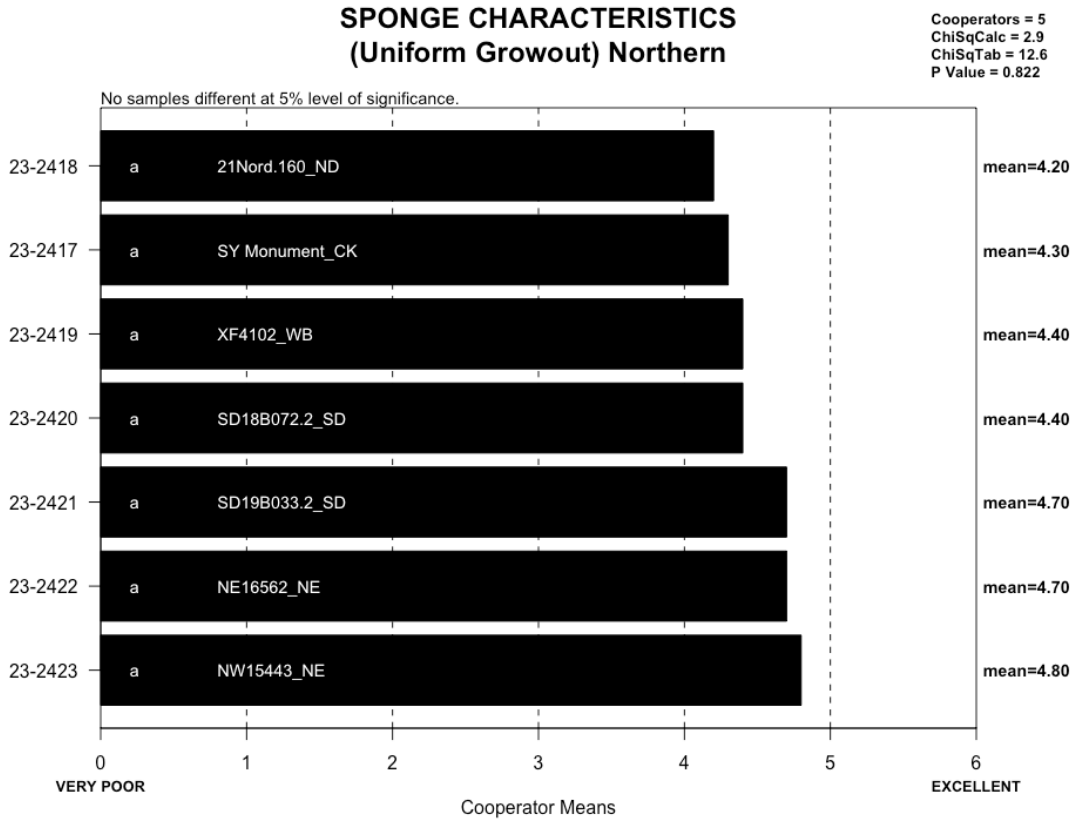
# Northern Growout: C-Cell Bread Images and Analysis
# 2023 (Small-Scale) Samples (Continued)

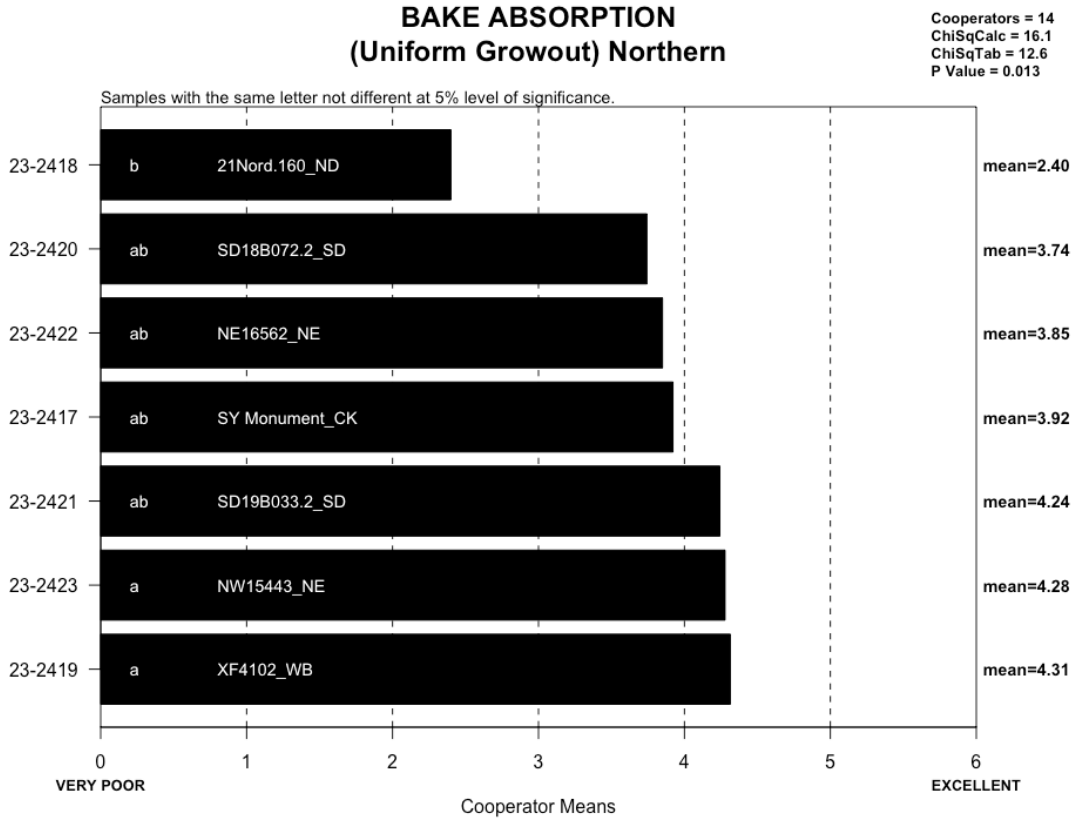



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2420** | 7188 | 112 | 3988 | 0.430 | 2.240 | 6.920 | 1.770 | -7.50 |
| **2421** | 6600 | 108 | 3488 | 0.440 | 2.265 | 9.665 | 1.705 | -9.40 |




| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2422** | 6305 | 112 | 3605 | 0.430 | 2.095 | 5.855 | 1.690 | -6.95 |
| **2423** | 6422 | 114 | 3450 | 0.440 | 2.045 | 1.155 | 1.805 | -2.65 |


SPONGE CHARACTERISTICS
(Uniform Growout) Northern
Cooperators = 5
ChiSqCalc = 2.9
ChiSqTab = 12.6
P Value = 0.822
No samples different at 5% level of significance.
23-2418 a 21Nord.160_ND mean=4.20
23-2417 a SY Monument_CK mean=4.30
23-2419 a XF4102_WB mean=4.40
23-2420 a SD18B072.2_SD mean=4.40
23-2421 a SD19B033.2_SD mean=4.70
23-2422 a NE16562_NE mean=4.70
23-2423 a NW15443_NE mean=4.80
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

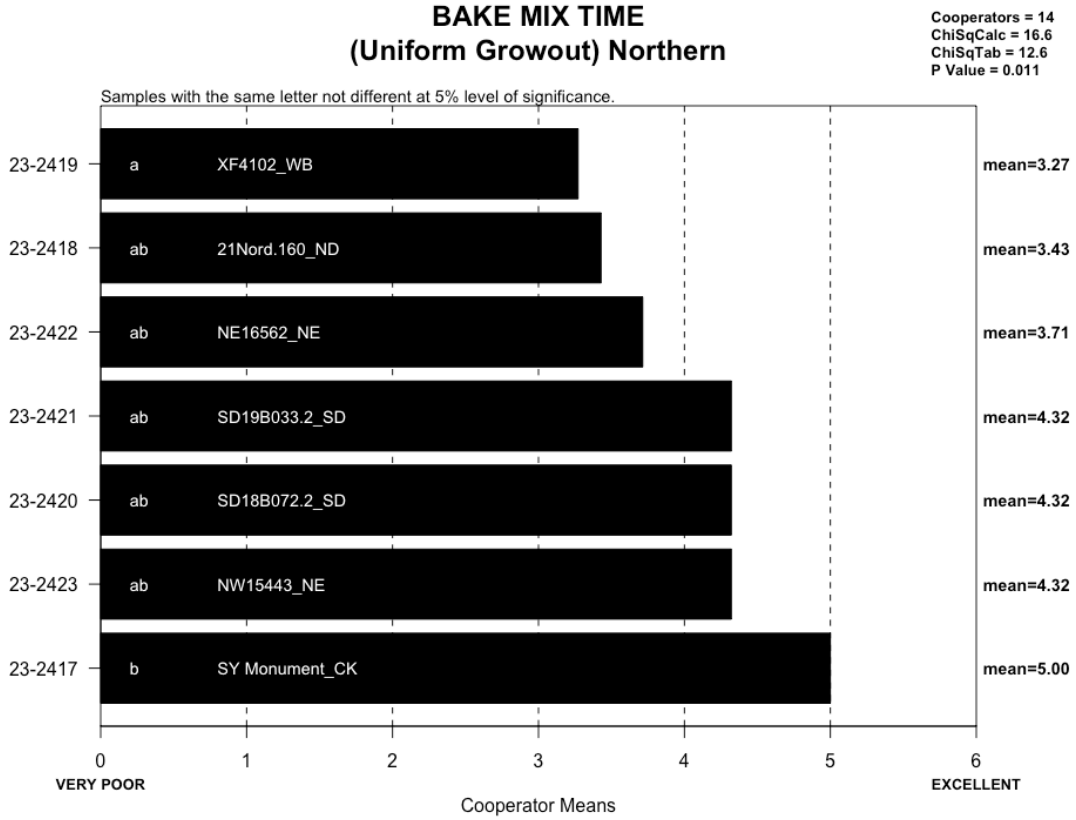

BAKE ABSORPTION
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 16.1
ChiSqTab = 12.6
P Value = 0.013
Samples with the same letter not different at 5% level of significance.
23-2418 b 21Nord.160_ND mean=2.40
23-2420 ab SD18B072.2_SD mean=3.74
23-2422 ab NE16562_NE mean=3.85
23-2417 ab SY Monument_CK mean=3.92
23-2421 ab SD19B033.2_SD mean=4.24
23-2423 a NW15443_NE mean=4.28
23-2419 a XF4102_WB mean=4.31
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

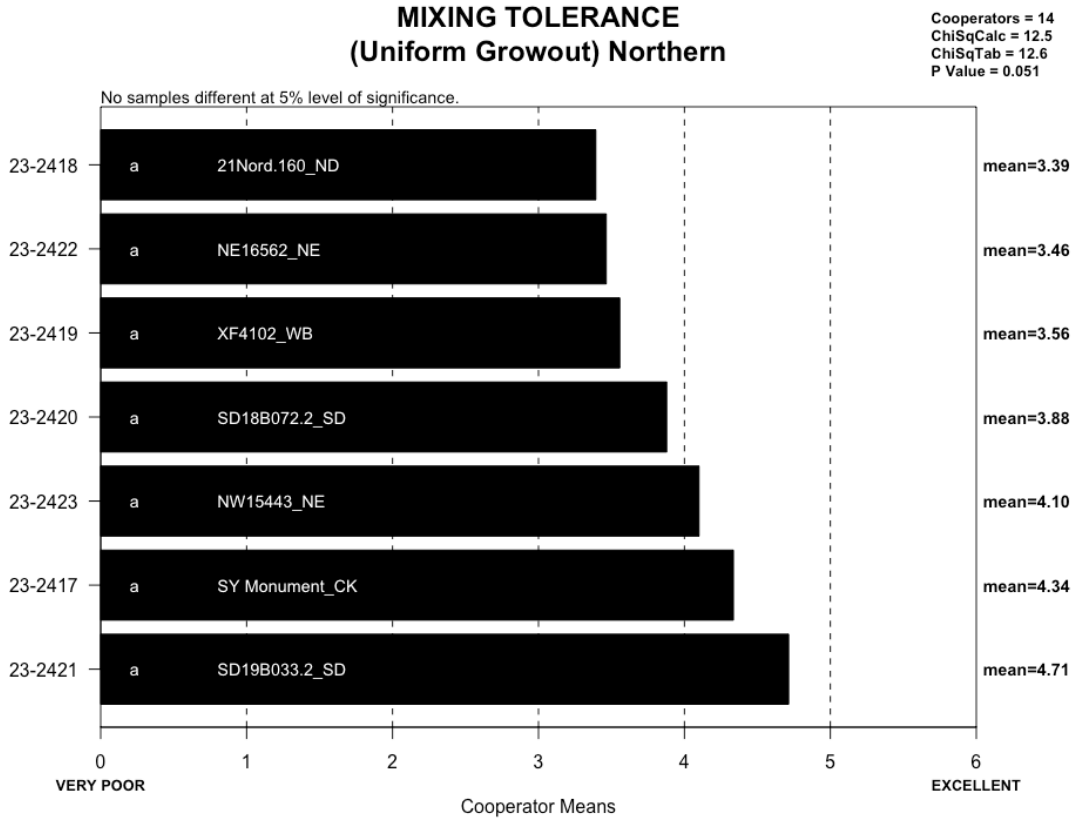
# BAKE ABSORPTION, ACTUAL (14% MB)
# (Uniform Growout) Northern
# Cooperators A – N

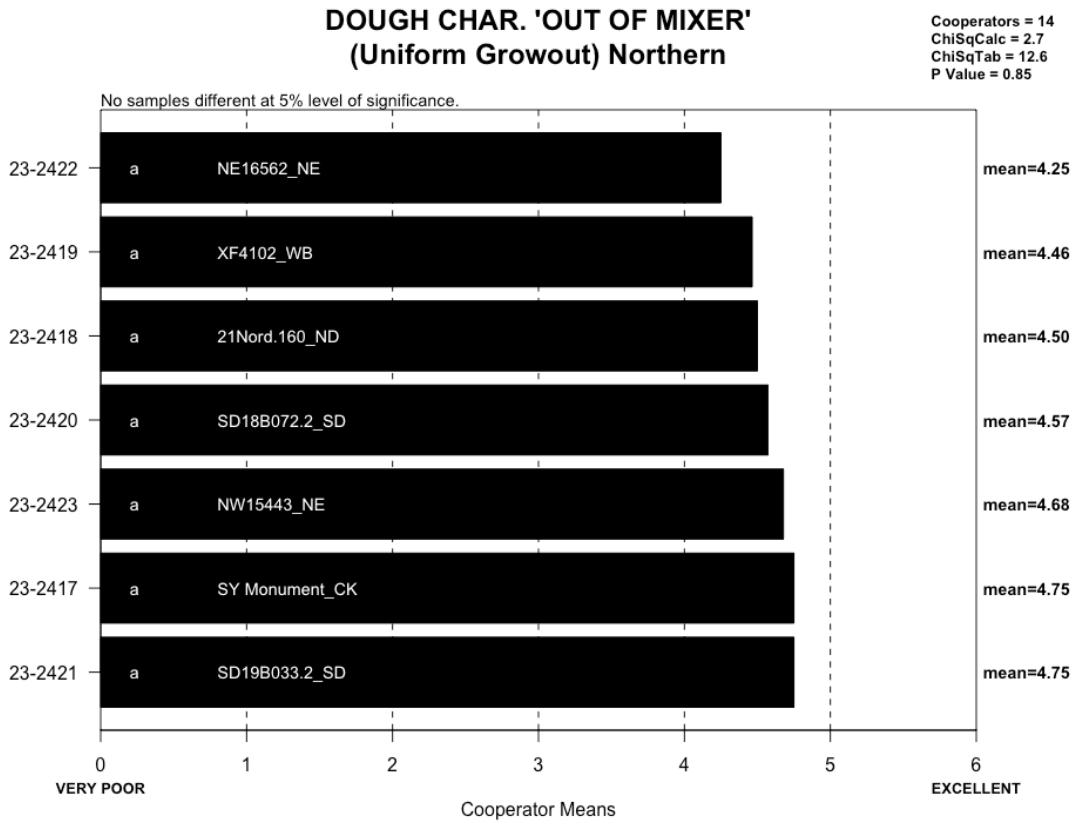
| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 67.0 | 65.4 | 60 | 65.1 | 65.2 | 63.9 | 63 | 66.6 | 58.7 | 62.3 | 65.1 | 65.3 | 64.3 | 64.6 |
| 23-2418 | 21Nord.160_ND | 64.2 | 63.1 | 58 | 63.5 | 63.7 | 63.6 | 60 | 63.4 | 55.1 | 57.5 | 63.7 | 60.1 | 59.5 | 60.7 |
| 23-2419 | XF4102_WB | 66.2 | 64.5 | 61 | 65.7 | 65.8 | 65.4 | 65 | 67.4 | 62.4 | 65.3 | 65.7 | 68.3 | 67.3 | 67.1 |
| 23-2420 | SD18B072.2_SD | 64.7 | 64.3 | 60 | 64.8 | 64.6 | 64.9 | 63 | 67.1 | 60.2 | 62.5 | 64.8 | 65.5 | 64.5 | 63.7 |
| 23-2421 | SD19B033.2_SD | 68.2 | 64.8 | 60 | 67.1 | 66.9 | 64.9 | 63 | 67.5 | 60.0 | 62.9 | 67.2 | 65.8 | 64.9 | 63.5 |
| 23-2422 | NE16562_NE | 65.1 | 64.2 | 60 | 64.6 | 65.0 | 63.9 | 64 | 67.6 | 61.4 | 63.9 | 64.6 | 67.0 | 65.9 | 64.4 |
| 23-2423 | NW15443_NE | 67.5 | 64.0 | 60 | 66.5 | 66.5 | 64.4 | 65 | 67.6 | 61.4 | 64.4 | 66.7 | 67.0 | 66.4 | 65.8 |

# 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 6.8 | 7.0 | 20 | 9.0 | 12.0 | 13.6 | 20 | 7.5 | 10 | 6.0 | 6.6 | 7 | 20 | 6.0 |
| 23-2418 | 21Nord.160_ND | 4.4 | 4.5 | 10 | 5.0 | 7.3 | 6.6 | 17 | 4.8 | 4 | 4.5 | 3.5 | 6 | 17 | 4.3 |
| 23-2419 | XF4102_WB | 3.9 | 3.8 | 10 | 4.5 | 5.0 | 5.8 | 12 | 3.8 | 6 | 7.0 | 3.8 | 7 | 13 | 3.8 |
| 23-2420 | SD18B072.2_SD | 5.2 | 6.0 | 12 | 5.8 | 7.5 | 7.9 | 20 | 5.5 | 8 | 5.0 | 5.6 | 7 | 20 | 4.5 |
| 23-2421 | SD19B033.2_SD | 4.7 | 5.1 | 15 | 6.0 | 7.4 | 7.8 | 20 | 5.3 | 8 | 6.0 | 6.0 | 7 | 20 | 4.3 |
| 23-2422 | NE16562_NE | 4.5 | 4.3 | 7 | 4.8 | 6.4 | 5.0 | 15 | 4.5 | 6 | 8.0 | 4.3 | 7 | 10 | 4.8 |
| 23-2423 | NW15443_NE | 5.4 | 6.0 | 10 | 6.5 | 8.3 | 8.4 | 20 | 5.8 | 7 | 5.0 | 6.0 | 7 | 18 | 4.8 |

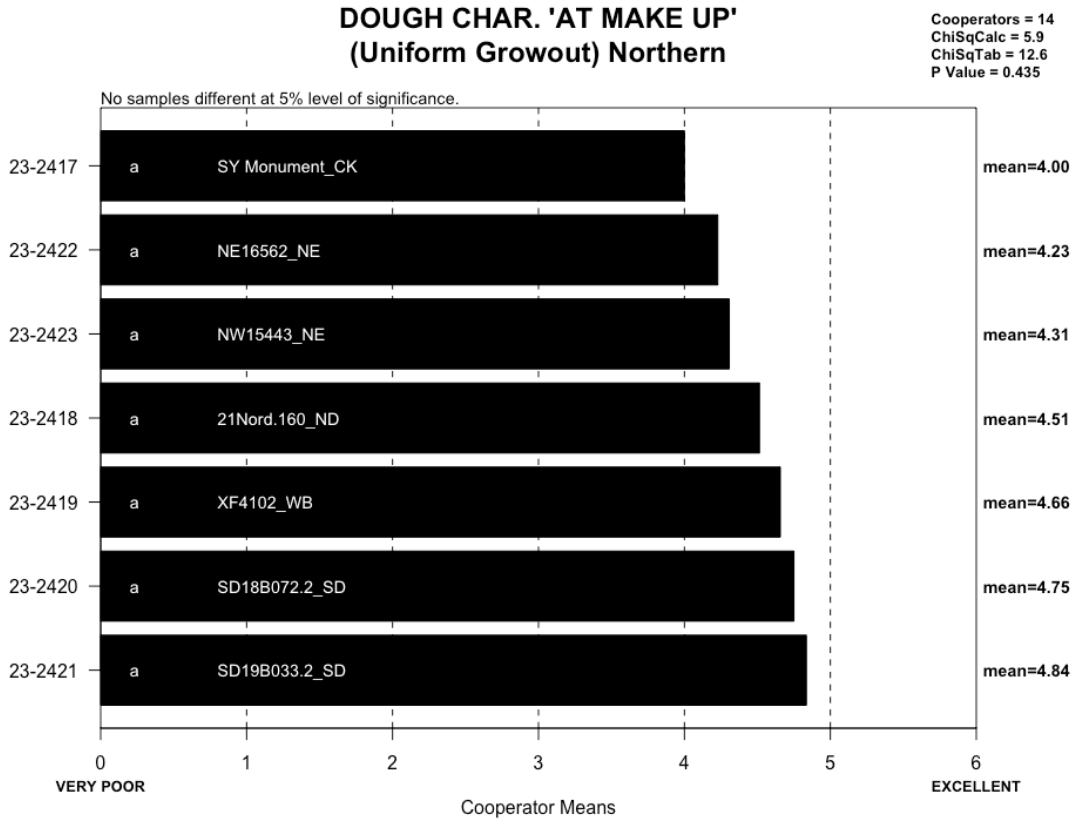

BAKE MIX TIME
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 16.6
ChiSqTab = 12.6
P Value = 0.011
Samples with the same letter not different at 5% level of significance.
23-2419 a XF4102_WB mean=3.27
23-2418 ab 21Nord.160_ND mean=3.43
23-2422 ab NE16562_NE mean=3.71
23-2421 ab SD19B033.2_SD mean=4.32
23-2420 ab SD18B072.2_SD mean=4.32
23-2423 ab NW15443_NE mean=4.32
23-2417 b SY Monument_CK mean=5.00
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 12.5
ChiSqTab = 12.6
P Value = 0.051
No samples different at 5% level of significance.
23-2418 a 21Nord.160_ND mean=3.39
23-2422 a NE16562_NE mean=3.46
23-2419 a XF4102_WB mean=3.56
23-2420 a SD18B072.2_SD mean=3.88
23-2423 a NW15443_NE mean=4.10
23-2417 a SY Monument_CK mean=4.34
23-2421 a SD19B033.2_SD mean=4.71
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



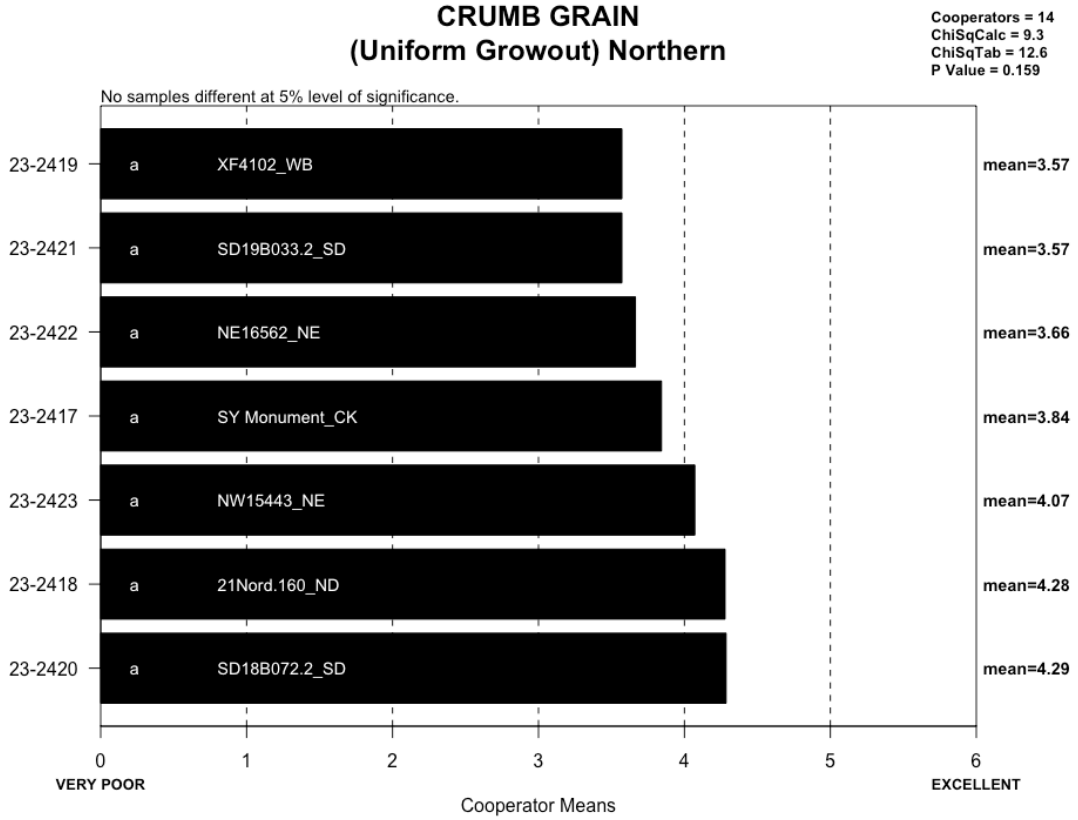

# DOUGH CHAR. 'OUT OF MIXER', DESCRIBED
# (Uniform Growout) Northern

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 1 | 0 | 5 | 5 | 3 |
| 23-2418 | 21Nord.160_ND | 4 | 1 | 0 | 7 | 2 |
| 23-2419 | XF4102_WB | 2 | 0 | 3 | 8 | 1 |
| 23-2420 | SD18B072.2_SD | 0 | 1 | 1 | 9 | 3 |
| 23-2421 | SD19B033.2_SD | 1 | 0 | 3 | 6 | 4 |
| 23-2422 | NE16562_NE | 1 | 1 | 3 | 6 | 3 |
| 23-2423 | NW15443_NE | 2 | 0 | 2 | 7 | 3 |




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

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 0 | 0 | 8 | 5 | 1 |
| 23-2418 | 21Nord.160_ND | 1 | 1 | 2 | 7 | 3 |
| 23-2419 | XF4102_WB | 0 | 0 | 2 | 9 | 3 |
| 23-2420 | SD18B072.2_SD | 0 | 0 | 2 | 9 | 3 |
| 23-2421 | SD19B033.2_SD | 0 | 0 | 1 | 11 | 2 |
| 23-2422 | NE16562_NE | 2 | 2 | 1 | 8 | 1 |
| 23-2423 | NW15443_NE | 3 | 0 | 1 | 8 | 2 |

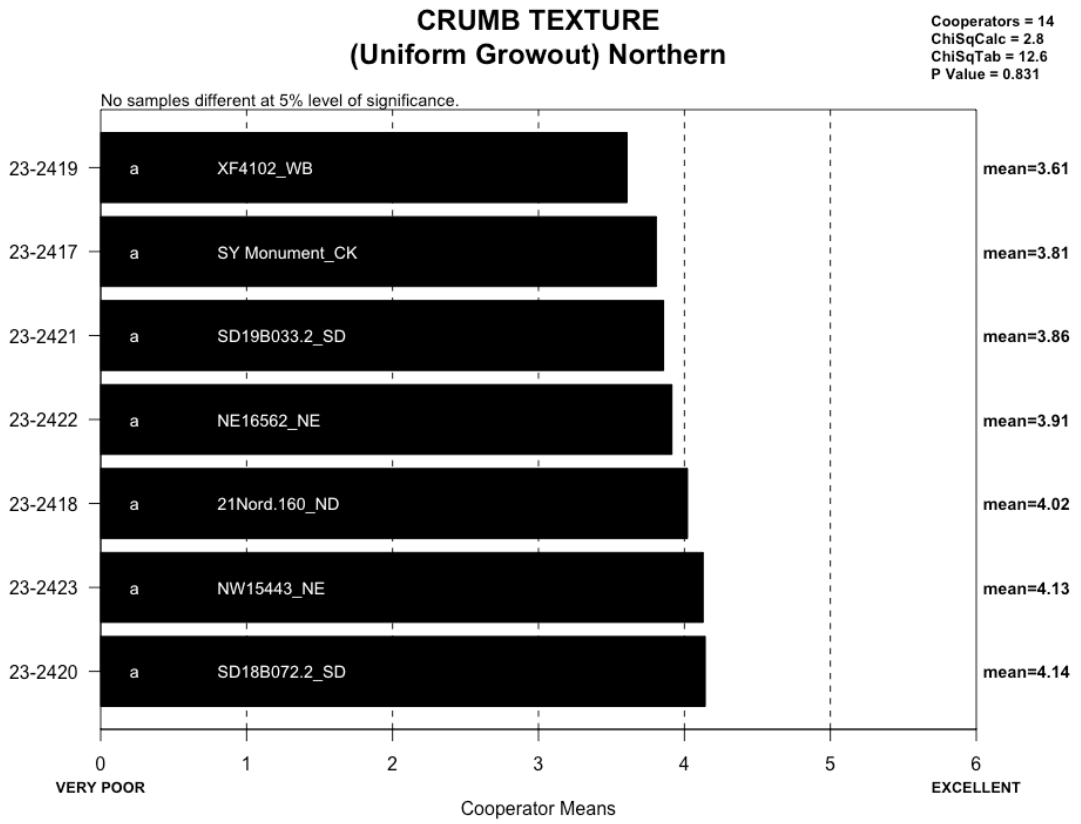



# CRUMB GRAIN, DESCRIBED
# (Uniform Growout) Northern

| IDCODE | ID | Open | Fine | Dense |
|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 5 | 7 | 2 |
| 23-2418 | 21Nord.160_ND | 7 | 4 | 3 |
| 23-2419 | XF4102_WB | 9 | 3 | 2 |
| 23-2420 | SD18B072.2_SD | 6 | 6 | 2 |
| 23-2421 | SD19B033.2_SD | 10 | 1 | 3 |
| 23-2422 | NE16562_NE | 6 | 5 | 3 |
| 23-2423 | NW15443_NE | 4 | 5 | 5 |

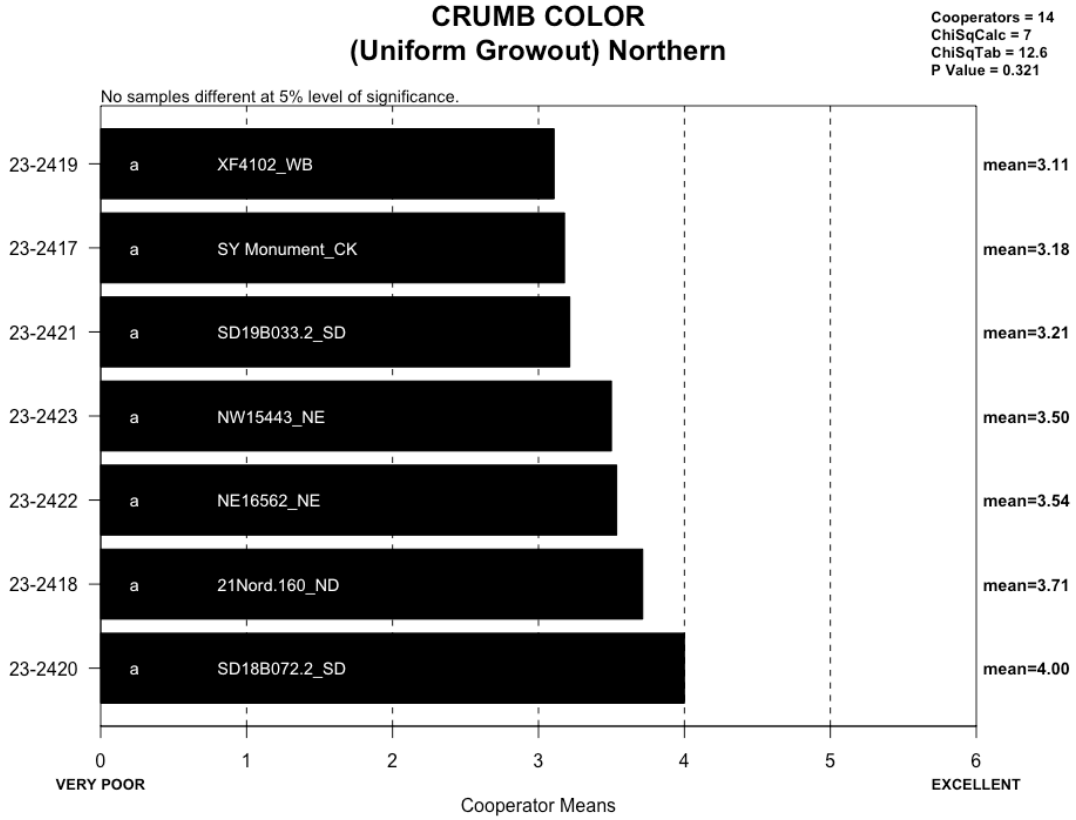
# CELL SHAPE, DESCRIBED
# (Uniform Growout) Northern

| IDCODE | ID | Round | Irregular | Elongated |
|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 5 | 5 | 4 |
| 23-2418 | 21Nord.160_ND | 3 | 7 | 4 |
| 23-2419 | XF4102_WB | 7 | 6 | 1 |
| 23-2420 | SD18B072.2_SD | 7 | 4 | 3 |
| 23-2421 | SD19B033.2_SD | 10 | 3 | 1 |
| 23-2422 | NE16562_NE | 5 | 5 | 4 |
| 23-2423 | NW15443_NE | 4 | 7 | 3 |




# CRUMB TEXTURE, DESCRIBED
# (Uniform Growout) Northern

| IDCODE | ID | Harsh | Smooth | Silky |
|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 4 | 7 | 3 |
| 23-2418 | 21Nord.160_ND | 1 | 10 | 3 |
| 23-2419 | XF4102_WB | 4 | 9 | 1 |
| 23-2420 | SD18B072.2_SD | 0 | 10 | 4 |
| 23-2421 | SD19B033.2_SD | 3 | 8 | 3 |
| 23-2422 | NE16562_NE | 3 | 10 | 1 |
| 23-2423 | NW15443_NE | 2 | 9 | 3 |




# CRUMB COLOR, DESCRIBED
# (Uniform Growout) Northern

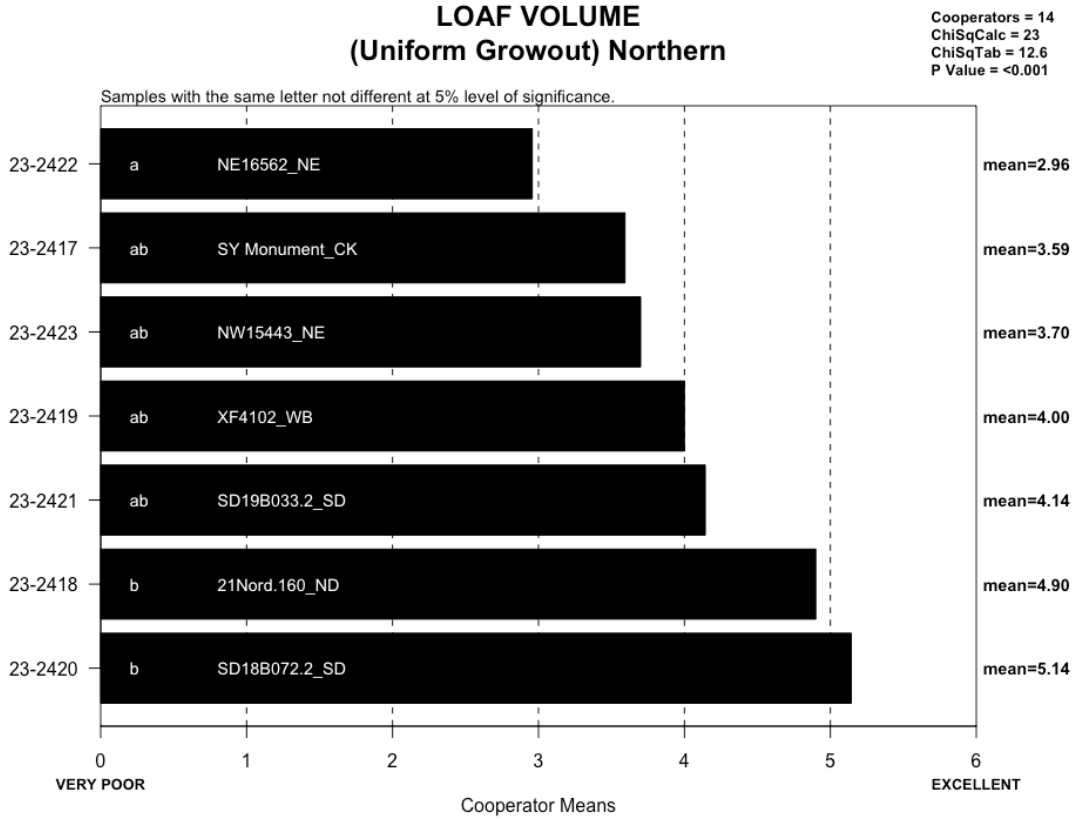
| IDCODE | ID | Gray | Dark Yellow | Yellow | Dull | Creamy | White | Bright_White |
|---|---|---|---|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 1 | 0 | 2 | 5 | 6 | 0 | 0 |
| 23-2418 | 21Nord.160_ND | 0 | 0 | 1 | 5 | 5 | 3 | 0 |
| 23-2419 | XF4102_WB | 1 | 0 | 4 | 4 | 4 | 1 | 0 |
| 23-2420 | SD18B072.2_SD | 0 | 0 | 2 | 3 | 3 | 6 | 0 |
| 23-2421 | SD19B033.2_SD | 0 | 0 | 3 | 7 | 4 | 0 | 0 |
| 23-2422 | NE16562_NE | 0 | 0 | 2 | 5 | 6 | 1 | 0 |
| 23-2423 | NW15443_NE | 0 | 2 | 1 | 3 | 6 | 2 | 0 |

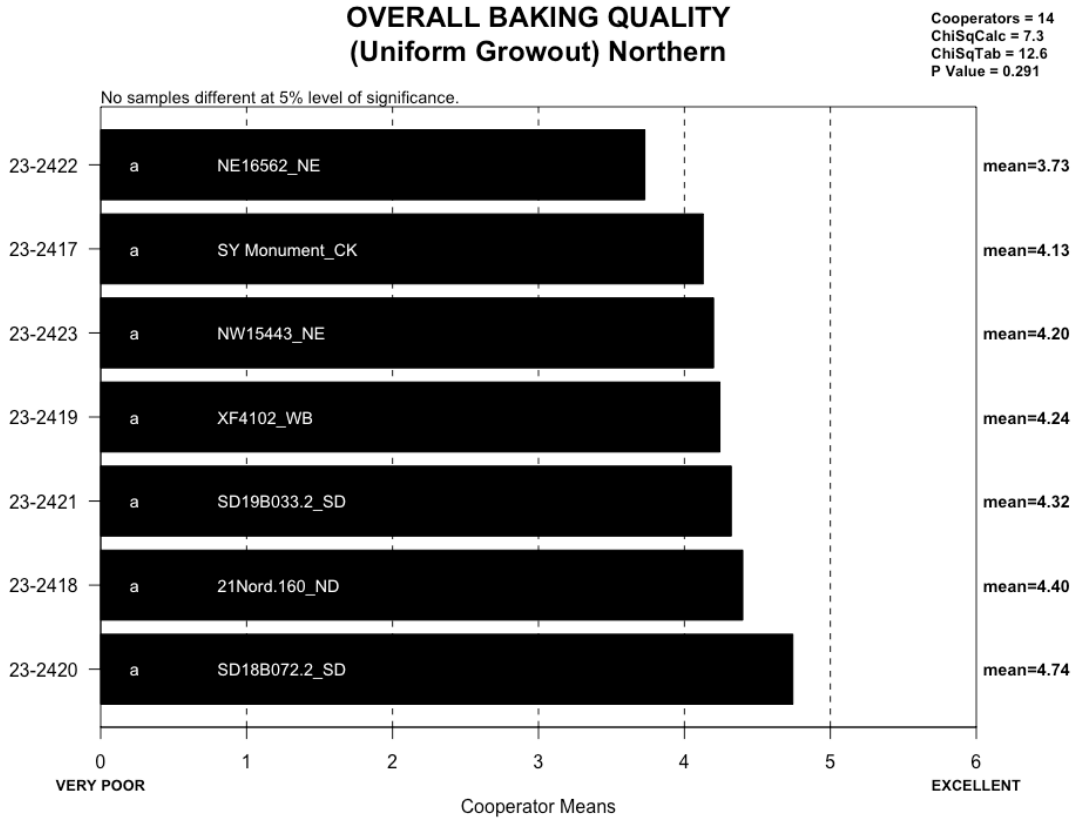
# LOAF WEIGHT, ACTUAL
# (Uniform Growout) Northern
# Cooperators A – N

| IDCODE | ID | A | B | C | D | E | F | H | I | J | K | L | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 142.7 | 154.3 | 410 | 139.0 | 152.0 | 139.6 | 144.0 | 480.6 | 460 | 142.6 | 443 | 129.2 |
| 23-2418 | 21Nord.160_ND | 139.2 | 155.1 | 410 | 139.3 | 148.3 | 140.7 | 144.1 | 470.4 | 461 | 140.2 | 444 | 127.7 |
| 23-2419 | XF4102_WB | 141.9 | 156.8 | 413 | 138.9 | 150.5 | 144.4 | 146.2 | 471.7 | 457 | 140.8 | 439 | 132.0 |
| 23-2420 | SD18B072.2_SD | 142.9 | 153.7 | 413 | 140.0 | 151.0 | 138.6 | 143.2 | 473.7 | 459 | 140.2 | 441 | 130.6 |
| 23-2421 | SD19B033.2_SD | 143.8 | 157.8 | 414 | 137.9 | 153.8 | 139.9 | 144.0 | 477.2 | 458 | 140.6 | 440 | 133.3 |
| 23-2422 | NE16562_NE | 143.3 | 158.2 | 414 | 141.4 | 152.1 | 140.9 | 145.4 | 481.7 | 457 | 140.4 | 439 | 134.7 |
| 23-2423 | NW15443_NE | 143.3 | 155.8 | 416 | 138.8 | 151.8 | 136.7 | 145.3 | 477.6 | 445 | 142.0 | 438 | 131.4 |

# 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2417 | SY Monument_CK | 945 | 779 | 2700 | 838 | 845 | 928 | 2897 | 995 | 2313 | 2395 | 855 | 2483 | 2750 | 850 |
| 23-2418 | 21Nord.160_ND | 965 | 832 | 2825 | 932 | 890 | 955 | 3074 | 1025 | 2838 | 2594 | 900 | 2676 | 2900 | 865 |
| 23-2419 | XF4102_WB | 860 | 798 | 2625 | 880 | 945 | 1000 | 2809 | 915 | 2500 | 2417 | 905 | 2613 | 2650 | 870 |
| 23-2420 | SD18B072.2_SD | 990 | 799 | 2825 | 941 | 970 | 1000 | 3104 | 1155 | 2563 | 2596 | 920 | 2747 | 2900 | 960 |
| 23-2421 | SD19B033.2_SD | 965 | 696 | 2725 | 903 | 945 | 1000 | 2941 | 1055 | 2338 | 2471 | 905 | 2572 | 2800 | 825 |
| 23-2422 | NE16562_NE | 775 | 769 | 2675 | 826 | 835 | 838 | 2853 | 840 | 2400 | 2388 | 860 | 2467 | 2475 | 745 |
| 23-2423 | NW15443_NE | 930 | 727 | 2675 | 857 | 875 | 975 | 2927 | 950 | 2138 | 2358 | 875 | 2528 | 2600 | 840 |


LOAF VOLUME
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 23
ChiSqTab = 12.6
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
23-2422 a NE16562_NE mean=2.96
23-2417 ab SY Monument_CK mean=3.59
23-2423 ab NW15443_NE mean=3.70
23-2419 ab XF4102_WB mean=4.00
23-2421 ab SD19B033.2_SD mean=4.14
23-2418 b 21Nord.160_ND mean=4.90
23-2420 b SD18B072.2_SD mean=5.14
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Uniform Growout) Northern
Cooperators = 14
ChiSqCalc = 7.3
ChiSqTab = 12.6
P Value = 0.291
No samples different at 5% level of significance.
23-2422 a NE16562_NE mean=3.73
23-2417 a SY Monument_CK mean=4.13
23-2423 a NW15443_NE mean=4.20
23-2419 a XF4102_WB mean=4.24
23-2421 a SD19B033.2_SD mean=4.32
23-2418 a 21Nord.160_ND mean=4.40
23-2420 a SD18B072.2_SD mean=4.74
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

# COOPERATOR'S COMMENTS
# (Uniform Growout) Northern
# Cooperators A – N

**23-2417 SY Monument_CK**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Long mix time Nice interior |
| D | No comment. |
| E | Long mix time, avg volume, low absorption and open grain |
| F | High Water Abs, Extremely Long MT, Slight Sticky & Strong Dough, High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Sponge slightly soft - low vol, excessive absorption, good mix time, seemed over-absorpbed (sticky handling), good volume |
| H | excellent externals |
| I | Low absorption, tough dough, fine nice grain, very low volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein. Good absorption, mixing tolerance and volume. Strong dough feels. |
| N | No comment. |

**23-2418 21Nord-160_ND**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Lowest absorption, long mix time, avg volume, wet dough throughout, good crumb grain. |
| F | High Water Abs, a Little Long MT, Sticky & Slight Strong Dough, High Loaf Volume, Dull Yellow Crumb Grain, Slight Open Elongate Cells, Good Resilient & Slight Harsh Texture |
| G | Sponge sticky / soft, target absorption, good stability / mix, excellent volume |
| H | excellent externals |
| I | Low absorption, lowest mixing time and tolerance, sticky dough, avg grain. Suprisingly one of the highest volumes. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein. Low absorption. Good dough feels, mixing tolerance and volume. |
| N | No comment. |

**23-2419 XF4102_WB**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Avg mix time, absorption and crumb grain, good volume. |
| F | High Water Abs, Medium MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Wide Open Round Cells, Soft Resilient & Slight Harsh Texture |
| G | Sponge sticky / soft, good mix, excellent dough handling, slightly open grain and dull color |
| H | No comment. |
| I | Avg absorption, mix time, crumb grain & volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein, absorption and dough feel. Fair mixing tolerance and volume. |
| N | No comment. |

**23-2420 SD18B072-2_SD**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Lowest absorption, long mix time, avg crumb grain, excellent volume. |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Silky Smooth Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | excellent externals |
| I | Avg absorption, mix time & tolerance, avg volume. Slightly above avg dull crumb grain. Good dough. |
| J | best bread of day 2 bakes |
| K | No comment. |
| L | No comment. |
| M | Fair protein. Good absorption, dough feels, mix tolerance and volume. |
| N | No comment. |

**23-2421 SD19B033-2_SD**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption and grain, good volume. |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Wide Open Round Cells, Soft Resilient & Slight Harsh Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | excellent externals |
| I | Avg absorption & mix time. High mix tolerance. Good dough. Slightly below avg open crumb grain.Very low volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein, absorption, dough feels, mix tolerance and volume. |
| N | No comment. |

**23-2422 NE16562_NE**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume. |
| F | High Water Abs, Medium MT, Slight Sticky & Strong Dough, Fair Loaf Volume, Dull Yellow Crumb Grain, Dense Elongate Cells, High Resilient & Harsh Texture |
| G | Target absorption, good stability / mix, good volume |
| H | No comment. |
| I | Avg absorption, mix time & tolerance, fine avg crumb grain. Lower volume. Sticky dough. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein and dough feels. Good absorption. Low mixing tolerance and volume. |
| N | No comment. |

**23-2423 NW15443_NE**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume. Good dough characteristics. Dark yellow crumb color. |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Creamy Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | Target absorption, good stability / mix, excellent volume |
| H | slight cap |
| I | Avg absorption, avg mix time and tolerance, sticky dough, dense grain, dark yellow crumb. Lowest volume. |
| J | over baked by 18 min |
| K | No comment. |
| L | No comment. |
| M | Fair protein, dough feels and volume. Good absorption and mixing tolerance. |
| N | No comment. |

Sponge and dough bake tests: C, G, I, L, and M

# NORTHERN MICRO-QUALITY ANALYSIS

| Entry_Code | Entry_ID | Entry_No | Breeding Program | Locations* |
|---|---|---|---|---|
| 23-AP2417 | SY Monument | 2417 | Check | AP |
| 23-AP2418 | 21Nord-160 | 2418 | North Dakota | AP |
| 23-AP2419 | XF4102 | 2419 | Bayer/WestBred | AP |
| 23-AP2420 | SD18B072-2 | 2420 | South Dakota | AP |
| 23-AP2421 | SD19B033-2 | 2421 | South Dakota | AP |
| 23-AP2422 | NE16562 | 2422 | Nebraska | AP |
| 23-AP2423 | NW15443 | 2423 | Nebraska | AP |
| 23-SD2417 | SY Monument | 2417 | Check | SD |
| 23-SD2418 | 21Nord-160 | 2418 | North Dakota | SD |
| 23-SD2419 | XF4102 | 2419 | Bayer/WestBred | SD |
| 23-SD2420 | SD18B072-2 | 2420 | South Dakota | SD |
| 23-SD2421 | SD19B033-2 | 2421 | South Dakota | SD |
| 23-SD2422 | NE16562 | 2422 | Nebraska | SD |
| 23-SD2423 | NW15443 | 2423 | Nebraska | SD |
| 23-ND2417 | SY Monument | 2417 | Check | ND |
| 23-ND2418 | 21Nord-160 | 2418 | North Dakota | ND |
| 23-ND2419 | XF4102 | 2419 | Bayer/WestBred | ND |
| 23-ND2420 | SD18B072-2 | 2420 | South Dakota | ND |
| 23-ND2421 | SD19B033-2 | 2421 | South Dakota | ND |
| 23-ND2422 | NE16562 | 2422 | Nebraska | ND |
| 23-ND2423 | NW15443 | 2423 | Nebraska | ND |
| *SD=South Dakota State Univeristy; | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | |

## 1. LOCATIONS AND ENTRIES

A. There are 3 locations:

Agripro = AP;

South Dakota = SD;

North Dakota = ND.

B. There are 7 entries from 4 breeding programs grown in each of locations:

SY Monument = 2417

21Nord-160 = 2418

XF4102 = 2419

SD18B072-2 = 2420

SD19B033-2 = 2421

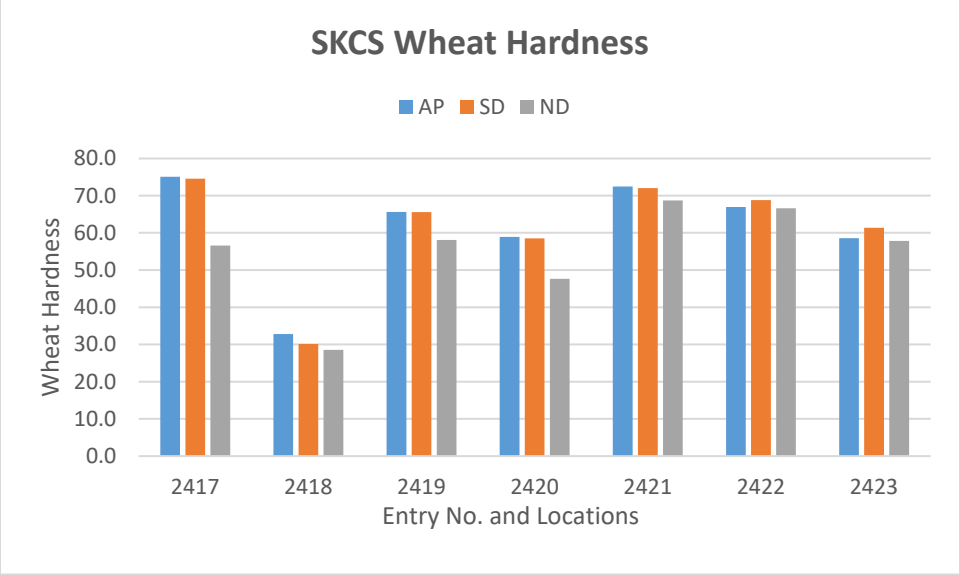
NE16562 = 2422

NW15443 = 2423

## 2. SKCS SINGLE KERNEL INFORMATION

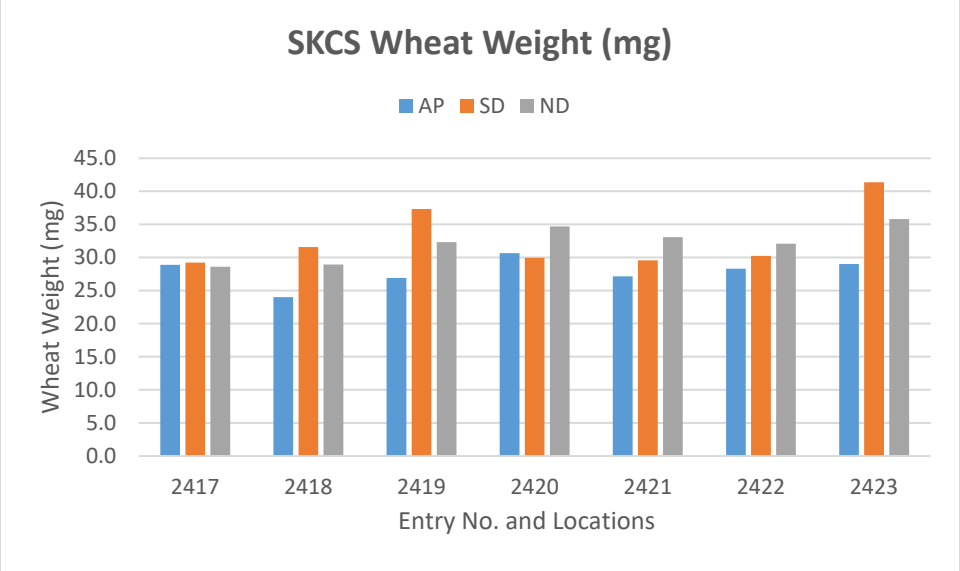
A. Kernel Hardness

| SKCS Wheat Kernel Hardness | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 75.1 | 74.6 | 56.6 | 68.7 | 10.53 |
| 2418 | 32.8 | 30.1 | 28.6 | 30.5 | 2.14 |
| 2419 | 65.6 | 65.6 | 58.1 | 63.1 | 4.32 |
| 2420 | 58.9 | 58.5 | 47.6 | 55.0 | 6.40 |
| 2421 | 72.4 | 72.0 | 68.7 | 71.1 | 2.04 |
| 2422 | 66.9 | 68.8 | 66.6 | 67.5 | 1.18 |
| 2423 | 58.6 | 61.4 | 57.8 | 59.3 | 1.86 |
| Avg. | 61.5 | 61.6 | 54.9 | | |
| Std | 14.08 | 14.96 | 13.52 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



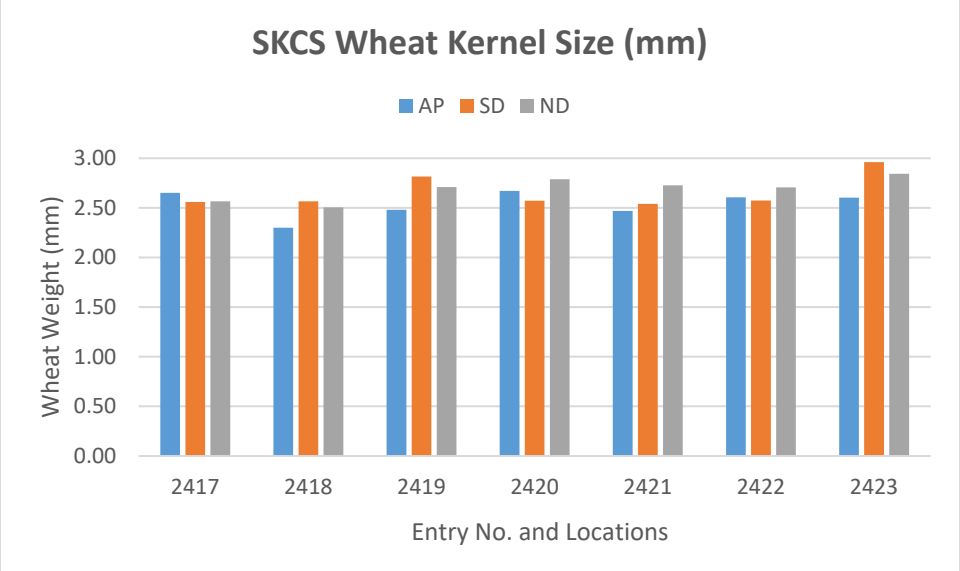
B. Kernel Weight (mg)

| SKCS Wheat Kernel Weight (mg) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 28.9 | 29.2 | 28.6 | 28.9 | 0.32 |
| 2418 | 24.0 | 31.6 | 28.9 | 28.2 | 3.84 |
| 2419 | 26.9 | 37.3 | 32.3 | 32.2 | 5.21 |
| 2420 | 30.6 | 30.0 | 34.7 | 31.8 | 2.55 |
| 2421 | 27.2 | 29.6 | 33.1 | 29.9 | 2.98 |
| 2422 | 28.3 | 30.2 | 32.1 | 30.2 | 1.88 |
| 2423 | 29.0 | 41.4 | 35.8 | 35.4 | 6.19 |
| Avg. | 27.8 | 32.7 | 32.2 | | |
| Std | 2.11 | 4.71 | 2.69 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



C. Kernel Size

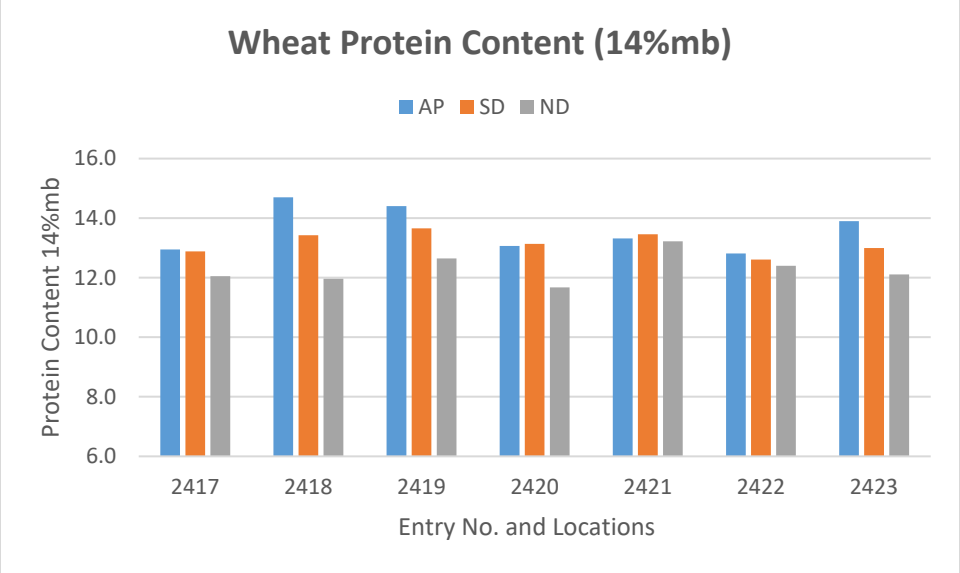
| SKCS Wheat Kernel Size (mm) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 2.65 | 2.56 | 2.57 | 2.59 | 0.05 |
| 2418 | 2.30 | 2.57 | 2.51 | 2.46 | 0.14 |
| 2419 | 2.48 | 2.82 | 2.71 | 2.67 | 0.17 |
| 2420 | 2.67 | 2.57 | 2.79 | 2.68 | 0.11 |
| 2421 | 2.47 | 2.54 | 2.73 | 2.58 | 0.13 |
| 2422 | 2.61 | 2.57 | 2.71 | 2.63 | 0.07 |
| 2423 | 2.60 | 2.96 | 2.84 | 2.80 | 0.18 |
| Avg. | 2.54 | 2.66 | 2.69 | | |
| Std | 0.13 | 0.16 | 0.12 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



## 3. PROTEN CONTENT

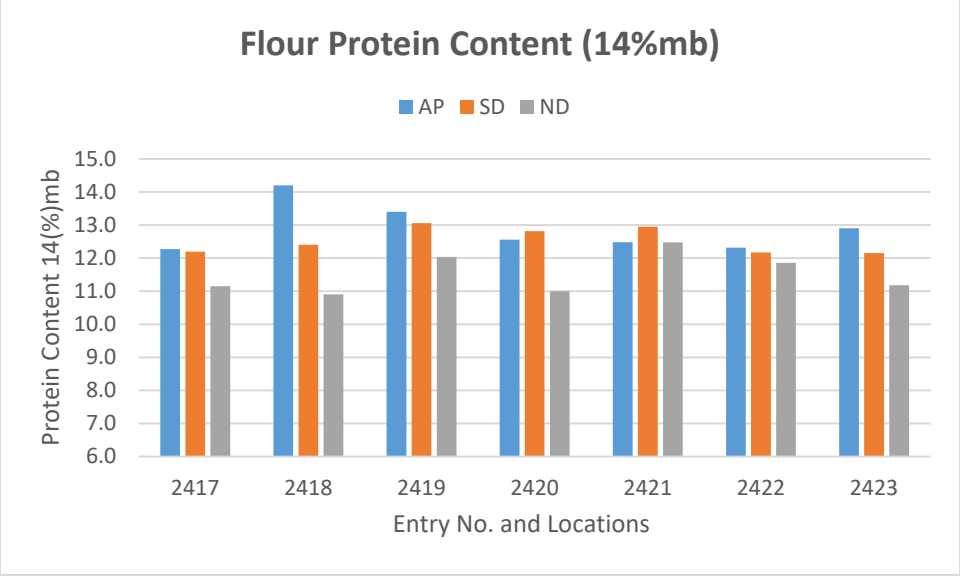
A. Wheat Protein

| Wheat Protein Content (14%mb) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 12.9 | 12.9 | 12.0 | 12.6 | 0.50 |
| 2418 | 14.7 | 13.4 | 12.0 | 13.4 | 1.37 |
| 2419 | 14.4 | 13.7 | 12.6 | 13.6 | 0.88 |
| 2420 | 13.1 | 13.1 | 11.7 | 12.6 | 0.82 |
| 2421 | 13.3 | 13.5 | 13.2 | 13.3 | 0.12 |
| 2422 | 12.8 | 12.6 | 12.4 | 12.6 | 0.21 |
| 2423 | 13.9 | 13.0 | 12.1 | 13.0 | 0.89 |
| Avg. | 13.6 | 13.2 | 12.3 | | |
| Std | 0.7 | 0.4 | 0.5 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



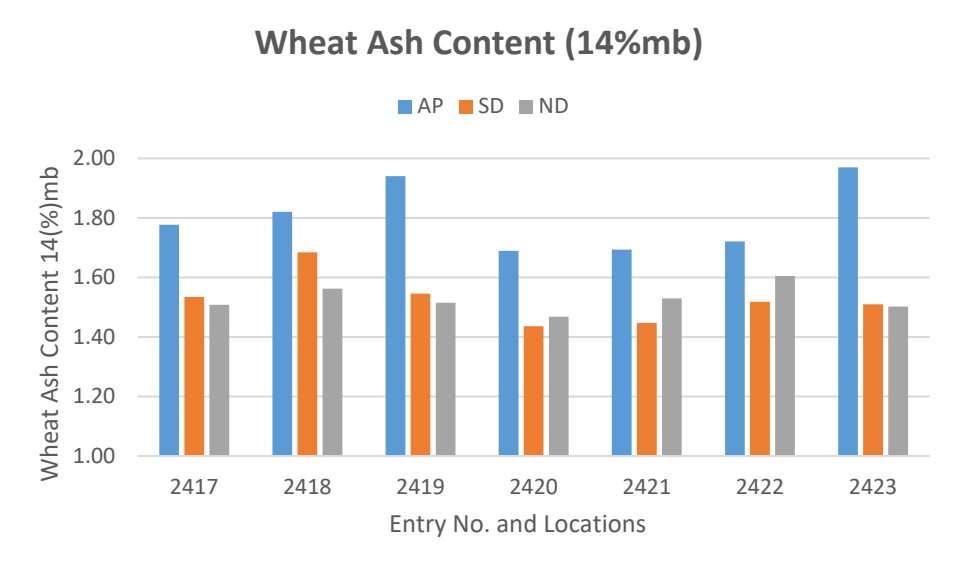
B. Flour Protein

| Flour Protein Content (14%) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 12.3 | 12.2 | 11.2 | 11.9 | 0.63 |
| 2418 | 14.2 | 12.4 | 10.9 | 12.5 | 1.65 |
| 2419 | 13.4 | 13.1 | 12.0 | 12.8 | 0.71 |
| 2420 | 12.6 | 12.8 | 11.0 | 12.1 | 0.98 |
| 2421 | 12.5 | 12.9 | 12.5 | 12.6 | 0.27 |
| 2422 | 12.3 | 12.2 | 11.9 | 12.1 | 0.23 |
| 2423 | 12.9 | 12.2 | 11.2 | 12.1 | 0.86 |
| Avg. | 12.9 | 12.5 | 11.5 | | |
| Std | 0.70 | 0.39 | 0.61 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



## 4. Wheat Ash

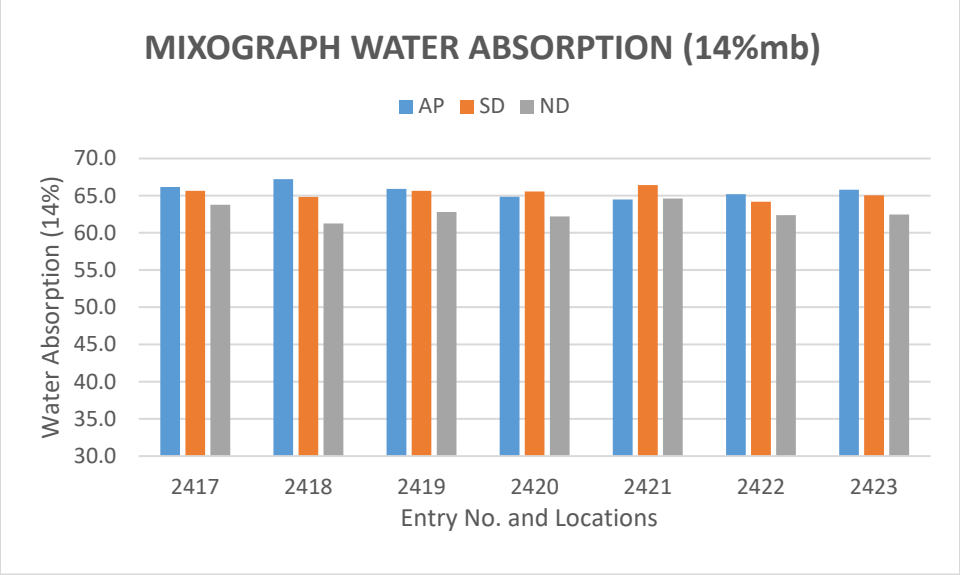
| Wheat Ash Content (14%) | | | | | |
|---|---|---|---|---|---|
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 1.78 | 1.53 | 1.51 | 1.61 | 0.15 |
| 2418 | 1.82 | 1.68 | 1.56 | 1.69 | 0.13 |
| 2419 | 1.94 | 1.55 | 1.51 | 1.67 | 0.24 |
| 2420 | 1.69 | 1.44 | 1.47 | 1.53 | 0.14 |
| 2421 | 1.69 | 1.45 | 1.53 | 1.56 | 0.13 |
| 2422 | 1.72 | 1.52 | 1.60 | 1.61 | 0.10 |
| 2423 | 1.97 | 1.51 | 1.50 | 1.66 | 0.27 |
| Avg. | 1.80 | 1.53 | 1.53 | | |
| Std | 0.11 | 0.08 | 0.04 | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



## 5. MIXOGRAPH TEST RESULTS

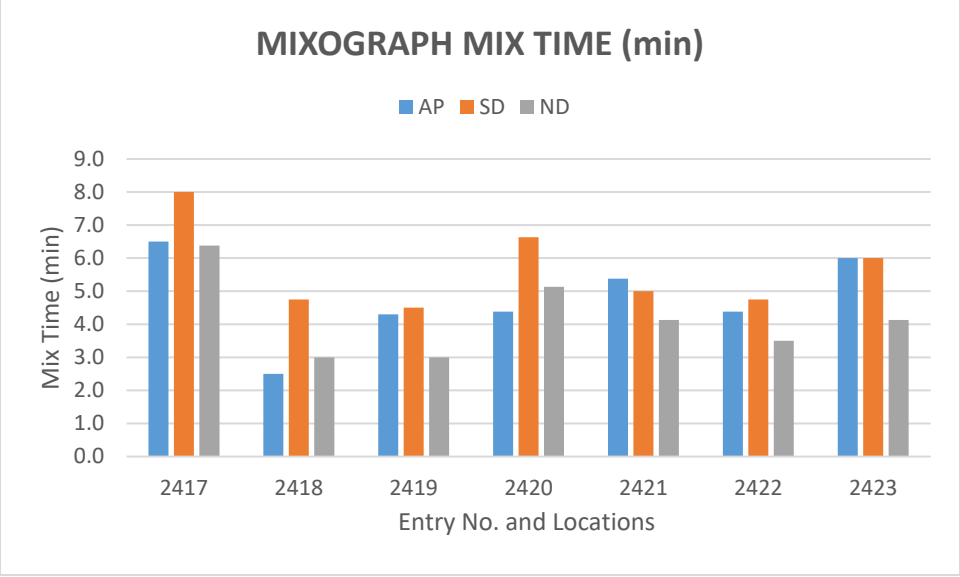
A. Mixograph Water Absorption

| Mixograph Water Absorption (14%mb) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 66.2 | 65.6 | 63.8 | 65.2 | 1.26 |
| 2418 | 67.2 | 64.8 | 61.3 | 64.4 | 2.99 |
| 2419 | 65.9 | 65.6 | 62.8 | 64.8 | 1.72 |
| 2420 | 64.8 | 65.6 | 62.2 | 64.2 | 1.77 |
| 2421 | 64.5 | 66.4 | 64.6 | 65.2 | 1.08 |
| 2422 | 65.2 | 64.2 | 62.4 | 63.9 | 1.42 |
| 2423 | 65.8 | 65.0 | 62.5 | 64.4 | 1.75 |
| Avg. | 65.7 | 65.3 | 62.8 | | |
| Std | 0.91 | 0.72 | 1.09 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



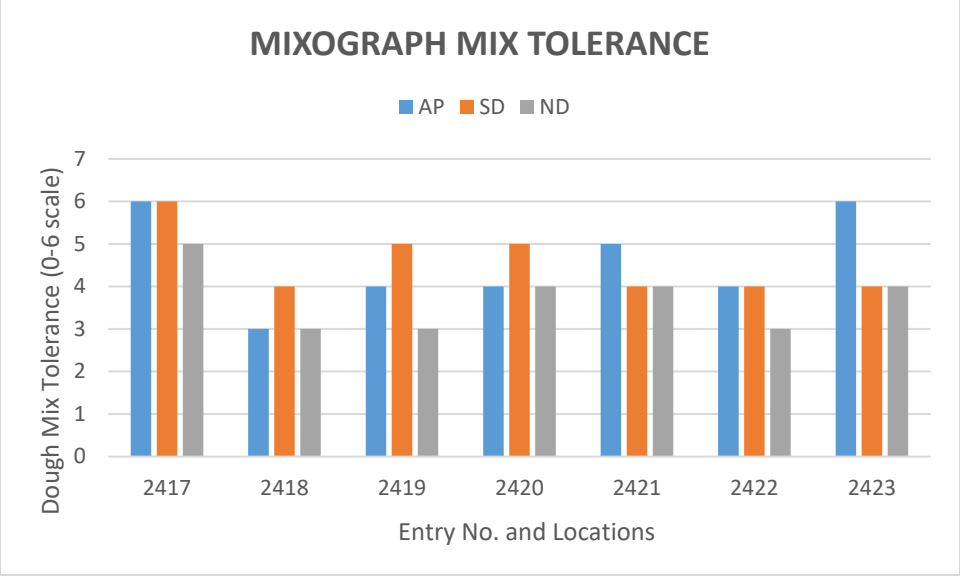
B. Mixograph Mix Time

| Mixograph Mix Time (min) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 6.5 | 8.0 | 6.4 | 7.0 | 0.90 |
| 2418 | 2.5 | 4.8 | 3.0 | 3.4 | 1.18 |
| 2419 | 4.3 | 4.5 | 3.0 | 3.9 | 0.81 |
| 2420 | 4.4 | 6.6 | 5.1 | 5.4 | 1.15 |
| 2421 | 5.4 | 5.0 | 4.1 | 4.8 | 0.64 |
| 2422 | 4.4 | 4.8 | 3.5 | 4.2 | 0.64 |
| 2423 | 6.0 | 6.0 | 4.1 | 5.4 | 1.08 |
| Avg. | 4.8 | 5.7 | 4.2 | | |
| Std | 1.33 | 1.29 | 1.22 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



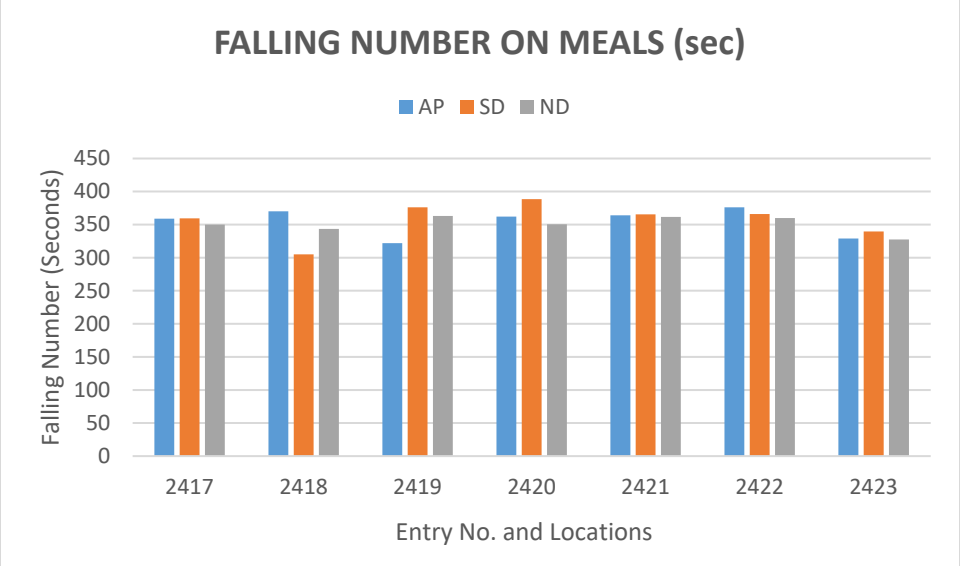
C. Mixograph Mix Tolerance

| Mixograph Mix Tolerance | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 6 | 6 | 5 | 5.7 | 0.58 |
| 2418 | 3 | 4 | 3 | 3.3 | 0.58 |
| 2419 | 4 | 5 | 3 | 4.0 | 1.00 |
| 2420 | 4 | 5 | 4 | 4.3 | 0.58 |
| 2421 | 5 | 4 | 4 | 4.3 | 0.58 |
| 2422 | 4 | 4 | 3 | 3.7 | 0.58 |
| 2423 | 6 | 4 | 4 | 4.7 | 1.15 |
| Avg. | 4.6 | 4.6 | 3.7 | | |
| Std | 1.13 | 0.79 | 0.76 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



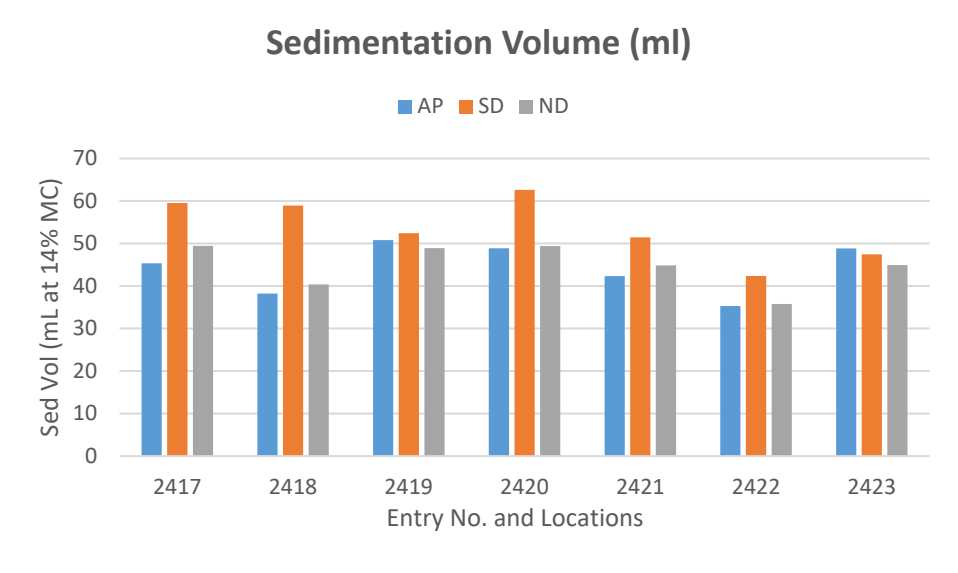
## 6. FALLING NUMBER TEST

| Falling Number on Meals (sec) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS* | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 359 | 360 | 350 | 356 | 5 |
| 2418 | 370 | 305 | 344 | 340 | 33 |
| 2419 | 322 | 376 | 363 | 354 | 28 |
| 2420 | 362 | 389 | 351 | 367 | 19 |
| 2421 | 364 | 366 | 362 | 364 | 2 |
| 2422 | 376 | 366 | 360 | 367 | 8 |
| 2423 | 329 | 340 | 328 | 332 | 7 |
| Avg. | 355 | 357 | 351 | | |
| Std | 21 | 27 | 13 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



## 7. SEDIMENTATION TEST

| Sedimentation Volume (ml) | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | LOCATIONS | | | | |
| Entry No. | AP | SD | ND | Avg | Std |
| 2417 | 45.3 | 59.5 | 49.4 | 51.4 | 7.29 |
| 2418 | 38.2 | 58.9 | 40.3 | 45.8 | 11.40 |
| 2419 | 50.8 | 52.4 | 48.9 | 50.7 | 1.75 |
| 2420 | 48.9 | 62.6 | 49.4 | 53.6 | 7.78 |
| 2421 | 42.3 | 51.4 | 44.9 | 46.2 | 4.69 |
| 2422 | 35.3 | 42.4 | 35.8 | 37.8 | 3.96 |
| 2423 | 48.8 | 47.4 | 44.9 | 47.1 | 1.98 |
| Avg. | 44.2 | 53.5 | 44.8 | | |
| Std | 5.88 | 7.24 | 5.17 | | |
| | | | | | |
| *SD=South Dakota State Univeristy; | | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | | |



# MONTANA

| | |
|---|---|
| 23-2424 | Yellowstone_CK |
| 23-2425 | SY Monument_CK |
| 23-2426 | MT2019_MT |
| 23-2427 | MTCL2010_MT |
| 23-2428 | MTF20189_MT |

# Description of Test Plots and Breeder Entries

## Montana – Suchismita (Sue) Mondal

**MT2019** is a late maturing, hollow, short hard red winter wheat line with moderate resistance to stripe rust and good resistance to stem rust. This line has good yield potential across locations. MT2019 has average protein, test weight and end-use quality parameters are similar to Yellowstone.

**MTCL2010** is a late maturing, hollow, high yielding hard red winter wheat line with 2-gene resistance to Beyond® herbicide. MTCL2010 has performed well across environments. It has shown very good resistance to stem and moderate resistance to stripe rust. MTCL2010 has low PPO, average protein, test weight and end-use quality parameters similar to Yellowstone

**MTF20189** is an early, tall, and awnless hard red winter line developed for forage production areas. MTF20189 has high forage yield and good seed yield, high test weight, excellent winter hardiness and resistance to stripe rust. Forage quality evaluations (crude protein, ADF, NDF) are similar to Willowcreek and Ray. MTF20189 has a strong combination of both forage and seed yield with good straw strength.

# Montana: 2023 (Small-Scale) Samples

| Test entry number | 23-2424 | 23-2425 | 23-2426 |
|---|---|---|---|
| **Sample identification** | **Yellowstone_CK** | **SY Monument_CK** | **MT2019_MT** |
| **Wheat Data** | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW |
| **Test weight (lb/bu)** | 61.1 | 61.1 | 61.7 |
| **Hectoliter weight (kg/hl)** | 80.4 | 80.4 | 81.1 |
| **1000 kernel weight (gm)** | 34.9 | 35.7 | 34.0 |
| **Wheat kernel size (Rotap)** | | | |
| Over 7 wire (%) | 84.5 | 87.6 | 84.9 |
| Over 9 wire (%) | 15.4 | 12.2 | 15.0 |
| Through 9 wire (%) | 0.1 | 0.2 | 0.2 |
| **Single kernel (skcs)[a]** | | | |
| Hardness (avg /s.d) | 56.7/14.6 | 52.6/12.9 | 59.0/16.3 |
| Weight (mg) (avg/s.d) | 36.7/9.8 | 36.4/8.5 | 34.6/8.0 |
| Diameter (mm)(avg/s.d) | 2.79/0.39 | 2.83/0.44 | 2.74/0.38 |
| Moisture (%) (avg/s.d) | 10.8/0.4 | 10.7/0.5 | 10.8/0.4 |
| SKCS distribution | 06-18-35-41-01 | 06-25-40-29-01 | 05-20-30-45-01 |
| Classification | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 13.1 | 12.8 | 12.2 |
| **Wheat ash (12% mb)** | 1.54 | 1.46 | 1.50 |
| **Milling and Flour Quality Data** | | | |
| **Flour yield (%, str. grade)** | | | |
| Miag Multomat Mill | 76.8 | 76.4 | 77.6 |
| Quadrumat Sr. Mill | 68.6 | 69.2 | 69.4 |
| **Flour moisture (%)** | 12.9 | 13.2 | 13.3 |
| **Flour protein (14% mb)** | 11.9 | 11.5 | 11.1 |
| **Flour ash (14% mb)** | 0.44 | 0.46 | 0.48 |
| **Rapid Visco-Analyser** | | | |
| Peak Time (min) | 6.1 | 6.1 | 6.2 |
| Peak Viscosity (RVU) | 171.5 | 171.3 | 205.1 |
| Breakdown (RVU) | 65.8 | 56.3 | 73.4 |
| Final Viscosity at 13 min (RVU) | 192.3 | 213.0 | 234.4 |
| **Minolta color meter** | | | |
| L* | 91.10 | 91.14 | 91.15 |
| a* | -1.10 | -1.02 | -1.36 |
| b* | 8.88 | 8.73 | 9.66 |
| **PPO** | 0.310 | 0.232 | 0.410 |
| **Falling number (sec)** | 365 | 360 | 392 |
| **Damaged Starch** | | | |
| (AI%) | 97.2 | 97.5 | 97.3 |
| (AACC76-31) | 7.2 | 7.5 | 7.3 |

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

# Montana: 2023 (Small-Scale) Samples (Continued)

| Test entry number | 23-2427 | 23-2428 |
|---|---|---|
| **Sample identification** | **MTCL2010_MT** | **MTF20189_MT** |
| **Wheat Data** | | |
| **GIPSA classification** | 1 HRW | 1 HRW |
| **Test weight (lb/bu)** | 61.6 | 62.1 |
| **Hectoliter weight (kg/hl)** | 81.0 | 81.7 |
| **1000 kernel weight (gm)** | 33.2 | 40.9 |
| **Wheat kernel size (Rotap)** | | |
| Over 7 wire (%) | 69.5 | 96.8 |
| Over 9 wire (%) | 30.2 | 3.3 |
| Through 9 wire (%) | 0.3 | 0.0 |
| **Single kernel (skcs)[a]** | | |
| Hardness (avg /s.d) | 42.3/15.3 | 50.2/13.1 |
| Weight (mg) (avg/s.d) | 34.7/9.3 | 43.3/8.6 |
| Diameter (mm)(avg/s.d) | 2.64/0.36 | 2.965/0.38 |
| Moisture (%) (avg/s.d) | 10.6/0.6 | 10.6/0.3 |
| SKCS distribution | 28-34-24-14-03 | 09-32-33-26-01 |
| Classification | Mixed | Hard |
| **Wheat protein (12% mb)** | 13.7 | 15.1 |
| **Wheat ash (12% mb)** | 1.59 | 1.50 |
| **Milling and Flour Quality Data** | | |
| **Flour yield (%, str. grade)** | | |
| Miag Multomat Mill | 78.9 | 72.7 |
| Quadrumat Sr. Mill | 71.8 | 66.3 |
| **Flour moisture (%)** | 12.9 | 12.7 |
| **Flour protein (14% mb)** | 12.3 | 14.0 |
| **Flour ash (14% mb)** | 0.43 | 0.42 |
| **Rapid Visco-Analyser** | | |
| Peak Time (min) | 6.1 | 6.5 |
| Peak Viscosity (RVU) | 146.6 | 193.0 |
| Breakdown (RVU) | 43.3 | 51.8 |
| Final Viscosity at 13 min (RVU) | 200.5 | 238.2 |
| **Minolta color meter** | | |
| L* | 91.18 | 91.65 |
| a* | -1.69 | -1.29 |
| b* | 10.94 | 8.85 |
| **PPO** | 0.624 | 0.102 |
| **Falling number (sec)** | 341 | 388 |
| **Damaged Starch** | | |
| (AI%) | 97.1 | 96.0 |
| (AACC76-31) | 7.2 | 6.2 |

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

# Montana: Physical Dough Tests and Gluten Analysis
# 2023 (Small-Scale) Samples

| Test Entry Number | 23-2424 | 23-2425 | 23-2426 |
|---|---|---|---|
| Sample Identification | Yellowstone_CK | SY Monument_CK | MT2019_MT |
| **MIXOGRAPH** | | | |
| Flour Abs (% as-is) | 67.6 | 66.7 | 66.1 |
| Flour Abs (14% mb) | 66.7 | 66.1 | 65.5 |
| Mix Time (min) | 6.0 | 6.0 | 4.1 |
| Mix tolerance (0-6) | 5 | 4 | 4 |
| **FARINOGRAPH** | | | |
| Flour Abs (% as-is) | 68.4 | 67.1 | 69.4 |
| Flour Abs (14% mb) | 67.5 | 66.5 | 68.8 |
| Peak time (min) | 4.5 | 5.4 | 5.3 |
| Mix stability (min) | 7.5 | 10.6 | 8.6 |
| Mix Tolerance Index (FU) | 33 | 23 | 27 |
| Breakdown time (min) | 9.3 | 11.5 | 10.4 |
| **ALVEOGRAPH** | | | |
| P(mm): Tenacity | 160 | 185 | 175 |
| L(mm): Extensibility | 57 | 50 | 49 |
| G(mm): Swelling index | 16.8 | 15.7 | 15.5 |
| W($10^{-4}$ J): strength (curve area) | 387 | 399 | 355 |
| P/L: curve configuration ratio | 2.81 | 3.70 | 3.57 |
| Ie($P_{200}$/P): elasticity index | 65.5 | 62.7 | 55.5 |
| **EXTENSIGRAPH** | | | |
| Resist (BU at 45/90/135 min) | 465/574/529 | 587/842/924 | 386/406/477 |
| Extensibility (mm at 45/90/135 min) | 151/148/144 | 147/120/115 | 160/167/169 |
| Energy ($cm^2$ at 45/90/135 min) | 133/160/135 | 158/163/167 | 122/139/157 |
| Resist $_{max}$ (BU at 45/90/135 min) | 722/902/793 | 854/1118/1240 | 606/674/731 |
| Ratio (at 45/90/135 min) | 3.1/3.9/3.7 | 4.0/7.0/8.1 | 2.4/2.4/2.8 |
| **PROTEIN ANALYSIS** | | | |
| HMW-GS Composition | 1, 7+9, 5+10 | 2*, 7+9, 5+10 | 1, 7+8, 5+10 |
| TPP/TMP | 0.70 | 0.78 | 0.76 |
| **SEDIMENTATION TEST** | | | |
| Volume (ml) | 70.8 | 69.6 | 66.6 |

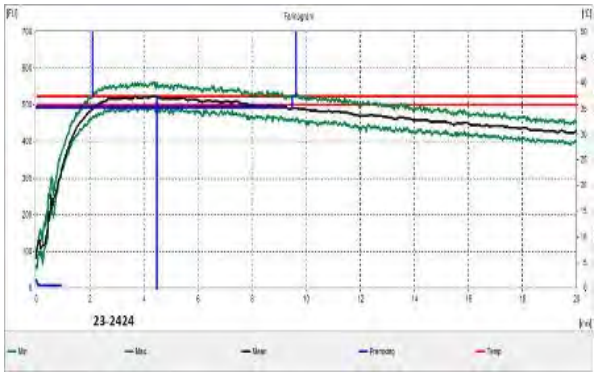
# Montana: Physical Dough Tests and Gluten Analysis 2023 (Small-Scale) Samples (Continued)

| Test Entry Number | 22-2427 | 22-2428 |
|---|---|---|
| Sample Identification | MTCL2010_MT | MTF20189_MT |
| **MIXOGRAPH** | | |
| Flour Abs (% as-is) | 67.9 | 72.2 |
| Flour Abs (14% mb) | 67.1 | 71.0 |
| Mix Time (min) | 4.8 | 4.3 |
| Mix tolerance (0-6) | 4 | 4 |
| **FARINOGRAPH** | | |
| Flour Abs (% as-is) | 66.5 | 72.5 |
| Flour Abs (14% mb) | 65.7 | 71.3 |
| Peak time (min) | 5.9 | 7.0 |
| Mix stability (min) | 12.8 | 9.3 |
| Mix Tolerance Index (FU) | 11 | 27 |
| Breakdown time (min) | 13.7 | 11.6 |
| **ALVEOGRAPH** | | |
| P(mm): Tenacity | 156 | 185 |
| L(mm): Extensibility | 79 | 79 |
| G(mm): Swelling index | 19.7 | 19.7 |
| W($10^{-4}$ J): strength (curve area) | 466 | 577 |
| P/L: curve configuration ratio | 1.97 | 2.34 |
| Ie($P_{200}$/P): elasticity index | 63.2 | 57.5 |
| **EXTENSIGRAPH** | | |
| Resist (BU at 45/90/135 min) | 481/699/814 | 372/405/454 |
| Extensibility (mm at 45/90/135 min) | 141/130/124 | 159/155/166 |
| Energy ($cm^2$ at 45/90/135 min) | 119/150/156 | 115/122/145 |
| Resist $_{max}$ (BU at 45/90/135 min) | 675/964/1075 | 574/630/702 |
| Ratio (at 45/90/135 min) | 3.4/5.4/6.5 | 2.4/2.6/2.7 |
| **PROTEIN ANALYSIS** | | |
| HMW-GS Composition | 1, 7+9, 5+10 | 2*, 7+9, 5+10 |
| TPP/TMP | 0.73 | 0.81 |
| **SEDIMENTATION TEST** | | |
| Volume (ml) | 69.4 | 70.7 |

# Physical Dough Tests

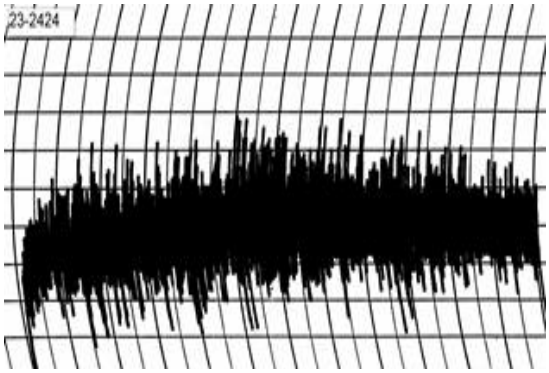
## 2023 (Small Scale) Samples – Montana

### Farinograms



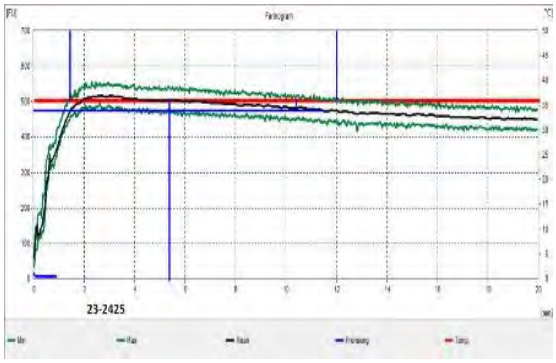

Water abs = 67.5%, Peak time = 4.5 min
Mix stab = 7.5 min, MTI = 33 FU

### Mixograms

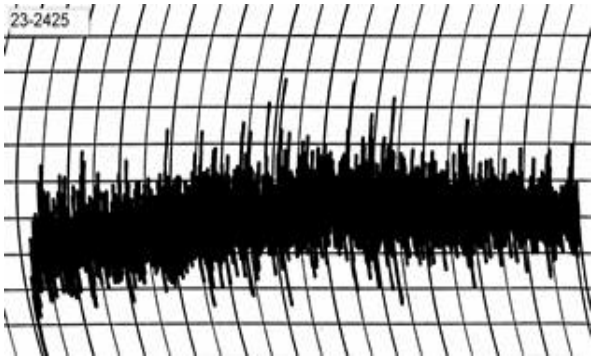



Water abs = 66.7%
Mix time = 6.0 min

## 23-2424, Yellowstone_CK




Water abs = 66.5%, Peak time = 5.4 min,
Mix stab = 10.6 min, MTI = 23 FU



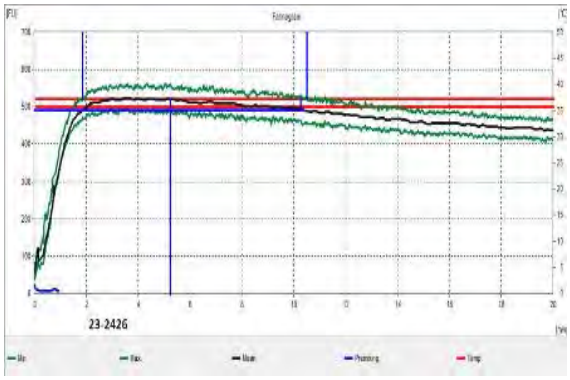

Water abs = 66.13%
Mix time = 6.0 min

## 23-2425, SY Monument_CK

# Physical Dough Tests

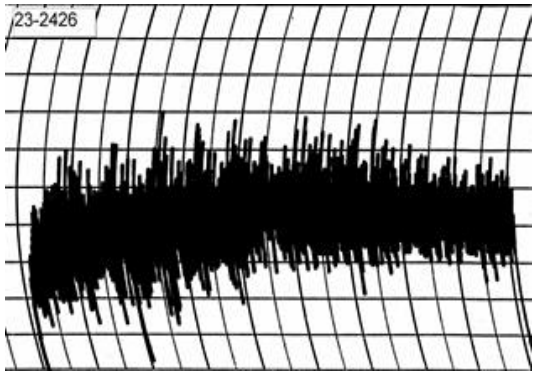
## 2022 (Small Scale) Samples – Montana (continued)

### Farinograms



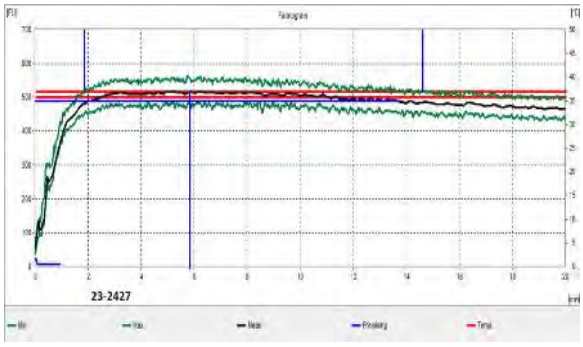

Water abs. = 68.8%, Peak time = 5.3 min,
Mix stab = 8.6 min, MTI = 27 FU

### Mixograms

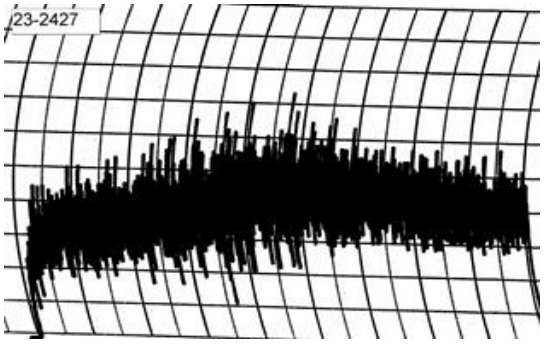



Water abs = 65.5%
Mix time = 4.1 min

**23-2426, MT2019_MT**




Water abs. = 65.7%, Peak time = 5.9 min,
Mix stab = 12.8 min, MTI = 11 FU



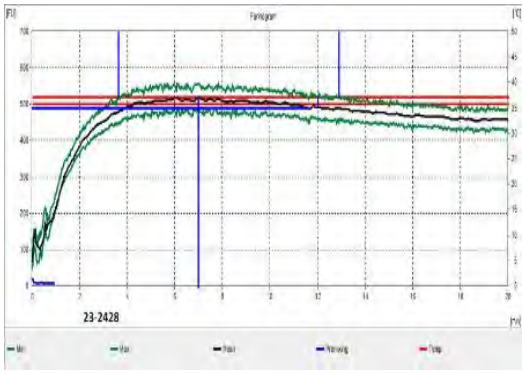

Water abs = 67.1%
Mix time = 4.8 min

**23-2427, MTCL2010_MT**

# Physical Dough Tests

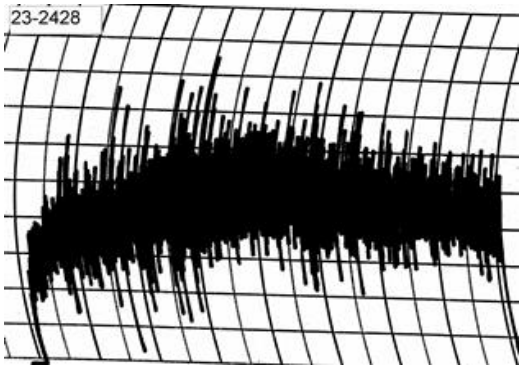
## 2023 (Small Scale) Samples – Montana (continued)

### Farinograms




Water abs. = 71.3%, Peak time = 7.0 min,
Mix stab = 9.3 min, MTI = 27 FU

### Mixograms

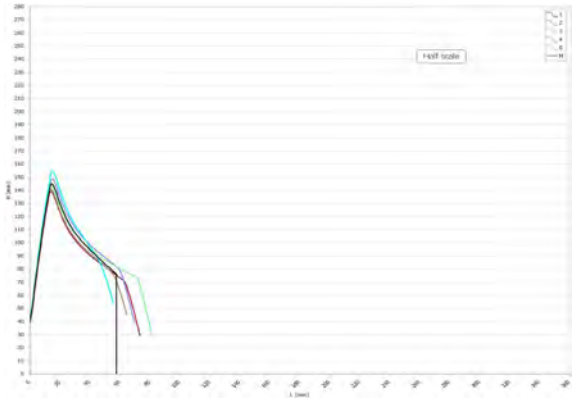



Water abs = 71.0%
Mix time = 4.3 min

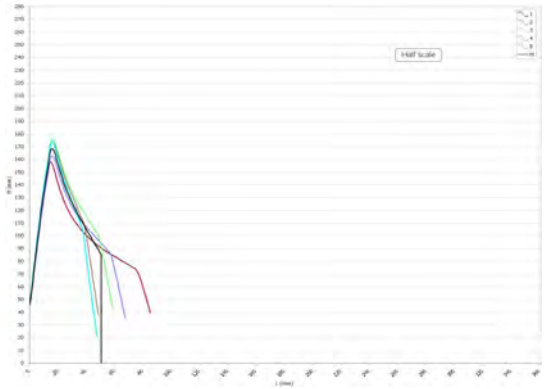
**23-2428, MTF20189_MT**

# Physical Dough Tests - Alveograph

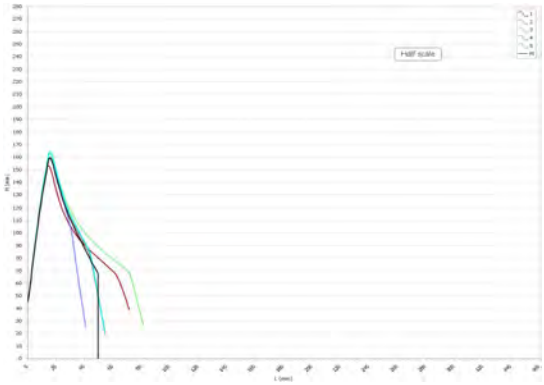
## 2023 (Small Scale) Samples – Montana



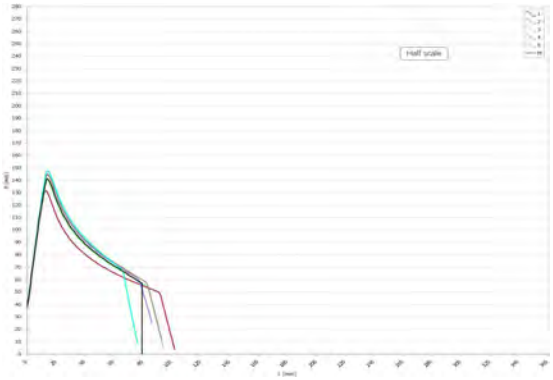
**23-2424, Yellowstone_CK**
P (mm $H_20$) = 160, L (mm) = 57, W ($10E^{-4}J$) = 387



**23-2425, SY Monument_CK**
P (mm $H_20$) = 185, L (mm) = 50, W ($10E^{-4}J$) = 399



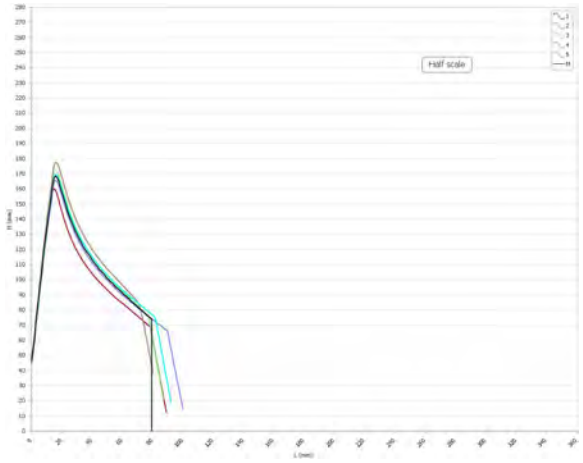
**23-2426, MT2019_MT**
P (mm $H_20$) = 175, L (mm) = 49, W ($10E^{-4}J$) = 355



**23-2427, MTCL2010_MT**
P (mm $H_20$) = 156, L (mm) = 79, W ($10E^{-4}J$) = 466

# Physical Dough Tests - Alveograph

## 2023 (Small Scale) Samples – Montana (Continued)

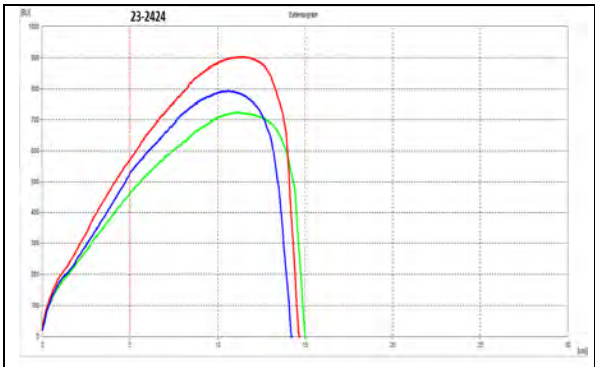



**23-2428, MTF20189_MT**

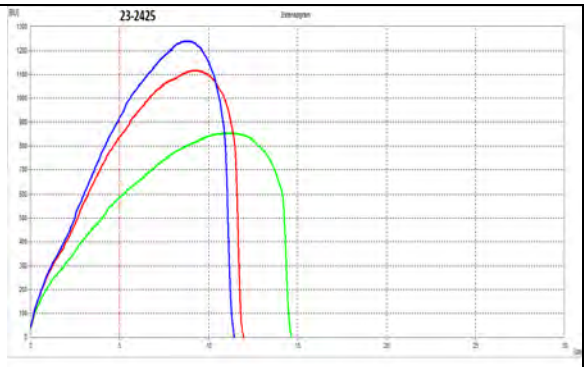
P (mm $H_20$) = 185, L (mm) = 79, W ($10E^{-4}J$) = 577

# Physical Dough Tests - Extensigraph

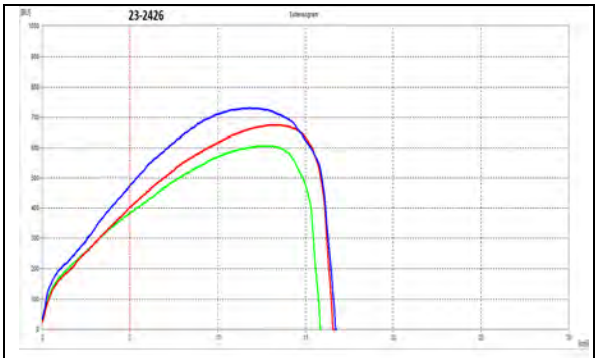
## 2023 (Small Scale) Samples – Montana



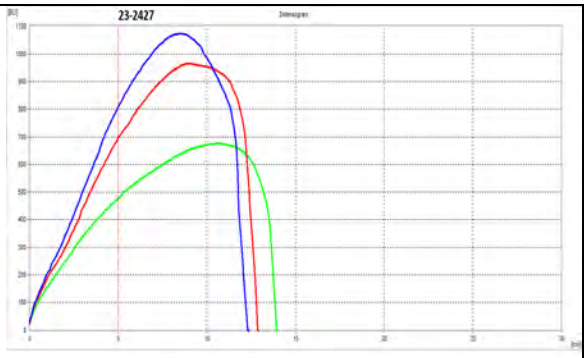

**23-2424, Yellowstone_CK**
R (BU) = 574, E (mm) = 148, W ($cm^2$) = 160
Rmax (BU) = 902, Ratio = 3.9 at 90 min




**23-2425, SY Monument_CK**
R (BU) = 842, E (mm) = 120, W ($cm^2$) = 163
Rmax (BU) = 1118, Ratio = 7.0 at 90 min




**23-2426, MT2019_MT**
R (BU) = 406, E (mm) = 167, W ($cm^2$) = 139
Rmax (BU) = 674, Ratio = 2.4 at 90 min

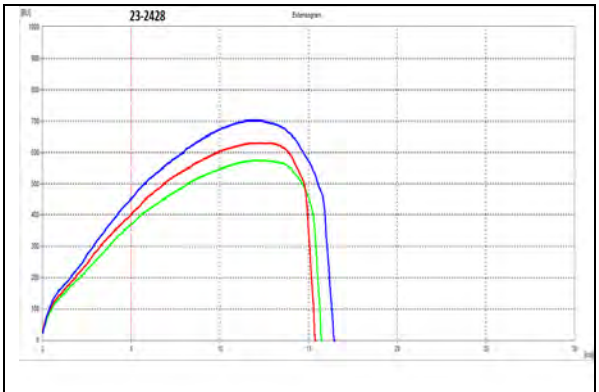



**23-2427, MTCL2010_MT**
R (BU) = 699, E (mm) = 130, W ($cm^2$) = 150
Rmax (BU) = 964, Ratio = 5.4 at 90 min

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.

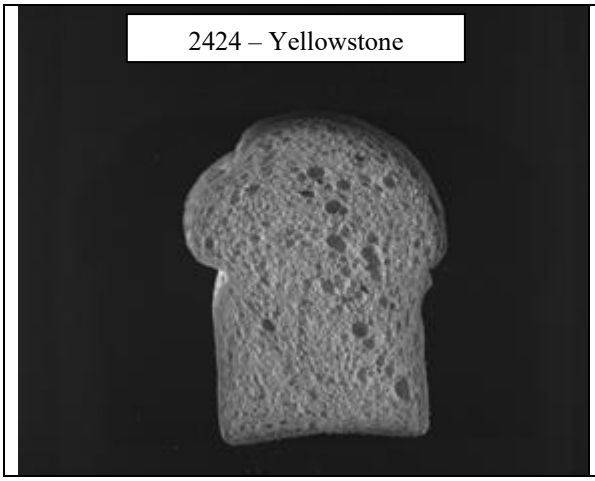
# Physical Dough Tests - Extensigraph

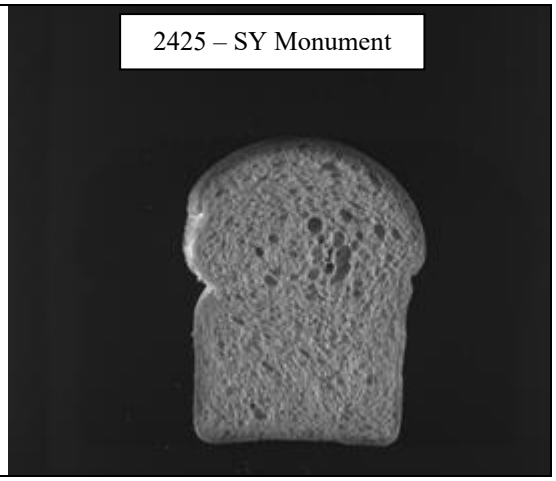
## 2023 (Small Scale) Samples – Montana (Continued)



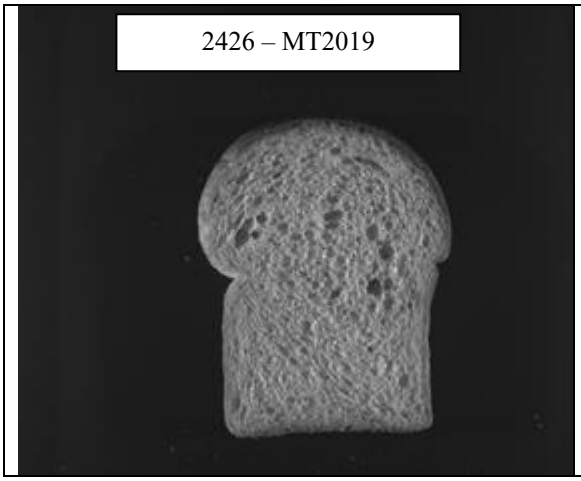

**23-2428, MTF20189_MT**
R (BU) = 405, E (mm) = 155, W ($cm^2$) = 122
Rmax (BU) = 630, Ratio = 2.6 at 90 min

# Montana: C-Cell Bread Images and Analysis
# 2023 (Small-Scale) Samples




| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2424** | 6558 | 113 | 3925 | 0.420 | 1.970 | 3.330 | 1.715 | -5.85 |
| **2425** | 5939 | 113 | 3653 | 0.420 | 1.825 | 1.495 | 1.735 | -4.90 |

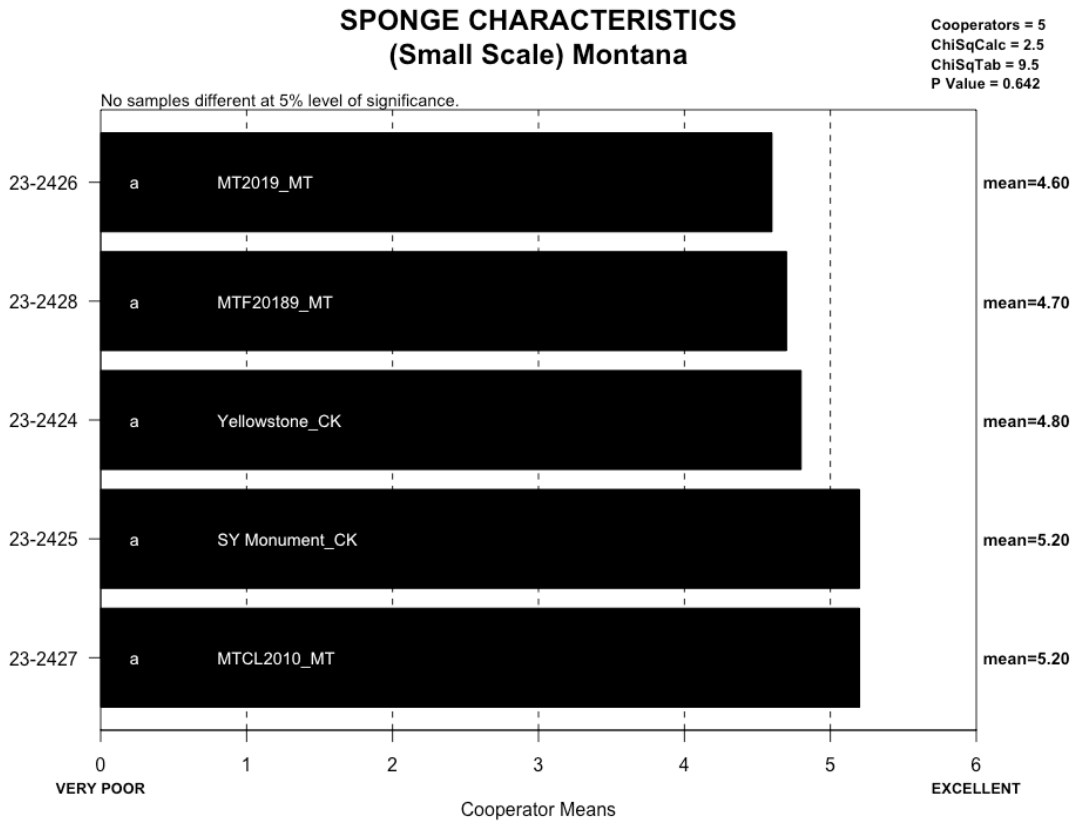


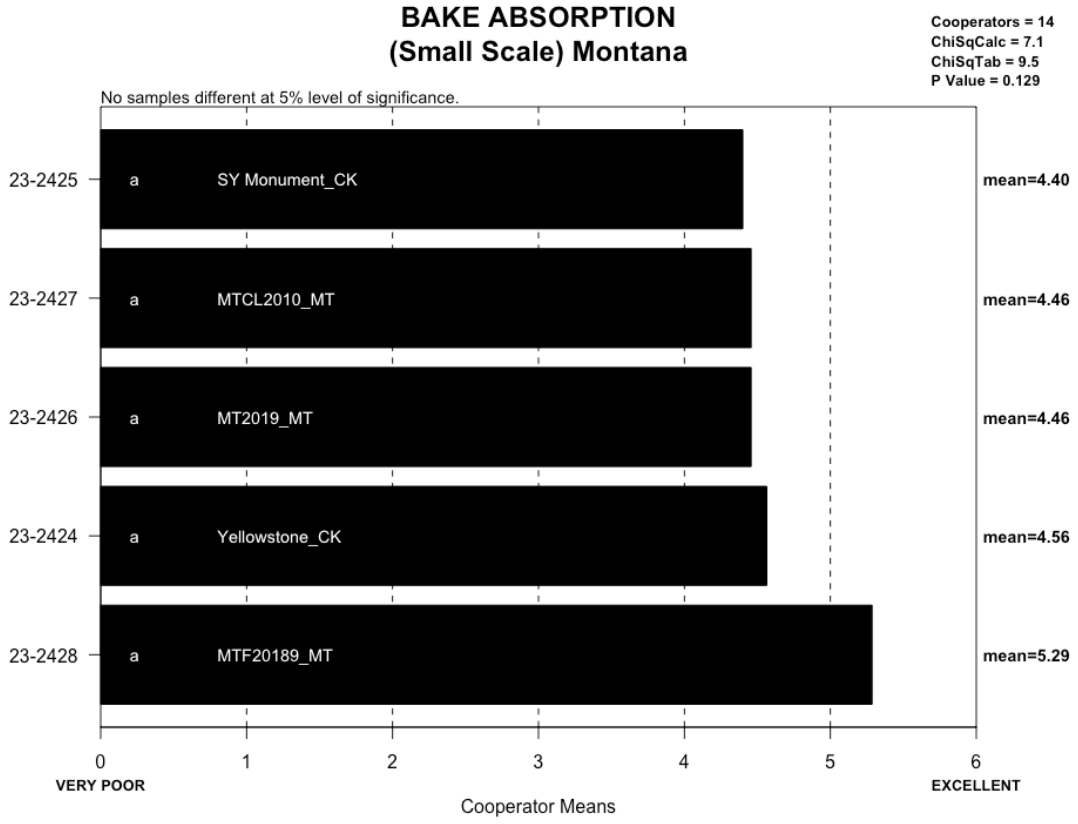


| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2426** | 6105 | 114 | 3745 | 0.418 | 1.948 | 6.185 | 1.695 | 0.05 |
| **2427** | 6500 | 113 | 4087 | 0.415 | 1.865 | 3.060 | 1.690 | -6.00 |

# Montana: C-Cell Bread Images and Analysis
# 2023 (Small-Scale) Samples (Continued)


| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2428** | 6595 | 114 | 3688 | 0.435 | 2.080 | 6.060 | 1.715 | -6.00 |


SPONGE CHARACTERISTICS
(Small Scale) Montana
Cooperators = 5
ChiSqCalc = 2.5
ChiSqTab = 9.5
P Value = 0.642
No samples different at 5% level of significance.
23-2426
a
MT2019_MT
mean=4.60
23-2428
a
MTF20189_MT
mean=4.70
23-2424
a
Yellowstone_CK
mean=4.80
23-2425
a
SY Monument_CK
mean=5.20
23-2427
a
MTCL2010_MT
mean=5.20
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

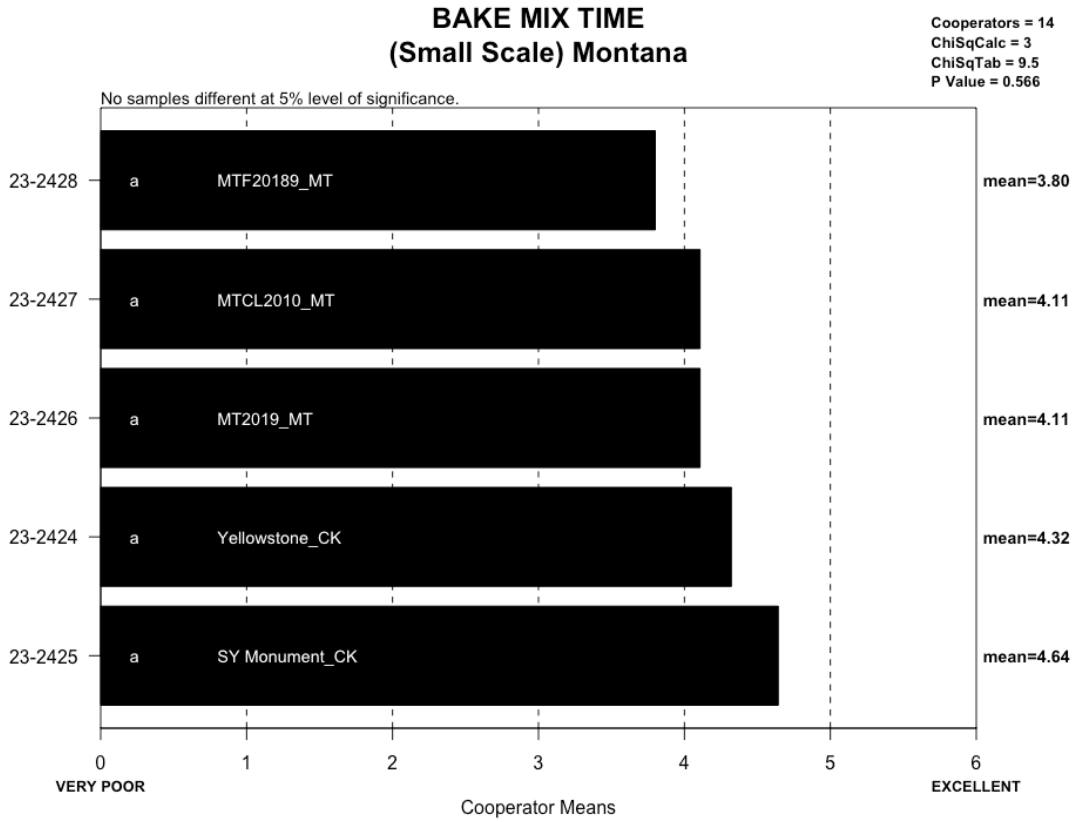

BAKE ABSORPTION
(Small Scale) Montana
Cooperators = 14
ChiSqCalc = 7.1
ChiSqTab = 9.5
P Value = 0.129
No samples different at 5% level of significance.
23-2425
a
SY Monument_CK
mean=4.40
23-2427
a
MTCL2010_MT
mean=4.46
23-2426
a
MT2019_MT
mean=4.46
23-2424
a
Yellowstone_CK
mean=4.56
23-2428
a
MTF20189_MT
mean=5.29
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

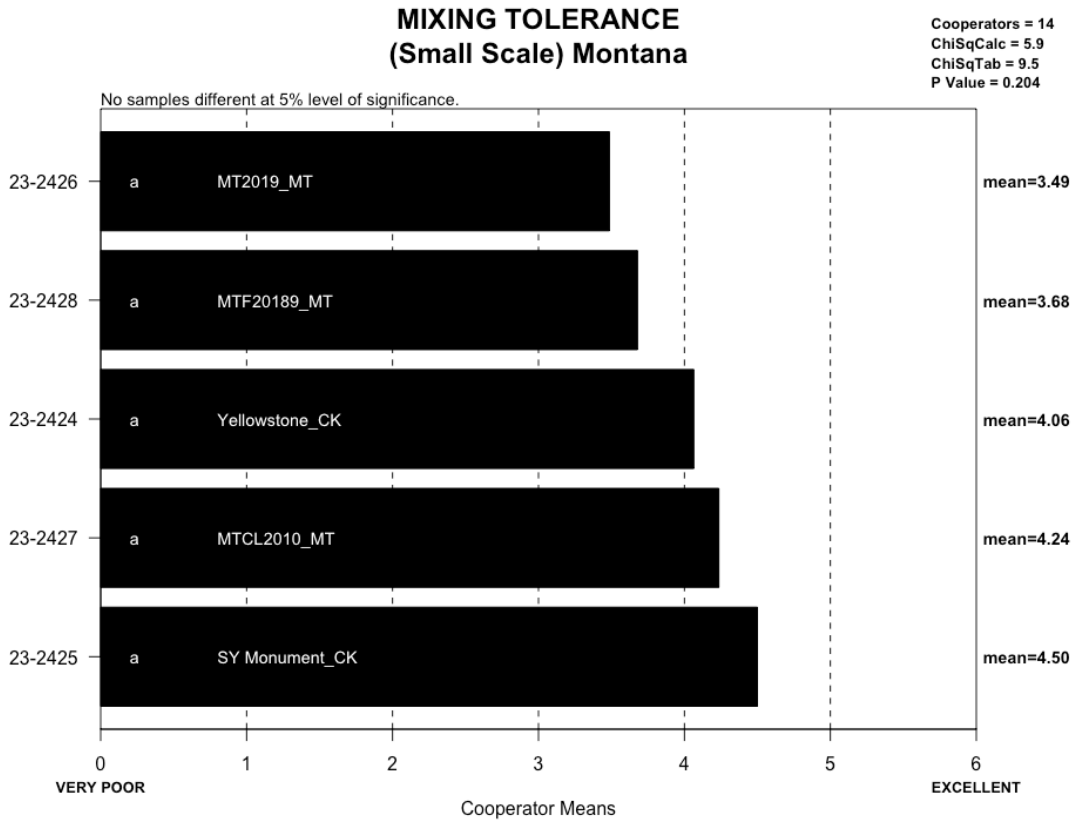
# BAKE ABSORPTION, ACTUAL (14% MB)
# (Small Scale) Montana
# Cooperators A – N

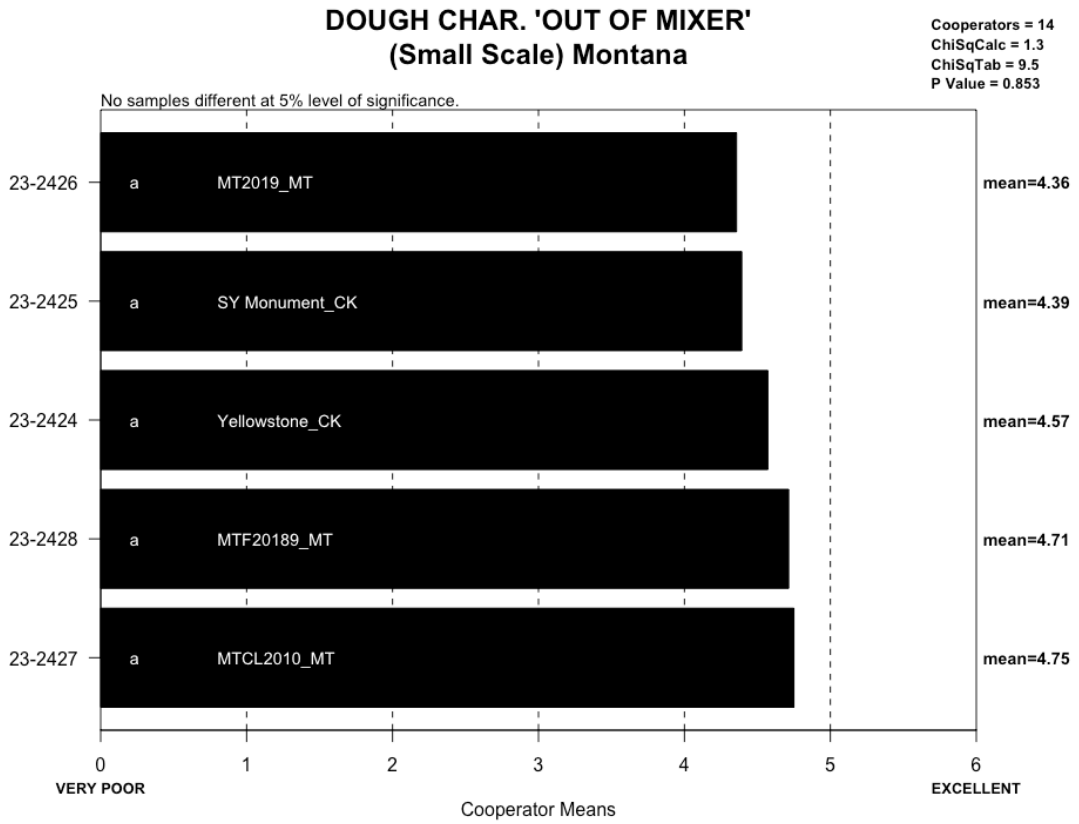
| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 67.2 | 63.9 | 61 | 66.8 | 66.8 | 64.9 | 67 | 68.7 | 61.7 | 67.5 | 66.7 | 70.5 | 69.5 | 68.5 |
| 23-2425 | SY Monument_CK | 65.9 | 64.3 | 61 | 66.1 | 66.1 | 62.6 | 67 | 67.5 | 62.6 | 66.5 | 66.1 | 69.5 | 68.5 | 66.9 |
| 23-2426 | MT2019_MT | 65.2 | 64.1 | 60 | 65.5 | 66.6 | 62.9 | 69 | 65.5 | 62.4 | 68.8 | 65.5 | 71.2 | 70.8 | 69.2 |
| 23-2427 | MTCL2010_MT | 67.0 | 63.4 | 61 | 67.3 | 66.9 | 64.9 | 65 | 67.1 | 62.4 | 65.7 | 67.1 | 68.7 | 67.7 | 66.5 |
| 23-2428 | MTF20189_MT | 71.3 | 63.4 | 63 | 71.0 | 71.0 | 66.4 | 71 | 72.7 | 62.8 | 71.3 | 71.0 | 74.0 | 73.3 | 71.7 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 5.5 | 5.5 | 9 | 7.3 | 9.6 | 10.7 | 20 | 6.0 | 7 | 5 | 6.0 | 7.0 | 20 | 5.5 |
| 23-2425 | SY Monument_CK | 5.9 | 6.5 | 15 | 7.3 | 10.5 | 9.2 | 20 | 6.5 | 11 | 6 | 6.0 | 8.0 | 20 | 6.0 |
| 23-2426 | MT2019_MT | 4.4 | 4.0 | 12 | 6.3 | 8.3 | 7.9 | 20 | 5.0 | 7 | 6 | 4.1 | 6.5 | 18 | 5.5 |
| 23-2427 | MTCL2010_MT | 4.4 | 4.5 | 15 | 5.3 | 7.1 | 6.3 | 20 | 4.8 | 8 | 6 | 4.8 | 7.0 | 18 | 4.8 |
| 23-2428 | MTF20189_MT | 4.1 | 3.5 | 9 | 5.8 | 6.9 | 4.2 | 25 | 4.0 | 9 | 8 | 4.3 | 7.0 | 16 | 4.8 |

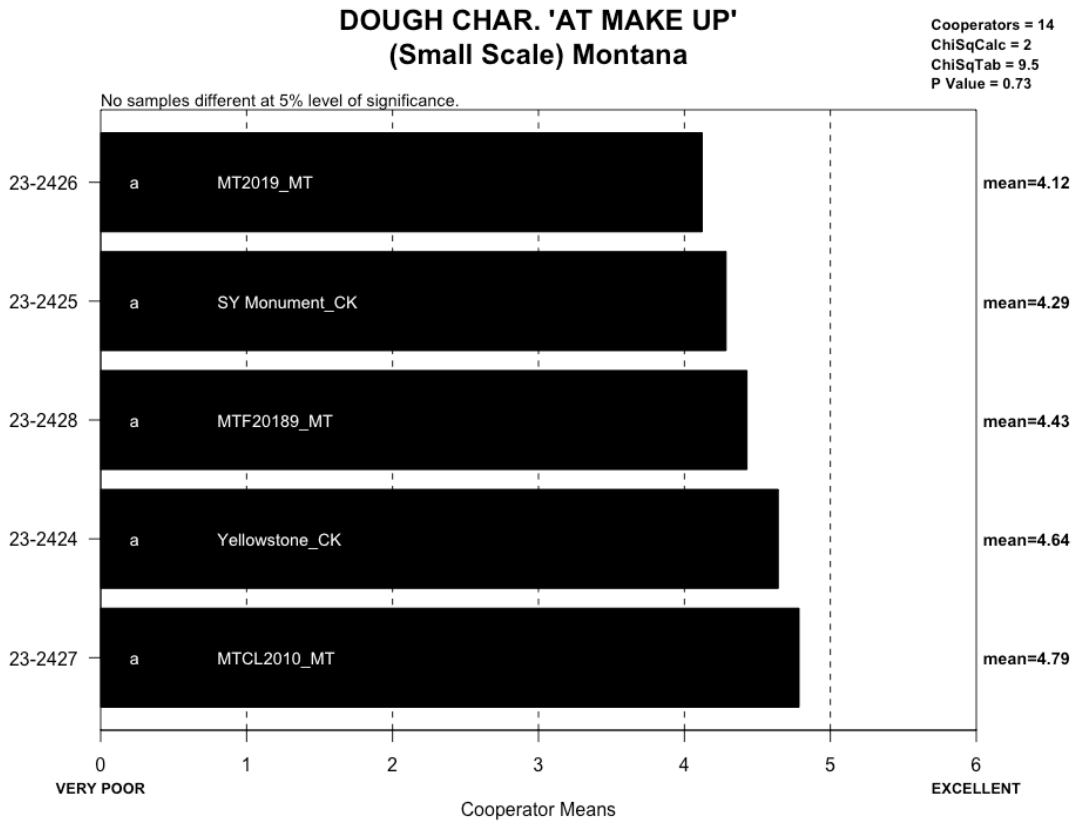

BAKE MIX TIME
(Small Scale) Montana
Cooperators = 14
ChiSqCalc = 3
ChiSqTab = 9.5
P Value = 0.566
No samples different at 5% level of significance.
23-2428
a
MTF20189_MT
mean=3.80
23-2427
a
MTCL2010_MT
mean=4.11
23-2426
a
MT2019_MT
mean=4.11
23-2424
a
Yellowstone_CK
mean=4.32
23-2425
a
SY Monument_CK
mean=4.64
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Montana
Cooperators = 14
ChiSqCalc = 5.9
ChiSqTab = 9.5
P Value = 0.204
No samples different at 5% level of significance.
23-2426
a
MT2019_MT
mean=3.49
23-2428
a
MTF20189_MT
mean=3.68
23-2424
a
Yellowstone_CK
mean=4.06
23-2427
a
MTCL2010_MT
mean=4.24
23-2425
a
SY Monument_CK
mean=4.50
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



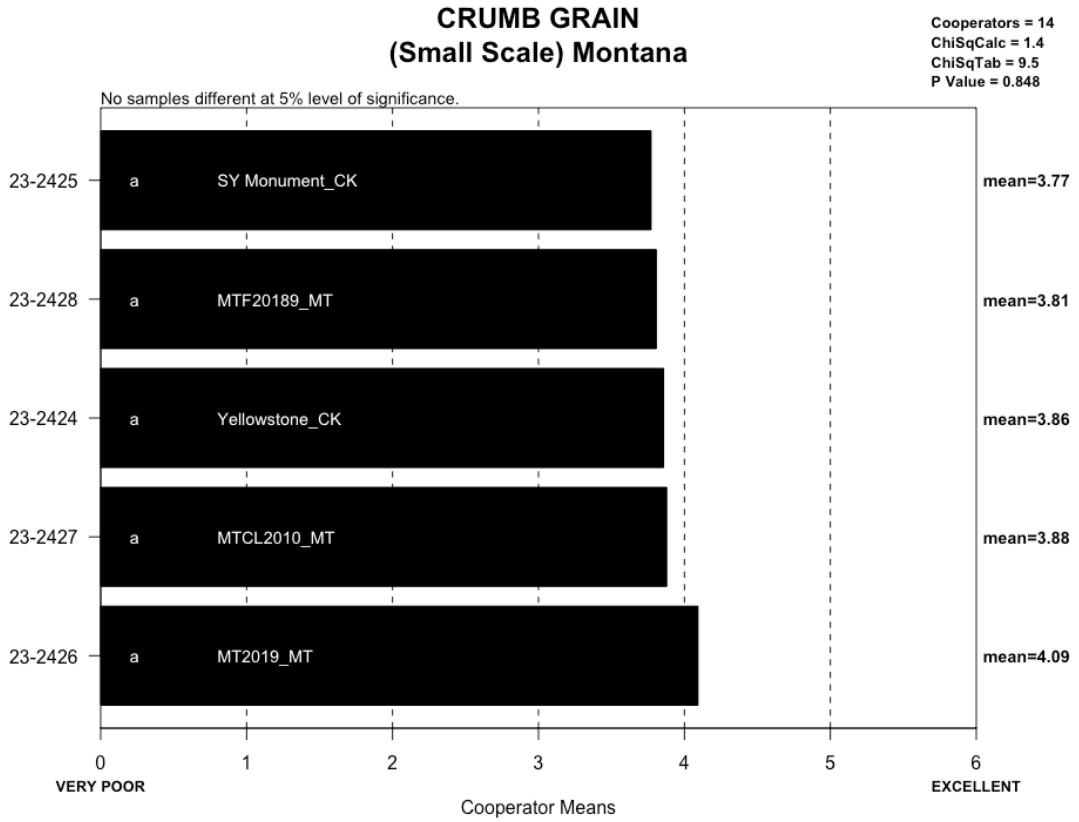

# DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Small Scale) Montana

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 1 | 0 | 2 | 6 | 5 |
| 23-2425 | SY Monument_CK | 2 | 0 | 3 | 7 | 2 |
| 23-2426 | MT2019_MT | 1 | 1 | 4 | 4 | 4 |
| 23-2427 | MTCL2010_MT | 1 | 0 | 2 | 8 | 3 |
| 23-2428 | MTF20189_MT | 0 | 0 | 3 | 8 | 3 |




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

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 1 | 0 | 4 | 4 | 5 |
| 23-2425 | SY Monument_CK | 1 | 0 | 4 | 5 | 4 |
| 23-2426 | MT2019_MT | 2 | 0 | 5 | 3 | 4 |
| 23-2427 | MTCL2010_MT | 1 | 0 | 2 | 6 | 5 |
| 23-2428 | MTF20189_MT | 1 | 1 | 2 | 6 | 4 |

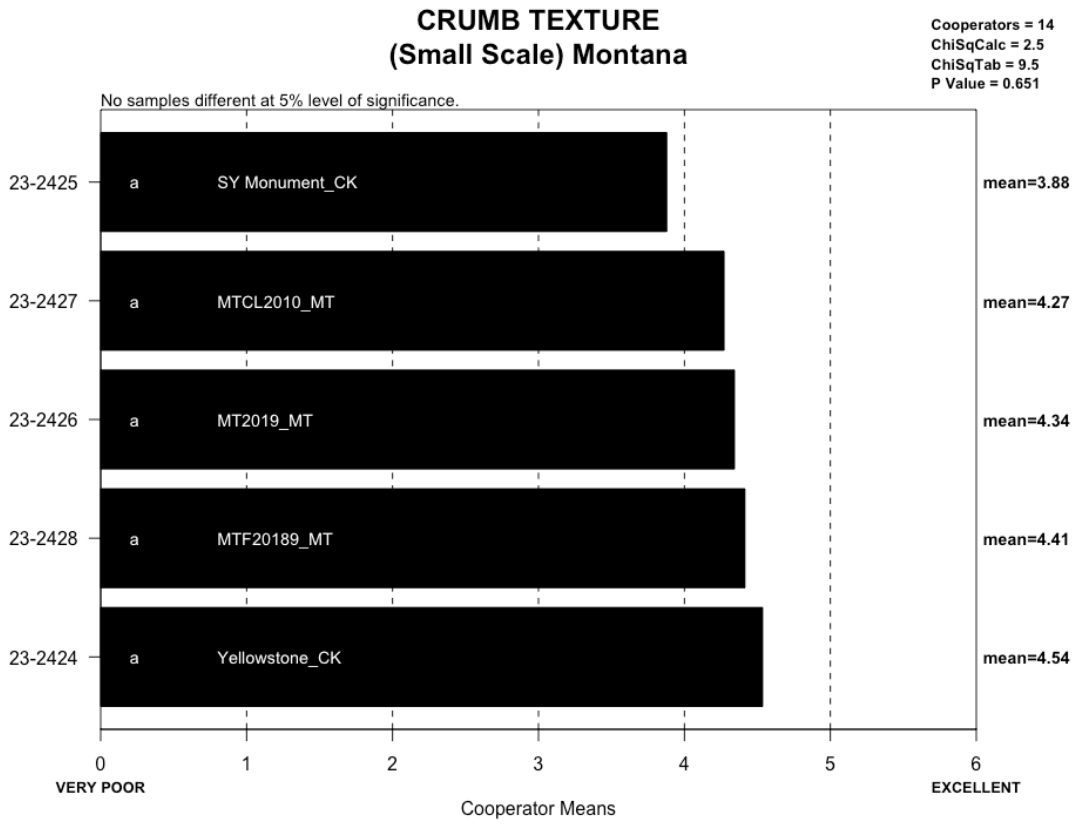



# CRUMB GRAIN, DESCRIBED
# (Small Scale) Montana

| IDCODE | ID | Open | Fine | Dense |
|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 9 | 1 | 4 |
| 23-2425 | SY Monument_CK | 7 | 2 | 5 |
| 23-2426 | MT2019_MT | 6 | 5 | 3 |
| 23-2427 | MTCL2010_MT | 8 | 2 | 4 |
| 23-2428 | MTF20189_MT | 10 | 2 | 2 |

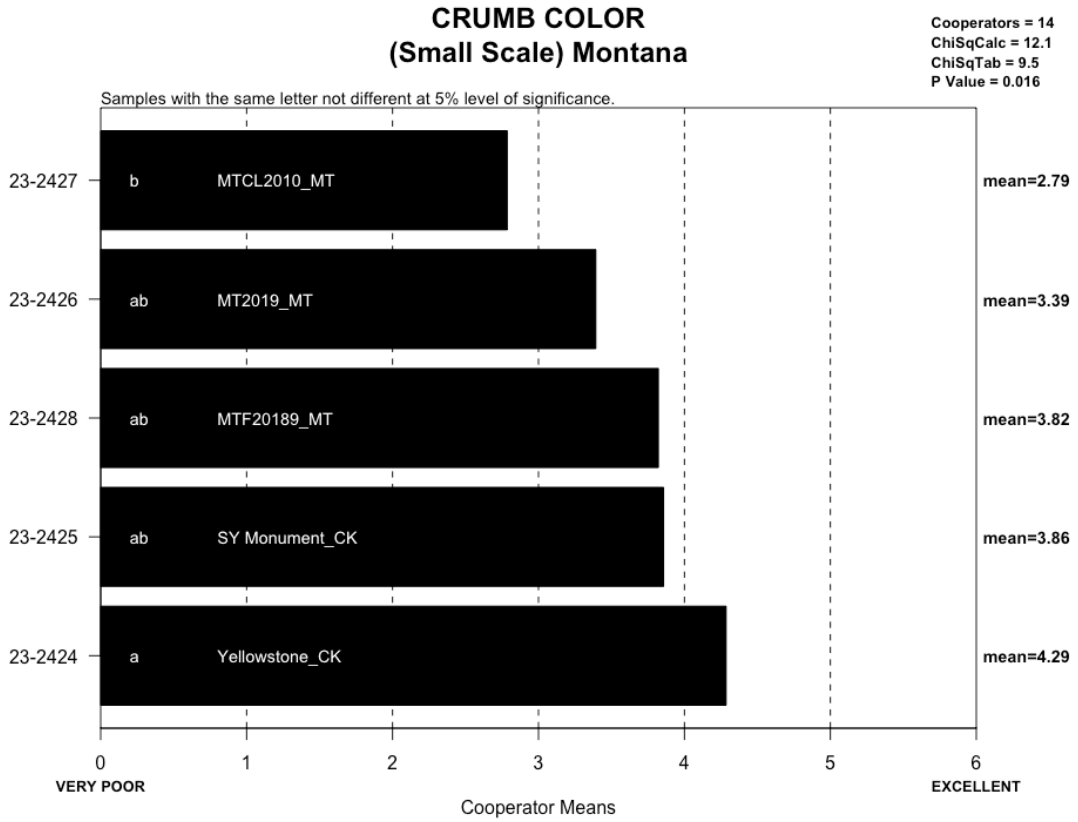
# CELL SHAPE, DESCRIBED
# (Small Scale) Montana

| IDCODE | ID | Round | Irregular | Elongated |
|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 6 | 5 | 3 |
| 23-2425 | SY Monument_CK | 4 | 6 | 4 |
| 23-2426 | MT2019_MT | 5 | 5 | 4 |
| 23-2427 | MTCL2010_MT | 4 | 8 | 2 |
| 23-2428 | MTF20189_MT | 6 | 5 | 3 |




# CRUMB TEXTURE, DESCRIBED
# (Small Scale) Montana

| IDCODE | ID | Harsh | Smooth | Silky |
|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 2 | 4 | 8 |
| 23-2425 | SY Monument_CK | 4 | 7 | 3 |
| 23-2426 | MT2019_MT | 1 | 9 | 4 |
| 23-2427 | MTCL2010_MT | 2 | 9 | 3 |
| 23-2428 | MTF20189_MT | 3 | 6 | 5 |




# CRUMB COLOR, DESCRIBED
# (Small Scale) Montana

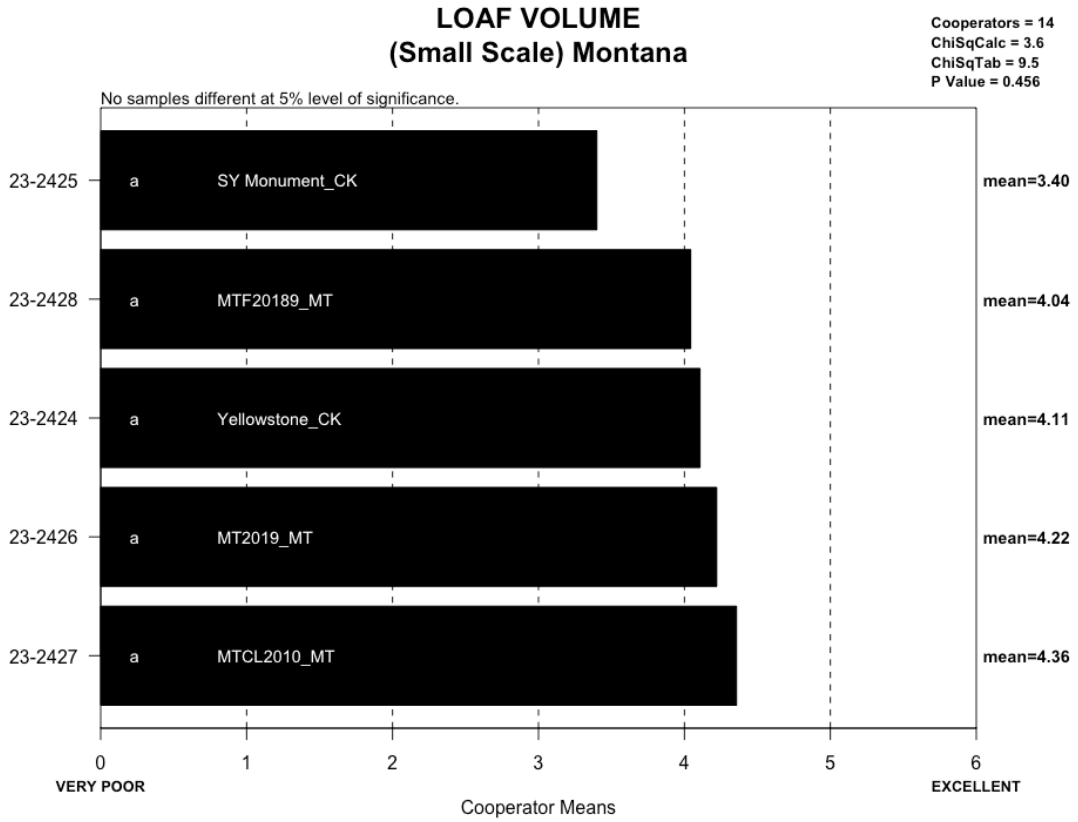
| IDCODE | ID | Gray | Dark Yellow | Yellow | Dull | Creamy | White | Bright_White |
|---|---|---|---|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 0 | 0 | 1 | 2 | 6 | 5 | 0 |
| 23-2425 | SY Monument_CK | 0 | 0 | 2 | 4 | 5 | 3 | 0 |
| 23-2426 | MT2019_MT | 0 | 1 | 3 | 4 | 5 | 1 | 0 |
| 23-2427 | MTCL2010_MT | 0 | 3 | 5 | 2 | 3 | 1 | 0 |
| 23-2428 | MTF20189_MT | 0 | 0 | 3 | 3 | 4 | 4 | 0 |

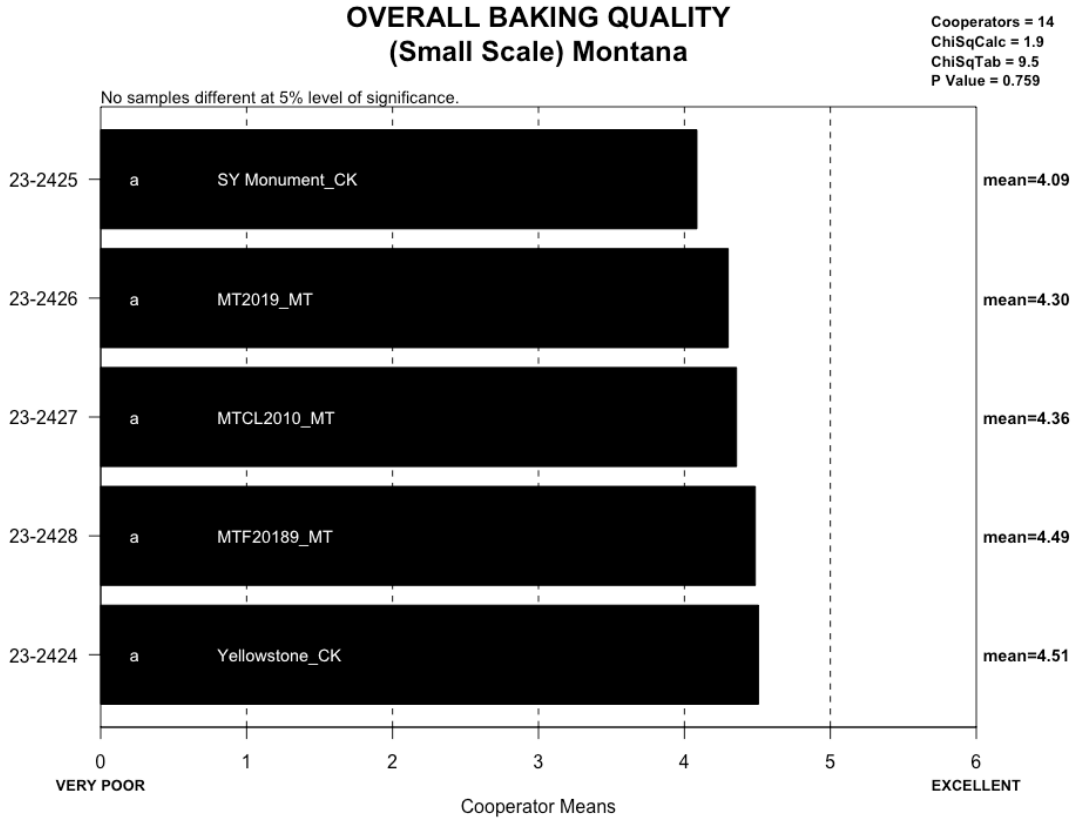
# LOAF WEIGHT, ACTUAL
# (Small Scale) Montana
# Cooperators A – N

| IDCODE | ID | A | B | C | D | E | F | H | I | J | K | L | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 144.2 | 152.2 | 412 | 141.3 | 153.1 | 140.0 | 146.8 | 478.9 | 460 | 142.2 | 437 | 133.7 |
| 23-2425 | SY Monument_CK | 143.4 | 156.8 | 411 | 141.2 | 153.6 | 139.3 | 141.9 | 478.3 | 467 | 141.9 | 439 | 133.1 |
| 23-2426 | MT2019_MT | 143.7 | 157.6 | 410 | 141.2 | 154.3 | 139.7 | 143.1 | 484.3 | 462 | 140.4 | 435 | 132.9 |
| 23-2427 | MTCL2010_MT | 142.1 | 155.9 | 416 | 141.0 | 153.8 | 138.9 | 143.5 | 478.0 | 462 | 141.8 | 438 | 131.7 |
| 23-2428 | MTF20189_MT | 146.7 | 159.6 | 414 | 139.7 | 156.8 | 144.2 | 146.1 | 479.4 | 455 | 142.6 | 439 | 132.7 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-2424 | Yellowstone_CK | 900 | 856 | 2675 | 821 | 890 | 1000 | 3044 | 1025 | 2450 | 2229 | 870 | 2498 | 2850 | 955 |
| 23-2425 | SY Monument_CK | 910 | 774 | 2825 | 818 | 810 | 963 | 2853 | 950 | 2375 | 1963 | 770 | 2397 | 2775 | 860 |
| 23-2426 | MT2019_MT | 835 | 801 | 2775 | 802 | 835 | 955 | 2941 | 1000 | 2688 | 2356 | 865 | 2495 | 2900 | 920 |
| 23-2427 | MTCL2010_MT | 975 | 865 | 2900 | 827 | 900 | 1000 | 3059 | 950 | 2650 | 2518 | 840 | 2560 | 2675 | 875 |
| 23-2428 | MTF20189_MT | 885 | 888 | 2650 | 831 | 960 | 958 | 2868 | 880 | 2550 | 2579 | 985 | 2486 | 2600 | 930 |


LOAF VOLUME
(Small Scale) Montana
Cooperators = 14
ChiSqCalc = 3.6
ChiSqTab = 9.5
P Value = 0.456
No samples different at 5% level of significance.
23-2425 a SY Monument_CK mean=3.40
23-2428 a MTF20189_MT mean=4.04
23-2424 a Yellowstone_CK mean=4.11
23-2426 a MT2019_MT mean=4.22
23-2427 a MTCL2010_MT mean=4.36
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Small Scale) Montana
Cooperators = 14
ChiSqCalc = 1.9
ChiSqTab = 9.5
P Value = 0.759
No samples different at 5% level of significance.
23-2425 a SY Monument_CK mean=4.09
23-2426 a MT2019_MT mean=4.30
23-2427 a MTCL2010_MT mean=4.36
23-2428 a MTF20189_MT mean=4.49
23-2424 a Yellowstone_CK mean=4.51
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

# COOPERATOR'S COMMENTS
# (Small Scale) Montana
# Cooperators A – N

**23-2424 Yellowstone_CK**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Shorter mix time Lower volume |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume. Tough dough throughout. |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, White Crumb Grain, Fine Elongate Cells, Good Resilient & Silky Smooth Texture |
| G | High - borderline excessive absorption, good stability / mix, excellent volume |
| H | long time to pick up, excellent externals |
| I | Avg absorption and mix time. Slightly below avg mix tolerance, crumb grain, and volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein. Good absorption, dough feels, mix tolerance and volume. Dough mixing not consistent with stability. |
| N | No comment. |

**23-2425 SY Monument_CK**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption, dense grain and low volume |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Dull Yellow Crumb Grain, Fine Elongate Cells, Good Resilient & Smooth Texture |
| G | High - borderline excessive absorption, good stability / mix, good volume |
| H | nice externals |
| I | High absorption & mix tolerance, longer mix time, tough dough, avg open crumb grain. Low volume. |
| J | least favorite bread of day 2 bakes |
| K | No comment. |
| L | No comment. |
| M | Fair protein. Good absorption, dough feels, mixing tolerance and volume. |
| N | No comment. |

**23-2426 MT2019_MT**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption and grain, low volume. Tough dough throughout. |
| F | High Water Abs, a Little Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Creamy Crumb Grain, Slight Open Elongate Cells, Good Resilient & Smooth Texture |
| G | High - borderline excessive absorption, good stability / mix, excellent volume. Noted: Lowest protein of Northern group. |
| H | tough, dry?, excellent externals |
| I | High absorption, avg mix time, nice grain & volume. Dark yellow crumb grain. Tough dough. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Fair protein and dough feels. Good absorption, mixing tolerance and volume. Dough mixing not consistent with stability. Recommend* |
| N | No comment. |

**23-2427 MTCL2010_MT**

| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | No comment. |
| D | No comment. |
| E | Long mix time, avg absorption, grain, and volume. Dark yellow crumb color. |
| F | High Water Abs, Long MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Open Elongate Cells, Good Resilient & Slight Harsh Texture |
| G | High absorption, excellent stability / mix, borderline yellow/high cream color |
| H | yellow dough, cap |
| I | High absorption, high mix tolerance, good dough, finest grain although dark yellow. Above average volume. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | Good protein, absorption, dough feels, mix tolerance and volume. |
| N | No comment. |

**23-2428 MTF20189_MT**

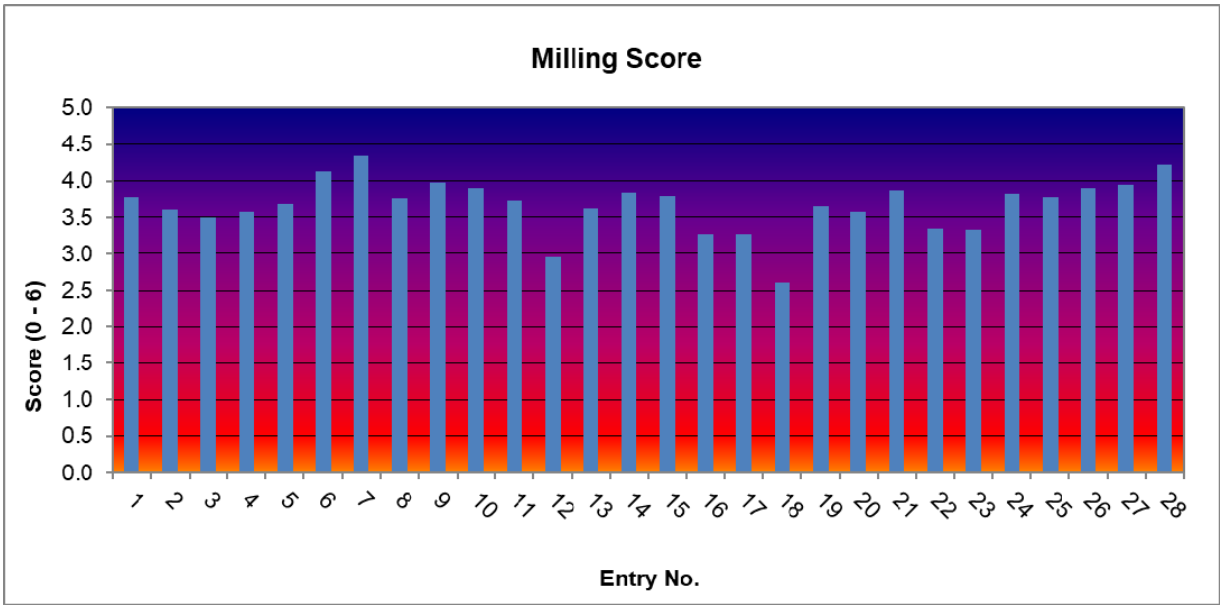
| | |
|---|---|
| A | No comment. |
| B | No comment. |
| C | Shorter mix Lower volume |
| D | No comment. |
| E | Long mix time, very high absorption, good mixing tolerance, avg crumb, excellent volume. |
| F | High Water Abs, Medium MT, Slight Sticky & Strong Dough, Very High Loaf Volume, Yellow Crumb Grain, Open Elongate Cells, Good Resilient & Slight Harsh Texture |
| G | Excessive absorption, excellent stability / mix, good volume. Noted: Highest protein of Northern group. |
| H | No comment. |
| I | High absorption, long mixing time, nice crumb grain and volume. Tough dough. |
| J | No comment. |
| K | No comment. |
| L | No comment. |
| M | High protein and absorption. Good dough feels and mix tolerance. Fair volume. |
| N | No comment. |

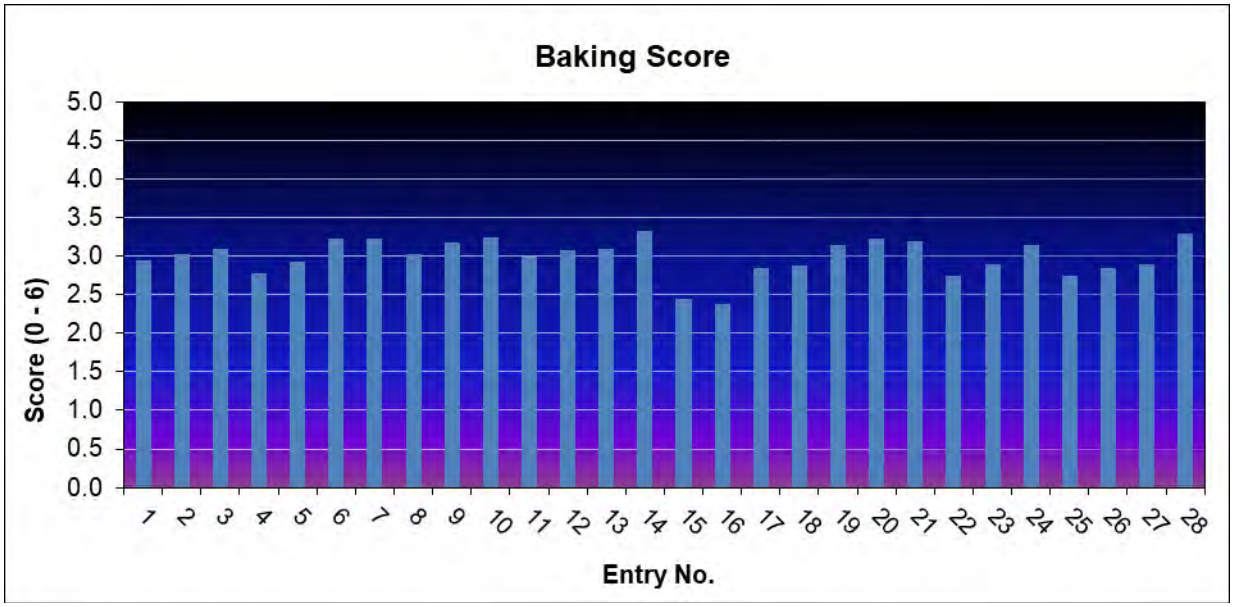
Sponge and dough bake tests: C, G, I, L, and M.

# *2023 WQC Milling and Baking Marketing Scores*

# 2023 WQC Milling & Baking Marketing Scores

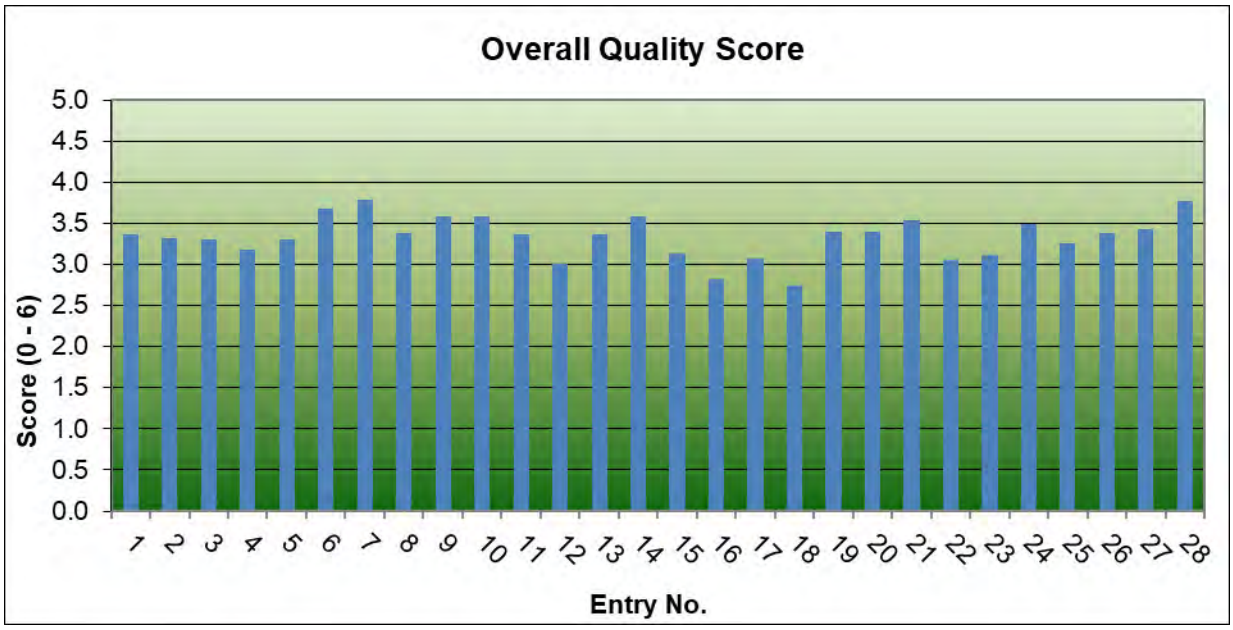
(Based upon HWWQL Quality Data and KSU Milling Data)



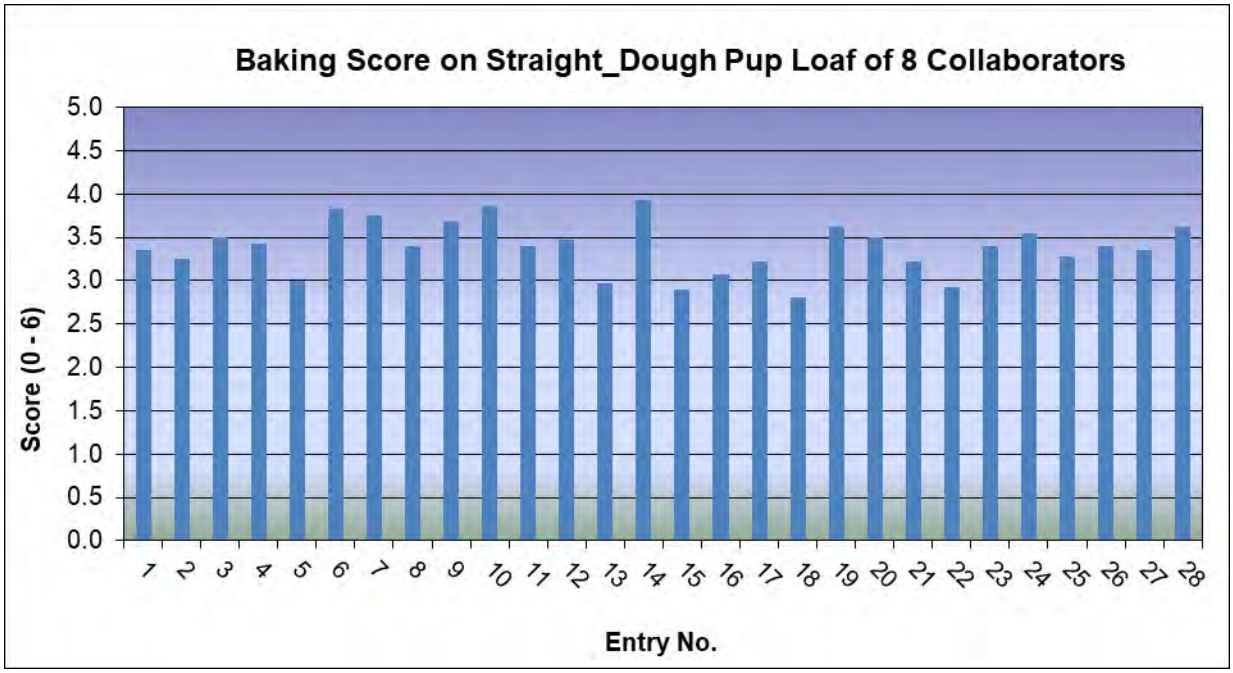
# 2023 WQC Milling & Baking Marketing Scores

(Based upon HWWQL Quality Data and KSU Milling Data)




# 2023 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

# 2023 WQC Hard Winter Wheat Entries

**USDA-ARS Hard Winter Wheat Quality Laboratory**

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**Rhett Kaufman, Rhett.Kaufman@usda.gov**

**Lucy Lu, Lucy.Lu@usda.gov**

# Alkaline Noodle Quality Report

**Objectives**: Evaluate alkaline noodle color and cooking characteristics.

**Materials**: 28 WQC hard winter wheat samples harvested in 2023.

**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 an 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:

1. 100 g flour with 1 g $Na_2CO_3$ + 35 mL water.
2. Mix at medium speed for 10 min (100 g Micro Mixer – no pins in the bowl, National MFG. Co., Lincoln, NE)
3. Rest for 30 min in a plastic bag.
4. Plug roll gap with plastic tubing and pour mixed dough.
5. Sheeting: roll gaps 4 (2x), 3, 2.3, 1.75, 1.35, 1.1 (mm).
6. Measure color at 0 and 24 hr.
7. Cutting

**Measurement of Noodle Dough Color:**

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

**Cooking Noodles:**

1. After cutting noodles, rest noodles in plastic bags for 2 hr at 21$^{o}$C.
2. Put the noodles (25 g) in the boiling distilled water (300 mL).
3. Cook continuously with gently 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$^{0}$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 x100.

**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 “firmnesss”.
- **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:**

The top 3 samples showing desirable properties were selected in each category.

Table I shows the following:

**Noodle Color** (L value, Higher is better) **at 0 hr:** 2405 (79.69), 2415 (78.42), 2423 (78.32).

**Noodle Color** (L value, Higher is better) **at 24 hr:** 2405 (68.08), 2415 (66.31), 2423 (65.32).

**Delta L** (Change of L value, lower absolute value is better).

2428 (-1.57), 2405 (-11.61), 2414 (-11.65)

**PPO** (Lower is better): 2428 (0.102), 2414 (0.144), 2405 (0.162).

Table II shows the following:

**Hardness:** 2425 (2.623), 2426 (2.619), 2415 (2.586).

**Springiness:** 2416 (0.913), 2428 (0.911), 2409 (0.911).

**Chewiness:** 2428 (1.660), 2426 (1.619), 2427 (1.603).

**Resilience:** 2409 (0.467), 2405 (0.453), 2427 (0.444).

**Cohesiveness:** 2409 (0.723), 2405 (0.713), 2428 (0.707).

**Water Uptake:** 2418 (94.00), 2412 (90.40), 2413 (89.20).

**Cooking Loss:** 2428 (6.40), 2427 (6.40), 2412 (6.40).

**Discussion**

The sample 2405 had the highest L-value (brightness) at both 0 and 24 hrs., the second lowest delta L* value, the highest b-value at 24 hrs. and the third lowest PPO value. This sample also had the second highest resilience and cohesiveness in texture after cooking. Bright noodle color 24 hrs. after production and a firmer texture following

cooking are considered desirable characteristics for alkaline noodles. Thus, the sample 2405 would be considered the most favorable variety overall for alkaline noodle quality.

The sample 2415 has the second highest L-value (brightness) at both 0 and 24 hrs., and also had the third highest hardness after cooking.

The sample 2423 had the third highest L-value (brightness) at both 0 and 24 hrs. This sample also had the lower harness and chewiness after cooking. Therefore, the sample 2423 would be considered the most favorable variety overall for white salted noodles quality (Japanese Udon-type), which are preferred to have a bright, creamy white color, smooth, and soft texture.

**Table I. Noodle Color and PPO Level**

| Sample ID | L*0 | L*24 | a*0 | a*24 | b*0 | b*24 | Δ L* | Δ a* | Δ b* | PPO |
|---|---|---|---|---|---|---|---|---|---|---|
| 2401 | 78.22 | 65.32 | -0.40 | 1.61 | 19.35 | 22.19 | -12.90 | 2.00 | 2.85 | 0.250 |
| 2402 | 76.70 | 62.31 | -0.32 | 1.93 | 21.67 | 24.80 | -14.39 | 2.25 | 3.14 | 0.554 |
| 2403 | 78.07 | 63.15 | -0.27 | 1.64 | 19.23 | 22.86 | -14.92 | 1.91 | 3.63 | 0.514 |
| 2404 | 78.10 | 64.93 | -0.87 | 1.04 | 21.16 | 23.59 | -13.17 | 1.91 | 2.44 | 0.542 |
| 2405 | 79.69 | 68.08 | -0.70 | 1.17 | 19.64 | 24.27 | -11.61 | 1.87 | 4.64 | 0.162 |
| 2406 | 75.28 | 61.47 | -0.33 | 2.05 | 23.27 | 25.61 | -13.82 | 2.38 | 2.34 | 0.576 |
| 2407 | 76.12 | 63.23 | 0.12 | 2.32 | 20.89 | 24.53 | -12.89 | 2.20 | 3.64 | 0.416 |
| 2408 | 74.09 | 58.89 | -0.14 | 2.08 | 22.80 | 23.56 | -15.20 | 2.22 | 0.76 | 0.540 |
| 2409 | 76.07 | 61.74 | -0.13 | 1.97 | 21.63 | 24.55 | -14.33 | 2.10 | 2.92 | 0.527 |
| 2410 | 74.97 | 60.37 | -0.02 | 2.07 | 21.95 | 24.19 | -14.60 | 2.09 | 2.25 | 0.575 |
| 2411 | 76.93 | 63.03 | -0.53 | 1.45 | 21.30 | 22.80 | -13.90 | 1.98 | 1.50 | 0.443 |
| 2412 | 77.00 | 63.37 | -0.52 | 1.65 | 20.78 | 23.09 | -13.63 | 2.17 | 2.32 | 0.367 |
| 2413 | 77.86 | 63.93 | -0.35 | 1.77 | 20.41 | 22.25 | -13.94 | 2.12 | 1.84 | 0.407 |
| 2414 | 76.20 | 64.55 | -0.18 | 2.10 | 21.77 | 25.12 | -11.65 | 2.27 | 3.35 | 0.144 |
| 2415 | 78.42 | 66.31 | -0.27 | 1.69 | 20.30 | 23.79 | -12.11 | 1.96 | 3.50 | 0.212 |
| 2416 | 77.82 | 64.66 | -0.75 | 1.57 | 22.29 | 25.91 | -13.16 | 2.32 | 3.62 | 0.545 |
| 2417 | 76.31 | 61.82 | 0.03 | 2.47 | 20.17 | 23.14 | -14.50 | 2.44 | 2.97 | 0.255 |
| 2418 | 76.06 | 62.03 | -0.26 | 2.12 | 21.48 | 23.35 | -14.04 | 2.38 | 1.87 | 0.397 |
| 2419 | 74.55 | 59.91 | 0.19 | 2.74 | 21.91 | 23.98 | -14.65 | 2.55 | 2.07 | 0.422 |
| 2420 | 75.90 | 61.59 | 0.01 | 2.50 | 21.41 | 23.88 | -14.31 | 2.49 | 2.47 | 0.564 |
| 2421 | 74.71 | 58.76 | 0.36 | 3.07 | 19.63 | 22.85 | -15.96 | 2.71 | 3.22 | 0.574 |
| 2422 | 75.12 | 60.73 | 0.03 | 2.50 | 20.88 | 23.72 | -14.40 | 2.48 | 2.84 | 0.551 |
| 2423 | 78.32 | 65.32 | -0.51 | 1.68 | 21.45 | 24.86 | -13.01 | 2.19 | 3.42 | 0.194 |
| 2424 | 76.15 | 63.92 | 0.04 | 2.86 | 22.69 | 25.84 | -12.23 | 2.82 | 3.15 | 0.310 |
| 2425 | 75.94 | 63.16 | 0.20 | 2.79 | 21.79 | 24.59 | -12.79 | 2.59 | 2.81 | 0.232 |
| 2426 | 77.12 | 64.85 | -0.28 | 2.53 | 23.65 | 27.17 | -12.28 | 2.81 | 3.52 | 0.410 |
| 2427 | 74.19 | 59.80 | -0.28 | 2.49 | 24.80 | 25.67 | -14.39 | 2.77 | 0.88 | 0.624 |
| 2428 | 76.34 | 64.77 | 0.09 | 2.81 | 23.34 | 27.56 | -11.57 | 2.72 | 4.22 | 0.102 |
| Avg | 76.51 | 62.93 | -0.22 | 2.09 | 21.48 | 24.27 | -13.58 | 2.31 | 2.79 | 0.407 |

| Table II. Texture Profile Analyis of Cooked Noodle and Cooking Quality | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample ID | Hardness | Springiness | Chewiness | Resilience | Cohesiveness | Water Uptake (%) | Cooking Loss (%) |
| 2401 | 2.499 | 0.900 | 1.525 | 0.425 | 0.678 | 80.40 | 7.60 |
| 2402 | 2.475 | 0.884 | 1.509 | 0.438 | 0.690 | 79.20 | 7.20 |
| 2403 | 2.533 | 0.905 | 1.570 | 0.421 | 0.685 | 81.20 | 7.60 |
| 2404 | 2.490 | 0.902 | 1.527 | 0.417 | 0.679 | 72.40 | 8.80 |
| 2405 | 2.194 | 0.898 | 1.405 | 0.453 | 0.713 | 81.20 | 7.20 |
| 2406 | 2.457 | 0.896 | 1.493 | 0.420 | 0.678 | 83.20 | 7.20 |
| 2407 | 2.391 | 0.898 | 1.465 | 0.431 | 0.682 | 80.40 | 7.60 |
| 2408 | 2.513 | 0.896 | 1.552 | 0.441 | 0.689 | 86.40 | 6.80 |
| 2409 | 2.348 | 0.911 | 1.546 | 0.467 | 0.723 | 76.00 | 7.20 |
| 2410 | 2.495 | 0.911 | 1.574 | 0.432 | 0.693 | 85.60 | 6.40 |
| 2411 | 2.406 | 0.869 | 1.416 | 0.432 | 0.677 | 86.40 | 6.80 |
| 2412 | 2.444 | 0.888 | 1.454 | 0.399 | 0.670 | 90.40 | 6.40 |
| 2413 | 2.526 | 0.902 | 1.565 | 0.423 | 0.687 | 89.20 | 6.80 |
| 2414 | 2.582 | 0.888 | 1.545 | 0.415 | 0.674 | 87.20 | 7.20 |
| 2415 | 2.586 | 0.871 | 1.506 | 0.422 | 0.668 | 87.20 | 7.20 |
| 2416 | 2.529 | 0.913 | 1.560 | 0.415 | 0.676 | 86.40 | 7.20 |
| 2417 | 2.293 | 0.895 | 1.356 | 0.393 | 0.661 | 82.40 | 7.60 |
| 2418 | 2.424 | 0.886 | 1.410 | 0.386 | 0.657 | 94.00 | 7.60 |
| 2419 | 2.339 | 0.905 | 1.458 | 0.420 | 0.689 | 83.60 | 6.80 |
| 2420 | 2.528 | 0.859 | 1.436 | 0.396 | 0.661 | 85.20 | 6.80 |
| 2421 | 2.272 | 0.907 | 1.407 | 0.411 | 0.683 | 80.00 | 7.20 |
| 2422 | 2.446 | 0.907 | 1.475 | 0.388 | 0.665 | 80.00 | 8.00 |
| 2423 | 2.333 | 0.886 | 1.396 | 0.398 | 0.676 | 85.20 | 6.40 |
| 2424 | 2.439 | 0.896 | 1.502 | 0.428 | 0.687 | 78.00 | 7.60 |
| 2425 | 2.623 | 0.909 | 1.600 | 0.410 | 0.671 | 74.00 | 8.00 |
| 2426 | 2.619 | 0.902 | 1.619 | 0.431 | 0.685 | 78.40 | 7.20 |
| 2427 | 2.531 | 0.902 | 1.603 | 0.444 | 0.702 | 82.00 | 6.40 |
| 2428 | 2.578 | 0.911 | 1.660 | 0.439 | 0.707 | 80.40 | 6.40 |
| Avg | 2.460 | 0.896 | 1.505 | 0.421 | 0.682 | 82.71 | 7.19 |

# TORTILLA BAKING TEST RESULTS of 2023 WQC SAMPLES

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(January 2024)

## SUMMARY

This report includes the production and evaluation methods of wheat flour tortillas and data for the 2023 WQC samples. The report contains tortilla quality data for 28 samples (23-2401-23-2428). The production and fresh tortilla evaluation was carried out over two days with an internal control sample baked on both days.

Samples 23-2406, 2407, 2408, 2414, 2422, 2426, 2427 and 2428 gave tortillas that were rated as "Excellent," based on their final diameter (≥14.5 cm) and subjective rollability score (>4.5 - very little cracking when rolled 16 days after baking). These samples also had good dough handling properties. Higher diameter and rollability scores suggest flour that is moderately strong with good extensibility characteristics, resulting in tortillas with longer shelf life.
Samples 2403, 2404 and 2417 were rated as "poor," based on their diameter (<14.0 cm) and <3 rollability scores. The dough samples were strong and greatly limited extensibility on hot-pressing.

The remaining samples had a general rating of “good” with rollability score ranges between 3 and 4.5 and lower diameters than the ones with “excellent” rating. Some of the samples (e.g. 2410, 20411, 2415, 2419, 2420, 2423, 2424, and 2425) had better rollability scores but their initial extensibility (average diameter) was limited.

## RESULTS

| Sample ID | Total Moisture (%), n=2 | Average Fresh Weight (g), n=10 | Average Thickness (cm), n=10 | Average Diameter (cm), n=10 | Specific Volume (cm^3/g) | Lightness (L*), n=2 (back, front) | Rollability Day 8, n=2 | Rollability Day 16, n=2 | *Average Rating, n=2 |
|---|---|---|---|---|---|---|---|---|---|
| 23-2401 | 33.21 | 40.82 | 0.41 | 13.26 | 1.38 | 73.47 | 4.5 | 3 | Good |
| 23-2402 | 32.10 | 40.29 | 0.41 | 13.98 | 1.58 | 75.56 | 4.5 | 3 | Good |
| 23-2403 | 32.76 | 40.45 | 0.40 | 13.87 | 1.49 | 75.41 | 3.5 | 2 | Poor |
| 23-2404 | 32.98 | 41.09 | 0.40 | 13.52 | 1.41 | 75.01 | 4 | 2.5 | Poor |
| 23-2405 | 33.86 | 40.42 | 0.38 | 13.46 | 1.34 | 73.21 | 4.5 | 3 | Good |
| 23-2406 | 32.62 | 39.85 | 0.38 | 15.04 | 1.71 | 73.73 | 5 | 5 | Excellent |
| 23-2407 | 39.13 | 39.99 | 0.35 | 14.60 | 1.45 | 74.47 | 4.5 | 4.5 | Excellent |
| 23-2408 | 31.70 | 39.53 | 0.38 | 15.03 | 1.73 | 73.84 | 5 | 5 | Excellent |
| 23-2409 | 32.89 | 39.98 | 0.40 | 13.56 | 1.45 | 74.85 | 4.5 | 3.5 | Good |
| 23-2410 | 32.71 | 39.73 | 0.40 | 14.06 | 1.56 | 74.30 | 5 | 4.5 | Good |
| 23-2411 | 34.58 | 39.55 | 0.39 | 13.98 | 1.50 | 72.09 | 5 | 5 | Good |
| 23-2412 | 32.69 | 39.64 | 0.39 | 14.07 | 1.54 | 73.24 | 4.5 | 4 | Good |
| 23-2413 | 33.65 | 39.56 | 0.44 | 12.83 | 1.42 | 73.55 | 4 | 3.5 | Good |
| 23-2414 | 34.45 | 39.33 | 0.38 | 14.85 | 1.66 | 73.89 | 5 | 5 | Excellent |
| 23-2415 | 33.07 | 40.01 | 0.35 | 14.14 | 1.39 | 72.34 | 5 | 5 | Good |
| 23-2416 | 33.11 | 39.79 | 0.40 | 13.43 | 1.44 | 72.61 | 3.5 | 3 | Good |
| 23-2417 | 32.43 | 39.73 | 0.42 | 13.48 | 1.51 | 72.20 | 3.5 | 2 | Poor |
| 23-2418 | 30.19 | 40.46 | 0.42 | 14.01 | 1.60 | 75.63 | 4 | 3.5 | Good |
| 23-2419 | 33.25 | 39.94 | 0.42 | 14.30 | 1.67 | 73.63 | 5 | 5 | Good |
| 23-2420 | 32.50 | 39.56 | 0.40 | 13.86 | 1.51 | 74.57 | 5 | 5 | Good |
| 23-2421 | 32.94 | 39.59 | 0.39 | 13.55 | 1.43 | 72.03 | 5 | 4 | Good |
| 23-2422 | 34.34 | 38.99 | 0.38 | 14.94 | 1.70 | 72.57 | 4.5 | 4.5 | Excellent |
| 23-2423 | 32.90 | 39.71 | 0.38 | 13.82 | 1.45 | 73.88 | 5 | 4.5 | Good |
| 23-2424 | 32.03 | 40.01 | 0.32 | 14.20 | 1.27 | 74.52 | 5 | 5 | Good |
| 23-2425 | 34.52 | 39.16 | 0.38 | 14.16 | 1.55 | 74.28 | 5 | 5 | Good |
| 23-2426 | 34.32 | 39.7 | 0.36 | 14.58 | 1.50 | 73.44 | 5 | 5 | Excellent |
| 23-2427 | 34.39 | 39.92 | 0.34 | 14.71 | 1.44 | 74.84 | 5 | 5 | Excellent |
| 23-2428 | 30.94 | 39.48 | 0.34 | 14.68 | 1.46 | 75.77 | 5 | 5 | Excellent |

*Subjective rating based primarily on diameter and rollability. Excellent >4.5 on day 16, ≥14.5 cm diameter; Good: rollability score >3.0 on day 16, and ≥13.0-14.4 cm diameter. Poor: rollability score <3.0 on day 16, any for diameter.

## PRODUCTION AND EVALUATION OF WHEAT FLOUR TORTILLAS

### Tortilla Formulation

| Ingredients | Amount |
|---|---|
| Wheat flour | 100% |
| Salt | 1.5% |
| Sodium Propionate | 0.8% |
| Potassium Sorbate | 0.4% |
| All-purpose Shortening | 6.0% |
| Sodium Bicarbonate | 0.6% |
| Fumaric Acid - encapsulated | 0.5% |
| Sodium Aluminum Phosphate | 0.82% |
| Water | 53% |

### Tortilla Processing

**MIX**

→ **PROOF**
5 min, 32 °C, 70% RH →

**DIVIDE and ROUND**
Obtain 43-g dough balls.

←

**PROOF**
10 min, 32 °C, 70% RH ←


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

↙

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

→ **COOL and PACKAGE**

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

**Evaluation of Tortilla Properties**

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

*1. Weight*

An average of 10 tortillas weighed on a balance and the reading divided by 10 to estimate weight of a single tortilla.

*2. Diameter*

It is an average diameter of 10 tortillas, which is measured using a ruler in two opposite directions. This varied widely among wheat samples depending on flour quality; desired values are > 14.5 cm.

*3. Thickness*

This is the average height of 10 tortillas, which is measured using a digital caliper and then divided by 10 to estimate a value for a single tortilla.

*4. Moisture*

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

*5. Color Values*

The color values of lightness (L*), +a* (redness and greenness), and +b* (yellowness and blueness) of tortillas were determined using a handheld colorimeter (model CR-300, Minolta Camera Co., Ltd., Chuo-Ku, Osaka, Japan). Only L*-values are included in the report as this correlates with opacity and are usually greater than 70.

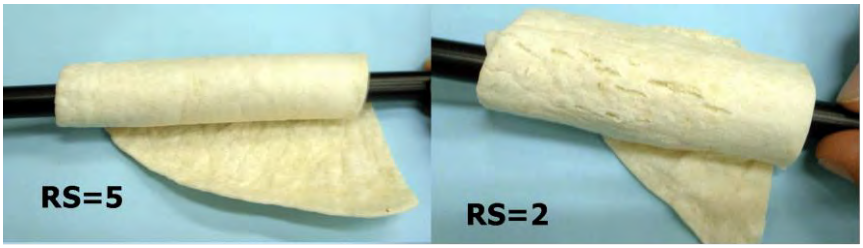
*6. Specific Volume*

$Specific\ volume\ \left[\frac{cm^3}{g}\right] = \frac{*(\frac{Diameter}{2})^2 * Height}{Weight}$ ; using the final values (estimates for single tortillas).

This corresponds to the fluffiness of the tortilla; the desired value is > 1.0 $cm^3/g$.

*7. Tortilla Rollability Score*

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



# 2023 WQC HARD WINTER WHEAT FLOUR PROTEIN ANALYSIS

Michael Tilley, Ph.D. and Bruna Mattioni, Ph.D.

**USDA, CGAHR, Manhattan, KS**

**Procedure for the separation of glutenins for determination of HMW glutenin subunits on Agilent 2100 Lab-on-a -Chip- bioanalyzer**

- Weight 100 mg of flour and add 1ml of 0.3 M Sodium Iodide solution containing 7.5 % isopropanol
- Include controls Karl 92 (1, 7+8, 5+10) and Chinese spring (null, 7+8, 2+12)
- Vortex shake for 15 min. and centrifuge for 5 min at 12,000 x g at room temp. Discard the supernatant.
- To the pellet add 1ml of deionized water, vortex shake for 5 min and centrifuge as above.
- Discard the supernatant.
- To the pellet add 1ml of 12.5 mM sodium borate buffer pH 10.0 + 2% SDS + 2% BME.
- Vortex shake for 30 minutes, centrifuge for 5 min. at 12,000 x g at room temp. and collect the supernatant (contains glutenins).

**Determination of polymeric to monomeric protein ratio**

**Protein extraction**

- Weight 10 mg flour and add 1 ml 0.05M Sodium phosphate buffer ($Na_2HPO_4$), pH 6.9, containing 0.5% SDS (w/v)
- Vortex the samples for 15 min.
- Sonicate the samples in ice for 15s at a power output of 6W. Collect the supernatant (contains total protein).
- Filter the supernatant in a 0.45 µm filter and analyze samples by size-exclusion HPLC (SE-HPLC).

**SE-HPLC**

- SE-HPLC was conducted using a 300.0 x 7.8 mm Yarra™ SEC-4000 column (Phenomenex, Torrance, CA) on an Agilent 1100 HPLC system, kept at 30°C, with a constant gradient composed of 50/50 ratio of HPLC grade

water + 0.1% Trifluoroacetic acid (TFA) and Acetonitrile + 0.1% TFA flow rate of 0.50 ml/min during 30 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 2023 Crop Protein Analysis**

| | High Molecular Weight Glutenin Subunits | | | Polymeric/Monomeric protein ratio |
|---|---|---|---|---|
| | **Glu-A1** | **Glu-B1** | **Glu-D1** | |
| **22-0002401** | 2* | 7+9 | 5+10 | 0.86 |
| **23-0002402** | 2* | 7+8 | 5+10 | 1.08 |
| **23-0002403** | 2* | 7+8 | 5+10 | 1.05 |
| **23-0002404** | 2* | $7^{OE}$ +8 | 5+10 | 0.85 |
| **23-0002405** | 2* | $7^{OE}$+8 | 5+10 | 0.91 |
| **23-0002406** | 1 | 7+8 | 5+10 | 0.88 |
| **23-0002407** | 1 | 7+8 | 5+10 | 0.93 |
| **23-0002408** | null | 7+9 | 5+10 | 1.02 |
| **23-0002409** | 2* | 7+8 | 5+10 | 0.93 |
| **23-0002410** | 1 | 7+8 | 5+10 | 0.98 |
| **23-0002411** | 2* | 7+9 | 5+10 | 0.86 |
| **23-0002412** | 2* | 7+8 | 5+10 | 0.95 |
| **23-0002413** | 2* | 7+8 | 5+10 | 1.01 |
| **23-0002414** | 1 | 7+8 | 5+10 | 0.93 |
| **23-0002415** | 2* | 7+8 | 5+10 | 0.95 |
| **23-0002416** | 2* | 7+9 | 5+10 | 0.99 |
| **23-0002417** | 1 | 7+9 | 5+10 | 0.92 |
| **23-0002418** | 1 | 7+8 | 5+10 | 1.12 |
| **23-0002419** | 1/2* | 7+9 | 5+10 | 0.81 |
| **23-0002420** | 2* | 7+9 | 5+10 | 0.82 |
| **23-0002421** | 2* | 17+18 | 5+10 | 0.71 |
| **23-0002422** | null | 7+9 | 2+12 | 0.75 |
| **23-0002423** | 2* | 7+9 | 5+10 | 0.80 |
| **23-0002424** | 1 | 7+9 | 5+10 | 0.70 |
| **23-0002425** | 2* | 7+9 | 5+10 | 0.78 |
| **23-0002426** | 1 | 7+8 | 5+10 | 0.76 |
| **22-0002427** | 1 | 7+9 | 5+10 | 0.73 |
| **22-0002428** | 2* | 7+9 | 5+10 | 0.81 |

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

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

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

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

**1000 Kernel Weight** - The weight in grams of 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.

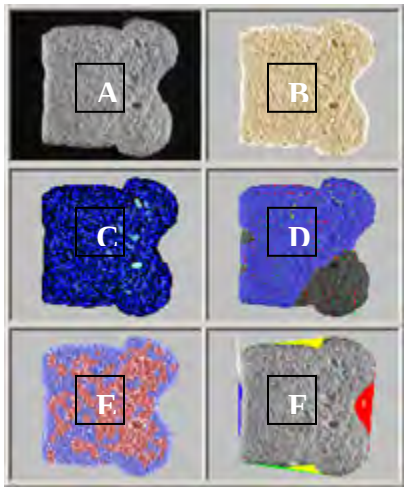
Similarly, cumulative protein curves are determined by arranging millstreams in ascending order of protein content, and tabulating the protein content of the total flour produced with the addition of successive millstreams. Wheat that gives high protein content at low extraction, and a fast rate of protein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

## 2023 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 | 385 | 20 |
| B | 2 | Pup-loaf straight dough | 100 g flour, approx 175 g dough | Mixograph | 90 min | 425 | 21 |
| C | 3 | Sponge and dough | 600 g flour, 480 g dough | Other | 240 min (sponge time) and 45 min (fermentation) | 420 | 20 |
| D | 4 | Pup-loaf straight dough | 200g, 170 g dough | Mixograph | 180 min | 419 | 24 |
| 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 | Farinograph and Mixograph | 180 fermentation and 60 min proof time | 400 | 25 |
| G | 7 | Sponge and dough | 675 g flour, 540 g dough | Mixing series | 210 min | 430 | 23 |
| H | 8 | Pup-loaf straight dough | 100 g, approx 170 g | Mixograph | 90 min | 400 | 25 |
| I | 9 | Sponge and dough | 700 g flour, 524 g dough | Farinograph with mixing evalu | 240 min (sponge time) and 60 min (fermentation) | 420 | 20 |
| J | 10 | Straight dough | 700 g flour, 525 g dough | Mixing series | 120 min | 400 | 25 |
| K | 11 | Pup-loaf straight dough | 100 g | Miograph | 90 min | 420 | 24 |
| L | 12 | Sponge and dough | 700 g flour, 500 g dough | Farinograph | 240 Sponge time | 425 | 25 |
| 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

## 2023 Technical Board Officers

| | |
|---|---|
| CHAIR: | **Mark Hodges,** Oklahoma Genetics |
| VICE CHAIR: | **Shawn Thiele,** Kansas State University |
| SECRETARY: | **Gang Guo,** Ardent Mills |
| MEMBER: | **Kevin Kloberdanz,** Grain Craft |
| MEMBER: | **Scott Baker,** Bay State Milling |

## 2023 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*** |

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

# APPENDIX D

Hard White Wheat Quality Targets
Adopted from PNW for Great Plains

# Hard White Wheat Quality Targets

## Dual Purpose -- Chinese Noodles and Western Pan Bread

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

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

Notes:

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

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

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

(4) Noodle formula: straight-grade flour, 100%; water, 28%; and sodium chloride, 1.2%.
Noodle sizes: 2.5 mm (width) x 1.2 mm (thickness).
Noodle textural measurement: cook 100 g noodles in 1000 ml deionized water for 5 min, rinse in $27^0$C 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. 23, 2023

# Minutes for 2023 Hard Winter Wheat Quality Council

February 23, 2023  8:00 am,  Embassy Suites Olathe Kansas

Welcome & Opening Comments – Dave Green and Rich Kendrick,  Acting Chair

Review of 2022 Minutes – Rich Kendrick, Acting Chair

Nomination and election of new members – Rich Kendrick, Acting Chair – Nominations were made and seconded.

Announcing Board for 2023 -

| | | |
|---|---|---|
| Chairman | Mark Hodges | Plains Grains |
| Vice Chairman | Shawn Thiele | Kansas State University |
| Secretary | Gang Guo | Ardent Mills |
| Member | Kevin Kloberdanz | GrainCraft |
| Member | Scott Baker | Bay State Milling |

Overview of Wheat Tours – Dave Green, WQC – Hard Winter Wheat Tour will be held May 15-18 2023. Arrangements are made.

Overview of Milling of Wheat Samples - Paul Blodgett, KSU Manhattan

Wheat Quality Council HRW Report for 2022 – Richard Chen, USDA/ARS Manhattan

Review of 2022 Wheat Crop – Mark Hodges, Plains Grains Inc.

New Growout Program for Hard Winter Wheat – Marla Barnett, Limagrain  New program is running well. No issues.

Soft Wheat Update – Byung-Kee Baik, USDA/ARS Wooster. Announced upcoming meeting in Wooster OH on March14. Meeting with Cincinnati Section CGA and Annual Soft Wheat Laboratory Review.

State Crop Reports 2022 Crop –

Texas – Jackie Rudd – TX Wheat
Oklahoma – Mike Schulte, Oklahoma Wheat Commission
Kansas – Justin Gilpin, Kansas Wheat Commission
Nebraska – Royce Schaneman, Nebraska Wheat Board
Colorado – Brad Erker, Colorado Wheat
South Dakota – Jon Kleinjan, SD Wheat Commission
Montana – Sam Anderson, Montana Wheat and Barley Committee

Financial Report – Dave Green, WQC

Hard Winter Wheat Budget is approved for this year.
Exhibitor's Session (10 minutes)- KPM Analytics, Buchi, Perkin Elmer, CW Brabender, Midland Scientific Exhibitors were introduced and allowed to talk about their companies.

Adjourned at 10 am.

# APPENDIX F

Past WQC Hard Winter
Wheat Entries
from 2001 to 2023

# Past WQC Hard Winter Wheat Entries

## 2023

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| SY Monument | 23-2401 | | | | | Check |
| CO18035RA | 23-2402 | | | | | Colorado |
| CO18042RA | 23-2403 | | | | | Colorado |
| CO18D007W | 23-2404 | | | | | Colorado |
| OK15MASBx7 ARS 8-19-18-4 | 23-2405 | | | | | Oklahoma |
| OK16107123-19-9 | 23-2406 | | | | | Oklahoma |
| OK19225 | 23-2407 | | | | | Oklahoma |
| LCH19DH-152-6 | 23-2408 | | | | | Limagrain |
| LCH16ACC421-64 | 23-2409 | | | | | Limagrain |
| KS16DH0010-17 | 23-2410 | | | | | KSU-Manhattan |
| KS19H10 | 23-2411 | HRW | Yes | KS Bill Snyder | 2023 | KSU-Hays |
| XF4412 | 23-2412 | | | | | Westbred (Bayer) |
| XF4402 | 23-2413 | | | | | Westbred (Bayer) |
| WB4422 | 23-2414 | | | | | Westbred (Bayer) |
| TX18A001119 | 23-2415 | | | | | Texas AM |
| TX18A001132 | 23-2416 | | | | | Texas AM |
| SY Monument | 23-2417 | | | | | Check |
| 21Nord-160 | 23-2418 | HRW | No | | | NDSU |
| XF4102 | 23-2419 | | | | | Westbred (Bayer) |
| SD18B072-2 | 23-2420 | | | | | SDSU |
| SD19B033-2 | 23-2421 | | | | | SDSU |
| NE16562 | 23-2422 | | | | | Nebraska |
| NW15443 | 23-2423 | | | | | Nebraska |
| Yellowstone | 23-2424 | | | | | Check |
| SY Monument | 23-2425 | | | | | Check |
| MT2019 | 23-2426 | | | | | Montana |
| MTCL2010 | 23-2427 | | | | | Montana |
| MTF20189 | 23-2428 | | | | | Montana |

## 2022

| | | | | | | |
|---|---|---|---|---|---|---|
| Jagalene_CK | 22-2401 | | | | | Check |
| SY Monument_CK | 22-2402 | | | | | Check |
| 19Nord-124_ND | 22-2403 | | | | | NSDU |
| SD15007-11_SD | 22-2404 | | | | | SDSU |
| SD18B025-8_SD | 22-2405 | HRW | Yes | SD Pheasant | 2023 | SDSU |
| NE17443_NE | 22-2406 | | | | | Nebraska |
| NE17441_NE | 22-2407 | | | | | Nebraska |
| WB4727_WB | 22-2408 | | | | | Westbred |
| SY Monument_CK | 22-2409 | | | | | Check |
| Jagalene_CK | 22-2410 | | | | | Check |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| LCH18-9027_LG | 22-2411 | HWW | yes | LCS White Lightning | 2022 | Limagrain |
| TX16M9216_TX | 22-2412 | HRW | yes | GO 9216H | 2022 | TAMU |
| BASF7_BF | 22-2413 | | | | | BASF |
| BASF12_BF | 22-2414 | | | | | BASF |
| WB4523_WB | 22-2415 | | | | | Westbred |
| WB0433004_WB | 22-2416 | | | | | Westbred |
| OK18510_OK | 22-2417 | HRW | yes | High Cotton | 2023 | Oklahoma |
| OK16107125C-17HR-2_OK | 22-2418 | | | | | Oklahoma |
| OKP17D101A666_OK | 22-2419 | | | | | Oklahoma |
| KS18H111-3_KH | 22-2420 | HRW | yes | KS Territory | 2022 | Kansas_Hays |
| CO16SF027_CO | 22-2421 | | | | | Colorado |
| CO18D297R_CO | 22-2422 | | | | | Colorado |
| KS13DH0041-35_KM | 22-2423 | HRW | yes | KS Providence | 2022 | Kansas_Manhattan |
| SY Monument_CK | 22-2424 | | | | | Check |
| Yellowstone_CK | 22-2425 | | | | | Check |
| MTFH1908_MT | 22-2426 | | | | | Montana |
| MTS1908_MT | 22-2427 | | | | | Montana |
| MTCL19151_MT | 22-2428 | | | | | Montana |

## 2021

| | | | | | | |
|---|---|---|---|---|---|---|
| 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 | 2021 | SDSU |
| SD15035-2 | 21-2408 | | | | | SDSU |
| LCH18-7071 | 21-2409 | HRW | yes | LCS Steel AX | 2021 | Limagrain |
| SY Monument | 21-2410 | | | | | Check |
| Jagalene | 21-2411 | | | | | Check |
| LCH17-4196 | 21-2412 | HRW | yes | LCS Runner | 2021 | Limagrain |
| SYMonument | 21-2413 | | | | | Check |
| OK15MASBx7 ARS 8-29 | 21-2414 | HRW | yes | Paradox | 2023 | OSU |
| AP Roadrunner | 21-2415 | HRW | yes | AP Roadrunner | 2020 | AgriPro(Syngenta) |
| OK15DMASBx7 ARS 6-8 | 21-2416 | HRW | yes | Firebox | 2023 | OSU |
| CO13007-F6R | 21-2417 | | | | | CSU |
| CO16D1487 | 21-2418 | | | | | CSU |
| TX15M8024 | 21-2419 | HRW | yes | Amigos | 2021 | Texas A&M |
| XE4101 | 21-2420 | | | | | Westbred(Bayer) |
| WB4401 | 21-2421 | | | | | Westbred(Bayer) |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| **2020** | | | | | | |
| 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 |
| OK15818 | 20-2423 | HRW | unofficiall | Gallagher Purific | 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 |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| **2019** | | | | | | |
| Byrd | 19-2401 | HRW | check | | | Colorado |
| Jagalene (CC01) | 19-2402 | HRW | check | | | Colorado |
| CO13D0787 | 19-2403 | HRW | yes | Guardian | 2019 | Colorado |
| CO15SFD107 | 19-2404 | HRW | yes | Fortify SF | 2019 | Colorado |
| CO15D098R | 19-2405 | HRW | yes | Steamboat | 2020 | Colorado |
| TAM 114 | 19-2406 | | | | | Texas |
| TX14A001035 | 19-2407 | HRW | yes | TAM 116 | 2021 | 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 | 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 |
| **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 |

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

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

## 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 |

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

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

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| OK05212 | 10-2413 | HRW | yes | Garrison | 2011 | OSU |
| OK07231 | 10-2414 | HRW | no | | | OSU |
| **Smoky Hill (check)** | 10-2415 | HRW | | | | Westbred |
| HV9W06-262R | 10-2416 | HRW | no | | | Westbred |
| HV9W06-218W | 10-2417 | HWW | no | | | Westbred |
| **Yellowstone (check)** | 10-2418 | HRW | | | | MSU |
| MTS0721 | 10-2419 | HRW | yes | Bearpaw | 2011 | MSU |
| **TAM 111 (check)** | 10-2420 | HRW | | | | TAMU |
| TX05A001822 | 10-2421 | HRW | no | | | TAMU |
| TX06A001263 | 10-2422 | HRW | no | | | TAMU |

## 2009

| | | | | | | |
|---|---|---|---|---|---|---|
| **Smoky Hill (check)** | 09-2401 | HRW | | | | Westbred |
| Stout (HV9W03-539R) | 09-2402 | HRW | yes | WB-Stout | 2009 | Westbred |
| **RonL (check)** | 09-2403 | HWW | | | | KSU-Hays |
| Tiger | 09-2404 | HWW | yes | | | KSU-Hays |
| **Hatcher (check)** | 09-2405 | HRW | | | | CSU |
| CO04393 | 09-2406 | HRW | no | | | CSU |
| CO04499 | 09-2407 | HRW | no | | | CSU |
| **OK Bullet (check)** | 09-2408 | HRW | | | | OSU |
| Billings | 09-2409 | HRW | yes | | | OSU |
| OK05526 | 09-2410 | HRW | yes | Ruby Lee | 2011 | OSU |
| **PostRock (check)** | 09-2411 | HRW | | | | AgriPro |
| CJ | 09-2412 | HRW | yes | | | AgriPro |
| SY Gold (AP00x0100-51) | 09-2413 | HRW | yes | SY Gold | 2010 | AgriPro |
| **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 |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| Tiger | 08-2410 | HWW | yes | | | KSU-Hays |
| **Karl 92 (check)** | 08-2411 | HRW | | | | KSU-Manhattan |
| KS970093-8-9-#1 | 08-2412 | HRW | yes | Everest | 2009 | KSU-Manhattan |
| **OK Bullet (check)** | 08-2413 | HRW | | | | OSU |
| OK03305 | 08-2414 | HRW | yes | Pete | 2009 | OSU |
| OK03522 | 08-2415 | HRW | yes | Billings | 2009 | OSU |
| OK03825-5403-6 | 08-2416 | HRW | | | | OSU |
| **Tandem (check)** | 08-2417 | HRW | yes | STARS0601W | 2006 | SDSU |
| SD05W030 | 08-2418 | HWW | no | | | SDSU |

## 2007

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hatcher (check)** | 07-2401 | HRW | | | | CSU |
| CO03W239 | 07-2402 | HWW | yes | Thunder CL | 2008 | CSU |
| CO03W054 | 07-2403 | HWW | yes | Snowmass | | CSU |
| CO02W237 | 07-2404 | HWW | no | | | CSU |
| **Millennium (check)** | 07-2405 | HRW | | | | NU |
| NH03614 | 07-2406 | HRW | yes | Settler CL | 2008 | NU |
| **OK Bullet (check)** | 07-2407 | HRW | | | | OSU |
| OK00514-05806 | 07-2408 | HRW | no | | | OSU |
| OK05737W | 07-2409 | HWW | no | | | OSU |
| OK03522 | 07-2410 | HRW | yes | Billings | 2009 | OSU |
| OK02405 | 07-2411 | HRW | no | | | OSU |
| **Tandem (check)** | 07-2412 | HRW | | | | SDSU |
| SD98W175-1 | 07-2413 | HRW | no | | | SDSU |
| SD01058 | 07-2414 | HRW | no | | | SDSU |
| SD0111-9 | 07-2415 | HRW | yes | Lyman | 2008 | SDSU |
| SD01273 | 07-2416 | HRW | no | | | SDSU |
| **Genou (check)** | 07-2417 | HRW | | | | MSU |
| 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 |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| **OK Bullet (check)** | 06-2413 | HRW | | | | OSU |
| Duster | 06-2414 | HRW | yes | | | OSU |
| OK01420 | 06-2415 | HRW | no | | | OSU |
| OK02405 | 06-2416 | HRW | no | | | OSU |
| OK02522W | 06-2417 | HWW | yes | OK Rising | 2008 | OSU |
| **Tandem (check)** | 06-2418 | HRW | | | | SDSU |
| SD96240-3-1 | 06-2419 | HRW | no | | | SDSU |
| SD01122 | 06-2420 | HRW | no | | | SDSU |
| SD01W065 | 06-2421 | HWW | no | | | SDSU |
| **TAM 111 (check)** | 06-2422 | HRW | | | | TAMU |
| TAM 112 | 06-2423 | HRW | yes | | | TAMU |
| TX01A5936 | 06-2424 | HRW | no | | | TAMU |
| TX01D3232 | 06-2425 | HRW | yes | TAM 304 | 2006 | TAMU |
| TX01V5314 | 06-2426 | HRW | yes | TAM 203 | 2007 | TAMU |

## 2005

| | | | | | | |
|---|---|---|---|---|---|---|
| **Akron (check)** | 05-2401 | HRW | | | | CSU |
| CO00016 | 05-2402 | HRW | yes | Ripper | 2006 | CSU |
| **Jagger (check)** | 05-2403 | HRW | | | | KSU-Hays |
| 2137 | 05-2404 | HRW | yes | | | KSU-Hays |
| KS03HW6-6 | 05-2405 | HWW | no | | | KSU-Hays |
| KS03HW158-1 | 05-2406 | HWW | yes | RonL | | KSU-Hays |
| **Jagger (check)** | 05-2407 | HRW | | | | AgriPro |
| Neosho | 05-2408 | HRW | yes | | | AgriPro |
| W03-20 | 05-2409 | HRW | yes | Postrock | 2005 | AgriPro |
| **Goodstreak (check)** | 05-2410 | HRW | | | | NU |
| Infinity CL | 05-2411 | HRW | yes | | | NU |
| **OK Bullet (check)** | 05-2412 | HRW | | | | OSU |
| OK93p656H3299-2c04 | 05-2413 | HRW | yes | Duster | 2006 | OSU |
| OK01307 | 05-2414 | HRW | no | | | OSU |
| OK03918C | 05-2415 | HRW | yes | Centerfield | 2006 | OSU |
| OK00611W | 05-2416 | HWW | no | | | OSU |
| **Tandem (check)** | 05-2417 | HRW | | | | SDSU |
| 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 |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| Arrowsmith | 04-2407 | HRW | yes | | | NE-USDA-ARS |
| NW99L7068 | 04-2408 | HRW | no | | | NE-USDA-ARS |
| **Millennium (check)** | 04-2409 | HRW | | | | NU |
| NE99495 | 04-2410 | HRW | yes | NE99495 | 2005 | NU |
| **OK102 (check)** | 04-2411 | HRW | | | | OSU |
| OK00618W | 04-2412 | HWW | yes | Guymon | 2005 | OSU |
| OK99212 | 04-2413 | HRW | no | | | OSU |
| OK00514 | 04-2414 | HRW | yes | OK Bullet | 2005 | OSU |
| OK02909C | 04-2415 | HRW | yes | Okfield | 2005 | OSU |
| **Tandem (check)** | 04-2416 | HRW | | | | SDSU |
| SD97W609 | 04-2417 | HWW | yes | Alice | 2006 | SDSU |
| SD97538 | 04-2418 | HRW | no | | | SDSU |
| SD98102 | 04-2419 | HRW | yes | Darrell | 2006 | SDSU |

## 2003

| | | | | | | |
|---|---|---|---|---|---|---|
| **Akron (check)** | 03-2401 | HRW | | | | CSU |
| CO980607 | 03-2402 | HRW | yes | Hatcher | 2004 | CSU |
| CO00D007 | 03-2403 | HRW | yes | Bond CL | 2004 | CSU |
| **Jagger (check)** | 03-2404 | HRW | | | | KSU-Hays |
| 2137 | 03-2405 | HRW | yes | | | KSU-Hays |
| KS01HW152-6 | 03-2406 | HWW | no | | | KSU-Hays |
| KS01HW163-4 | 03-2407 | HWW | no | | | KSU-Hays |
| KS02HW34 | 03-2408 | HWW | yes | Danby | 2005 | KSU-Hays |
| **Jagger (check)** | 03-2409 | HRW | | | | KSU-Manhattan |
| 2137 | 03-2410 | HRW | yes | | | KSU-Manhattan |
| Overley | 03-2411 | HRW | yes | | | KSU-Manhattan |
| KS940786-6-9 | 03-2412 | HRW | no | | | KSU-Manhattan |
| **OK 102 (check)** | 03-2413 | HRW | | | | OSU |
| OK94P549-11 | 03-2414 | HRW | yes | Endurance | 2004 | OSU |
| OK98690 | 03-2415 | HRW | yes | Deliver | 2004 | OSU |
| **Crimson (check)** | 03-2416 | HRW | | | | SDSU |
| SD97W604 | 03-2417 | HWW | yes | Wendy | 2004 | SDSU |
| SD92107-5 | 03-2418 | HRW | no | | | SDSU |

## 2002

| | | | | | | |
|---|---|---|---|---|---|---|
| **Jagger (check)** | 02-2401 | HRW | | | | AgriPro |
| Cutter | 02-2402 | HRW | yes | | | AgriPro |
| Dumas | 02-2403 | HRW | yes | | | AgriPro |
| 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 |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| CO980607 | 02-2410 | HRW | yes | Hatcher | 2004 | CSU |
| CO980630 | 02-2411 | HRW | no | | | CSU |
| **Jagger (check)** | 02-2412 | HRW | | | | KSU-Manhattan |
| KS940748-2-2 | 02-2413 | HRW | no | | | KSU-Manhattan |
| KS940786-6-7 | 02-2414 | HRW | yes | Overley | 2003 | KSU-Manhattan |
| KS940786-6-9 | 02-2415 | HRW | no | | | KSU-Manhattan |
| **Millennium (check)** | 02-2416 | HRW | | | | NU |
| NE97V121 | 02-2417 | HRW | no | | | NU |
| NE98466 | 02-2418 | HRW | no | | | NU |
| NE98471 | 02-2419 | HRW | yes | Hallam | 2004 | NU |
| NI98439 | 02-2420 | HRW | no | | | NU |
| **2174 (check)** | 02-2421 | HRW | | | | OSU |
| OK102 | 02-2422 | HRW | yes | | | OSU |
| OK95548-54 | 02-2423 | HRW | no | | | OSU |
| OK95616-56 | 02-2424 | HRW | no | | | OSU |
| OK96705-38 | 02-2425 | HRW | no | | | OSU |
| OK98699 | 02-2426 | HRW | no | | | OSU |

## 2001

| | | | | | | |
|---|---|---|---|---|---|---|
| **Jagger (check)** | 01-2401 | HRW | | | | Cargill |
| G970380A | 01-2402 | HRW | no | | | Cargill |
| G970209W | 01-2403 | HWW | no | | | Cargill |
| **Prowers 99 (check)** | 01-2404 | HRW | | | | CSU |
| CO970547 | 01-2405 | HRW | no | | | CSU |
| **Millennium (check)** | 01-2406 | HRW | | | | NU |
| NE97426 | 01-2407 | HRW | no | | | NU |
| NE97465 | 01-2408 | HRW | yes | Goodstreak | 2002 | NU |
| NE97638 | 01-2409 | HRW | yes | Empire | 2002 | NU |
| NE97669 | 01-2410 | HRW | no | | | NU |
| NE97689 | 01-2411 | HRW | yes | Harry | 2002 | NU |
| **2174 (check)** | 01-2412 | HRW | | | | OSU |
| OK96717-99-6756 | 01-2413 | HRW | no | | | OSU |
| OK97508 | 01-2414 | HRW | yes | Ok102 | 2002 | OSU |

Thank you for reviewing this report of 2023 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