# Milling and Baking Test Results for Hard Winter Wheat

## Harvested in 2022


## 73rd 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:**

**Dave G. Green**
**The Wheat Quality Council**
**P.O. Box 19539**
**Lenexa, KS 66285**
**Voice: (913) 634-0248**
**Email: Dave.green.wqc@gmail.com**
**http://www.wheatqualitycouncil.org**

# 2022

## Milling and Baking Test Results for

# Hard Winter Wheats


**Editor:** **Yuanhong (Richard) Chen, Ph.D**
Research Food Technologist, Associate Director
USDA-ARS-CGAHR
Hard Winter Wheat Quality Laboratory
1515 College Ave.
Manhattan, KS 66502

**Co-Editor:** **Bradford W. Seabourn, Ph.D**
Supervisory Research Chemist, Director
USDA-ARS-CGAHR
Hard Winter Wheat Quality Laboratory
1515 College Ave.
Manhattan, KS 66502

**Coordinator:** **Dave Green**
Executive Vice President
Wheat Quality Council
P.O. Box 19539.
Lenexa, KS 66285

# The MISSION
## of the WHEAT QUALITY COUNCIL:

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

# The GOAL
## of the WHEAT QUALITY COUNCIL:

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

# TABLE OF CONTENTS

## MONTANA



## 2022 WQC MILLING AND BAKING SCORE



## ALKALINE NOODLE TEST



## TORTILLA BAKING TEST

## PROTEIN ANALYSIS



## APPENDIX A ---- Credits and Methods



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



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



## APPENDIX D ---- Hard White Wheat Quality Targets



## APPENDIX E ---- Meeting Minutes



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

# Description of the 2022 Testing Program

Founded in 1949, this is the **73rd** 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 hard winter 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 had 8 composite entries including 2 checks and 6 breeding lines from 4 breeding programs grown in 4 locations (ND, SD, NE and AP) and The Southern had 15 composite entries including 2 checks and 13 breeding lines from 8 breeding programs grown in 7 locations (AP, KH, LM, OK, CO, BF, and TB). Wheat samples were milled on the Miag Multomat mill in the Kansas State University Department of Grain Science and Industry (Methods, Appendix A). The flours were distributed to 17 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.

# 2022 WQC HWW Entries & Breeding Programs

| Breeding Programs | Entry Number | Sample Identification |
|---|---|---|
| **NORTHERN** | 22-2401 | Jagalene_CK |
| | 22-2402 | SY Mounment_CK |
| | 22-2403 | 19Nord-124_ND |
| | 22-2404 | SD15007-11_SD |
| | 22-2405 | SD18B025-8_SD |
| | 22-2406 | NE17443_NE |
| | 22-2407 | NE17441_NE |
| | 22-2408 | WB4727_WB |
| **SOUTHERN** | 22-2409 | SY Monument_CK |
| | 22-2410 | Jagalene_CK |
| | 22-2411 | LCH18-9027_LM |
| | 22-2412 | TX16M9216_TX |
| | 22-2413 | BASF7_BF |
| | 22-2414 | BASF12_BF |
| | 22-2415 | WB4523_WB |
| | 22-2416 | WB0433004_WB |
| | 22-2417 | OK18510_OK |
| | 22-2418 | OK16107125C-17HR-2_OK |
| | 22-2419 | OKP17D101A666_OK |
| | 22-2420 | KS18H111-3_KH |
| | 22-2421 | CO16SF027_CO |
| | 22-2422 | CO18D297R_CO |
| | 22-2423 | KS13DH0041-35_KM |
| MONTANA | 22-2424 | SY Monument_CK |
| | 22-2425 | Yellowstone_CK |
| | 22-2426 | MTFH19132_MT |
| | 22-2427 | MTS1908_MT |
| | 22-2428 | MTCL19151_MT |

CK=Check; AP=Agripro (Syngenta); LM=Limagrain; WB=Westbred (Bayer); BF=BASF; KH= KSU-Hay; KM=KSU-Manhattan;

# 2022 Wheat Classification Results from GIPSA

# GIPSA Wheat Market Classification

| ID | CL | DKG | TW | M | ODOR | HT | DKT | FM | SHBN | DEF | CCL | WOCL | GRADE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **22-2401** | HRW | 0.0 | 58.3 | 11.9 | OK | 0.0 | 0.4 | 0.0 | 0.6 | 1.0 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% |
| **22-2402** | HRW | 0.0 | 57.0 | 12.0 | OK | 0.0 | 0.5 | 0.0 | 0.6 | 1.1 | 0.0 | 0.0 | U.S. NO. 3 HRW, DKG 0.0% |
| **22-2403** | HRW | 0.0 | 58.1 | 12.0 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% |
| **22-2404** | HRW | 0.0 | 58.9 | 12.3 | OK | 0.0 | 0.6 | 0.0 | 0.4 | 1.0 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% |
| **22-2405** | HRW | 0.0 | 58.8 | 12.0 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% |
| **22-2406** | HRW | 0.1 | 57.1 | 12.0 | OK | 0.0 | 1.4 | 0.0 | 0.4 | 1.8 | 0.0 | 0.0 | U.S. NO. 3 HRW, DKG 0.1% |
| **22-2407** | HRW | 0.0 | 59.5 | 12.2 | OK | 0.0 | 0.5 | 0.0 | 0.2 | 0.7 | 0.0 | 0.0 | U.S. NO. 2 HRW, DKG 0.0% |
| **22-2408** | HRW | 0.2 | 55.2 | 11.9 | OK | 0.0 | 0.8 | 0.0 | 0.6 | 1.4 | 0.0 | 0.0 | U.S. NO. 4 HRW, DKG 0.2% |
| **22-2409** | HRW | 0.0 | 60.2 | 10.9 | OK | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2410** | HRW | 0.1 | 62.2 | 10.9 | OK | 0.0 | 0.2 | 0.0 | 0.5 | 0.7 | 0.0 | 0.0 | U.S. NO. 1 HRW,, DKG 0.1% |
| **22-2411** | HDWH | 0.0 | 61.6 | 11.0 | OK | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.0 | 2.0 | U.S. NO. 1 HDWH, DKG 0.0% |
| **22-2412** | HRW | 0.1 | 60.9 | 10.9 | OK | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.1% |
| **22-2413** | HRW | 0.0 | 60.9 | 10.7 | OK | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2414** | HRW | 0.0 | 61.8 | 10.9 | OK | 0.0 | 0.2 | 0.0 | 0.5 | 0.7 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2415** | HRW | 0.1 | 60.3 | 10.7 | OK | 0.0 | 0.0 | 0.0 | 0.8 | 0.8 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.1% |
| **22-2416** | HRW | 0.0 | 60.2 | 10.8 | OK | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2417** | HRW | 0.0 | 62.1 | 10.9 | OK | 0.0 | 0.2 | 0.0 | 0.2 | 0.4 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2418** | HRW | 0.0 | 61.7 | 10.8 | OK | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2419** | HRW | 0.0 | 61.8 | 10.7 | OK | 0.0 | 0.5 | 0.0 | 0.3 | 0.8 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2420** | HRW | 0.0 | 61.2 | 10.7 | OK | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2421** | HRW | 0.0 | 61.2 | 10.6 | OK | 0.0 | 0.1 | 0.0 | 0.4 | 0.5 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2422** | HRW | 0.0 | 62.2 | 10.8 | OK | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 | 0.3 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2423** | HRW | 0.0 | 60.9 | 10.5 | OK | 0.0 | 0.3 | 0.0 | 0.4 | 0.7 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2424** | HRW | 0.0 | 63.2 | 9.6 | OK | 0.0 | 0.0 | 0.0 | 0.9 | 0.9 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2425** | HRW | 0.0 | 62.8 | 9.9 | OK | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2426** | HRW | 0.0 | 62.1 | 9.3 | OK | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2427** | HRW | 0.0 | 64.4 | 9.5 | OK | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |
| **22-2428** | HRW | 0.0 | 64.0 | 9.3 | OK | 0.0 | 0.0 | 0.0 | 0.6 | 0.6 | 0.0 | 0.0 | U.S. NO. 1 HRW, DKG 0.0% |

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

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

# NORTHERN GROWOUT

| | |
|---|---|
| 22-2401 | Jagalene_CK |
| 22-2402 | SY Mounment_CK |
| 22-2403 | 19Nord-124_ND |
| 22-2404 | SD15007-11_SD |
| 22-2405 | SD18B025-8_SD |
| 22-2406 | NE17443_NE |
| 22-2407 | NE17441_NE |
| 22-2408 | WB4727_WB |

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

# Description of Test Plots and Breeder Entries

## Northern Growout (ND, SD, NE, and WB)

## 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 126') were seeded on Sept. 23rd, 2021, into un-tilled soybean stubble. Timely rainfall towards the end of the summer in 2021 had helped ease drought conditions in the region, and promoted good plant establishment after seeding. The winter did not produce significant snow amounts, yet it did produce many cold temperature streaks like in previous years. Although there were many concerns for potential winter kill, we did not see any significant winter kill in the WQC strips. The 2022 spring growing season was cool and incredibly wet. Many other spring crops were long delayed in seeding and were greatly affected by the dryer conditions later in the summer. However, the winter wheat plants were able to use the cool temperatures and moisture to get a great start and re-established very well. Urea was applied at a rate of 260 lbs/A (120 lbs N) by the ASF on May 17th, 2022. The pesticide Wolverine Advanced was sprayed on May 27th at the wheat jointing stage, to control weed growth. On June 15th, the insecticide Province II was applied via aerial application to combat grasshopper infestation. The WQC strips were harvested on July 27th, 2022. Seed quality appeared to be adequate among the entries, as dry conditions late in the summer provided good ripening and proper maturation of the crop. Rainfall became rather scarce in July through August, making harvest relatively simple and successful. Below are the yields for the harvested strips at Casselton.

| Entry Name | Yield (lbs) |
|---|---|
| | |
| **Jagalene** | 66.5 |
| **SY Monument** | 72.5 |
| **19NORD-124** | 80.2 |
| **SD15007-11** | 83.2 |
| **SD18B025-8** | 86.7 |
| **NE17443** | 76.3 |
| **NE17441** | 75.9 |
| **WB4727** | 69.7 |
| | |
| **20NORD-148 - excluded** | 74.3 |
| **SD15007-5 – excluded** | 87.0 |
| **NE18573 - excluded** | 75.4 |

**19NORD-124**

19NORD-124 is an NDSU experimental line scheduled for pre-release in 2023. 19NORD-124 is a doubled haploid derived line of a NDSU winter wheat project cross (15K590, Pedigree: *Crux (Fhb1,5A)/Nord1401*). 19NORD-124 is slightly shorter than the cultivar Jerry, although has shown to have generally good standability. 19NORD-124 has very good winter survival ratings, and has performed well in grain yield in North Dakota. In the NDSU winter wheat project disease screenings, 19NORD-124 has shown to have adequate resistance to both leaf and stem rust races prevalent in North Dakota. *Fhb1*, *Lr34/Yr18*, and *tsn1* are among confirmed DNA markers possessed by 19NORD-124. In 2023, 19NORD-124 will be included in regional variety trials in ND, SD, & MN, as well as another year of assessment in the NRPN trial.

## SOUTH DAKOTA by Sunish Sehgal

**Growing Location and Conditions**

A total of 9 entries with two checks (Jagalene and SY Monument) were evaluated under the 2022 Northern Wheat Quality Council (WQC) grow-outs. At Brookings (SD), all entries were timely planted on September 29, 2021, as 150' long and 5' wide strips (7-rows) in oat stubble (no-till). A starter fertilizer 10-34-0 (10 gallons/ac) was applied at seeding. All entries had uniform emergence and good growth going into winter. No visible winter kill was observed. In spring, 28-0-0 (40 gallons/acre) fertilizer was stream-bar applied at Feekes 5 and the strips were also sprayed with 13 oz Bromac + 13 oz Puma. Good spring moisture supported very good tillering however, the majority of South Dakota experienced a severe drought in late summer of 2022 and the test weight was negatively impacted in the grow-outs at Brookings, SD. The grow-outs were harvested on August 3rd, 2022. The grain protein content ranged from 13.1% to 14.7% and the test weight ranged from 53.4 lb/bu – 58.8 lb/bu among the 11 entries.

**SD15007-11**

SD15007-11 was developed from a threeway cross Art/SD07184//Ideal and it has medium-tall height and late maturity similar to Ideal. It has a very good winter hardiness. SD15007-11 has been evaluated in 28 environments over two years in South Dakota Crop Performance Trials. Overall, SD15007-11 ranked 8th in eastern, 13th in central, and 14th in western SD locations among 29 entries, demonstrating a good yield potential. It has an average test weight and average grain protein concentration. SD15007-11 has above-average tolerance to FHB and is moderately resistant to leaf rust, stem rust, dwarf bunt, and hessian fly. SD15007-11 was rated overall good milling quality and acceptable baking quality. Across multiple trial locations (2019), its milling quality parameters (average flour yield 67.5 %), mixograph mix time (mins) of 5.0, and mix tolerance of 4.0 and baking quality parameters (average loaf volume 865 $cm^3$ and specific volume 5.8 cc/g) were comparable to Winner (average flour yield 65.0%, mix time 3.3 and mix tolerance 3.5, average loaf volume 890 $cm^3$, and specific volume 6.0 cc/g).

**SD18B025-8**

SD18B025-8 was developed from the cross X120032 (OK07719W/SD07W083-4//SD07W053/3/SD09161). It is a medium-tall variety (*Rht-B1b*) with medium maturity. It is high yielding line with good test weight and grain protein content. SD18B025-8 has been evaluated for 61-year locations to date in various trials**.** It demonstrated a good yield potential (ranked 3$^{rd}$) in the 2021 USDA Northern Regional Performance Nursery (NRPN). In SDSU Advanced and Elite yield trials in 2019 and 2020 where SD18B025-8 ranked 3$^{rd}$ and 8$^{th}$, respectively. In South Dakota Crop Performance Trials across 28 environments over 2 years SD18B025-8 ranked 1$^{st}$ in eastern SD, 2$^{nd}$ in central SD, and 29$^{th}$ in western SD. It was rated resistant to leaf rust and stem rust and tolerant to stripe rust. SD18B025-8 has average milling characteristics but good baking characteristics in in-house and USDA evaluations. Across multiple trial locations (2019), its milling quality parameters (average flour yield 66.6 %), mixograph mix time of 4.7 and mix tolerance of 4.0 and baking quality parameters (average loaf volume 900 cm$^3$ and specific volume 6.1 cc/g) were better than Winner (average flour yield 65.0%, mix time 3.3 and mix tolerance 3.5, average loaf volume 890 cm$^3$, and specific volume 6.0 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, 2021 and 2022).

| Eastern South Dakota (2021 and 2022) | | | | | | | Central South Dakota (2021 and 2022) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2022 | | | 2 year | | | | 2022 | | | 2 year | | |
| **Variety** | **Yield** | **Test Wt** | **Protein** | **Yield** | **Test Wt** | **Protein** | **Variety** | **Yield** | **Test Wt** | **Protein** | **Yield** | **Test Wt** | **Protein** |
| **SD18B025-8** | **65.7** | **59.5** | **13.8** | **69.0** | **60.3** | **13.5** | SY Wolverine | 71.3 | 59.6 | 13.9 | 73.6 | 60.0 | 13.9 |
| SD17B210-2 | 63.4 | 57.7 | 14.3 | 67.9 | 58.9 | 14.1 | **SD18B025-8** | **71.2** | **59.3** | **14.3** | **72.2** | **59.8** | **14.4** |
| SD Midland | 62.4 | 59.0 | 13.6 | 67.4 | 59.9 | 13.1 | AP Clair | 69.8 | 59.4 | 14.2 | 71.5 | 59.8 | 14.1 |
| SD17B032-1 | 63.6 | 59.0 | 13.9 | 66.6 | 60.0 | 13.6 | CP7017AX | 71.4 | 59.1 | 13.4 | 71.4 | 59.3 | 13.3 |
| SD Andes | 61.3 | 58.9 | 13.5 | 66.6 | 60.1 | 13.1 | WB4309 | 69.4 | 58.4 | 14.1 | 71.2 | 58.9 | 14.1 |
| SD15007-5 | 62.0 | 59.6 | 13.8 | 66.3 | 60.7 | 13.2 | SD Andes | 70.4 | 60.0 | 14.0 | 71.1 | 60.6 | 14.0 |
| AP Clair | 60.9 | 58.9 | 13.9 | 66.2 | 59.7 | 13.4 | LCS Steel AX | 68.7 | 58.6 | 13.4 | 70.5 | 59.1 | 13.4 |
| **SD15007-11** | **60.4** | **59.2** | **14.0** | **65.6** | **60.2** | **13.4** | AP Bigfoot | 68.3 | 58.8 | 14.0 | 70.2 | 59.1 | 14.0 |
| Ideal | 59.4 | 58.9 | 13.9 | 65.4 | 60.3 | 13.3 | Draper | 68.0 | 58.3 | 14.2 | 69.9 | 58.6 | 14.2 |
| WB4309 | 59.5 | 58.3 | 13.7 | 65.3 | 59.3 | 13.4 | Winner | 64.7 | 59.3 | 14.5 | 69.1 | 59.7 | 14.2 |
| Winner | 60.8 | 58.4 | 13.8 | 65.2 | 59.5 | 13.3 | CP7909 | 69.0 | 58.9 | 13.7 | 69.1 | 59.0 | 13.7 |
| SD15035-2 | 61.0 | 58.9 | 14.1 | 64.9 | 60.3 | 13.7 | SD Midland | 67.2 | 59.4 | 14.3 | 68.9 | 59.9 | 14.1 |
| CP7017AX | 63.0 | 58.1 | 12.9 | 64.9 | 59.1 | 12.6 | **SD15007-11** | **65.2** | **59.5** | **14.2** | **68.5** | **59.9** | **14.1** |
| SY Wolverine | 60.6 | 58.8 | 13.6 | 64.8 | 59.6 | 13.4 | SD15007-5 | 66.0 | 59.3 | 14.1 | 68.5 | 60.0 | 14.0 |
| AP Bigfoot | 61.3 | 58.6 | 13.5 | 64.1 | 59.5 | 13.3 | SD15035-2 | 64.4 | 59.9 | 14.3 | 68.5 | 60.3 | 14.3 |
| LCS Steel AX | 59.8 | 58.3 | 13.0 | 64.1 | 58.8 | 12.6 | LCS Helix AX | 69.5 | 60.2 | 13.5 | 68.1 | 60.8 | 13.5 |
| Draper | 60.6 | 57.8 | 13.9 | 63.7 | 59.2 | 13.6 | LCS Julep | 67.1 | 60.3 | 14.4 | 68.1 | 61.2 | 14.5 |
| CP7869 | 60.0 | 58.9 | 13.2 | 63.7 | 59.6 | 12.7 | SD17B032-1 | 65.6 | 58.7 | 14.3 | 67.6 | 59.3 | 14.4 |
| Redfield | 58.8 | 58.5 | 14.4 | 63.4 | 59.6 | 14.0 | AP 18AX | 66.5 | 58.8 | 13.6 | 67.5 | 58.9 | 13.7 |
| LCS Helix AX | 60.7 | 58.8 | 13.3 | 63.2 | 60.2 | 12.8 | Ideal | 63.7 | 59.4 | 14.3 | 67.5 | 59.7 | 14.3 |
| CP7909 | 59.4 | 59.8 | 13.3 | 62.0 | 60.4 | 13.1 | MS Iceman | 64.6 | 60.2 | 14.7 | 66.7 | 60.7 | 15.0 |
| LCS Julep | 59.5 | 60.1 | 14.1 | 61.8 | 61.4 | 13.8 | SD17B210-2 | 67.5 | 57.6 | 14.8 | 66.4 | 58.1 | 15.0 |
| AP 18AX | 58.4 | 57.8 | 13.6 | 61.2 | 58.9 | 13.3 | Crescent AX | 68.6 | 59.3 | 13.5 | 65.7 | 60.0 | 13.9 |
| Crescent AX | 58.6 | 58.7 | 13.4 | 59.7 | 59.8 | 13.4 | CP7869 | 64.0 | 59.2 | 14.0 | 65.5 | 59.4 | 13.9 |
| LCS Photon AX | 59.9 | 59.5 | 14.5 | 58.6 | 60.3 | 14.2 | LCS Chrome | 64.2 | 58.1 | 14.8 | 65.5 | 59.0 | 14.8 |
| MS Iceman | 56.8 | 60.2 | 14.9 | 58.5 | 61.1 | 14.5 | Redfield | 66.4 | 58.3 | 14.6 | 65.4 | 59.2 | 14.6 |
| Expedition | 57.4 | 58.9 | 14.5 | 58.5 | 60.0 | 14.1 | Expedition | 63.2 | 59.0 | 14.6 | 64.0 | 59.6 | 14.5 |
| LCS Chrome | 55.0 | 58.2 | 14.6 | 58.2 | 59.3 | 14.2 | CP7050AX | 64.0 | 60.4 | 14.5 | 63.4 | 60.9 | 14.4 |
| CP7050AX | 56.6 | 59.3 | 14.2 | 56.5 | 60.2 | 14.1 | LCS Photon AX | 63.0 | 60.4 | 14.7 | 62.5 | 60.9 | 14.6 |
| Trial Average | 59.8 | 58.7 | 13.8 | 63.6 | 59.9 | 13.5 | Trial Average | 66.5 | 59.1 | 14.1 | 68.2 | 59.7 | 14.2 |
| LSD | 1.7 | 0.5 | 0.3 | 1.7 | 0.3 | 0.2 | LSD | 2.9 | 0.9 | 0.3 | 2.3 | 0.4 | 0.2 |
| CV | 4.6 | 1.2 | 3.6 | 6.1 | 1.2 | 3.7 | CV | 7.8 | 1.9 | 3.2 | 7.9 | 1.6 | 3.5 |

## NEBRASKA by Katherine Frels

2022 Nebraska WQC Samples:
Two Nebraska breeding lines were grown in the Northern uniform growout, NE17441 and NE17443. Six other breeding lines and the check lines Jagalene and SY Monument were grown in Lincoln, NE. No winterkilling was observed due to a mild winter. Growth and development were normal from winter to early spring, and moisture was close to average during this period. Anthesis occurred approximately and rainfall was minimal after anthesis. Drought conditions were present from anthesis to harvest. The plots were not sprayed with fungicides, and no diseases were observed. Lodging was minimal and plant height was slightly below normal. Plots were harvested later than normal, but due to the dry weather were not exposed to high humidity or heavy rains after maturity.

**UNL Variety Descriptions**
NE17441 is a hard red winter wheat derived from the cross Hitch/NE07409. NE17441 is broadly adapted to Nebraska environments and is moderately early. NE17441 has high yield potential especially in higher rainfall environments. It is resistant to SBMV, moderately resistant to stripe rust and FHB, and moderately susceptible to stem rust. It is susceptible to WSMV and a hollow stem variety susceptible to wheat stem sawfly. Protein is higher than average, with good test weight. The line has good water absorption, good dough characteristics, and a good baking evaluation.

NE17443 is hard red winter wheat derived from the cross NW07534/Freeman. NE17441 is targeted toward west central and Panhandle Nebraska. It is moderately early and has been a top yielding line in Western NE trials under drier conditions. It is moderately resistant to FHB, susceptible to SBMV and WSMV, and moderately susceptible stem, leaf and stripe rust. It is a hollow stem variety susceptible to wheat stem sawfly. The test weight and protein level are acceptable, but lower than NE17441. It has average dough characteristics and better baking scores than NE17441.

## WESTBRED (Bayer) by Adam Bray

# WB4727

WB4727 is a hard red winter wheat, with medium-late maturity, great straw strength, and good test weight. It has good winterhardiness and is well adapted to Montana and the western northern plains region with improved yields compared to Keldin. It is resistant to Wheat Streak Mosaic Virus. Internal quality testing indicates below average protein with above average functionality. WB4727 was released in 2021 as a high yielding product for Montana.

# Northern Growout: 2022 (Small-Scale) Samples

| Test entry number | 22-2401 | 22-2402 | 22-2403 | 22-2404 |
|---|---|---|---|---|
| **Sample identification** | **Jagalene_CK** | **SY Monument_CK** | **19Nord-124_ND** | **SD15007-11_SD** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 2 HRW | 3 HRW | 2 HRW | 2 HRW |
| **Test weight (lb/bu)** | 58.3 | 57.0 | 58.1 | 58.9 |
| **Hectoliter weight (kg/hl)** | 76.7 | 75.1 | 76.5 | 77.5 |
| **1000 kernel weight (gm)** | 31.2 | 30.0 | 31.6 | 31.2 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 61.7 | 69.2 | 75.6 | 55.7 |
| Over 9 wire (%) | 37.2 | 30.4 | 24.2 | 43.3 |
| Through 9 wire (%) | 1.1 | 0.4 | 0.2 | 1.0 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 65.6/17.1 | 66.5/16.1 | 48.3/16.0 | 57.6/16.1 |
| Weight (mg) (avg/s.d) | 31.2/11.0 | 30.0/10.6 | 31.6/10.8 | 31.2/11.9 |
| Diameter (mm)(avg/s.d) | 2.67/0.42 | 2.62/0.39 | 2.68/0.38 | 2.59/0.36 |
| Moisture (%) (avg/s.d) | 12.0/0.4 | 12.5/0.4 | 12.0/0.4 | 12.3/0.4 |
| SKCS distribution | 03-10-27-60-01 | 02-06-23-69-01 | 17-29-29-25-03 | 06-20-30-44-01 |
| Classification | Hard | Hard | Mixed | Hard |
| **Wheat protein (12% mb)** | 13.6 | 12.8 | 12.8 | 13.3 |
| **Wheat ash (12% mb)** | 1.64 | 1.59 | 1.54 | 1.65 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 76.2 | 76.0 | 76.1 | 74.2 |
| Quadrumat Sr. Mill | 67.5 | 67.8 | 68.4 | 66.5 |
| **Flour moisture (%)** | 11.8 | 11.9 | 11.4 | 12.3 |
| **Flour protein (14% mb)** | 12.5 | 11.4 | 11.3 | 11.8 |
| **Flour ash (14% mb)** | 0.56 | 0.52 | 0.45 | 0.47 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 6.1 | 6.0 | 6.1 | 6.1 |
| Peak viscosity (RVU) | 189.5 | 197.6 | 193.4 | 187.1 |
| Breakdown (RVU) | 70.8 | 82.7 | 71.3 | 72.9 |
| Final viscosity at 13 min (RVU) | 230.9 | 228.3 | 234.6 | 222.5 |
| **Minolta color meter** | | | | |
| L* | 90.51 | 90.69 | 90.99 | 91.09 |
| a* | -1.31 | -1.18 | -1.50 | -1.24 |
| b* | 9.14 | 8.56 | 9.29 | 8.12 |
| **PPO** | 0.594 | 0.385 | 0.232 | 0.665 |
| **Falling number (sec)** | 447 | 409 | 423 | 401 |
| **Damaged Starch** | | | | |
| (AI%) | 98.4 | 98.2 | 97.8 | 98.5 |
| (AACC76-31) | 8.2 | 8.1 | 7.7 | 8.2 |

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

# Northern Growout: 2022 (Small-Scale) Samples (continued)

| Test entry number | 22-2405 | 22-2406 | 22-2407 | 22-2408 |
|---|---|---|---|---|
| **Sample identification** | **SD18B025-8_SD** | **NE17443_NE** | **NE17441_NE** | **WB4727_WB** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 2 HRW | 3 HRW | 2 HRW | 4HRW |
| **Test weight (lb/bu)** | 58.8 | 57.1 | 59.5 | 55.2 |
| **Hectoliter weight (kg/hl)** | 77.4 | 75.2 | 78.3 | 72.7 |
| **1000 kernel weight (gm)** | 32.4 | 31.8 | 31.7 | 29.3 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 71.3 | 73.2 | 69.6 | 57.6 |
| Over 9 wire (%) | 28.3 | 26.4 | 29.9 | 40.5 |
| Through 9 wire (%) | 0.4 | 0.4 | 0.5 | 1.9 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 63.3/15.4 | 50.5/17.2 | 58.8/16.9 | 52.9/18.3 |
| Weight (mg) (avg/s.d) | 32.4/10.7 | 31.8/10.1 | 31.7/10.2 | 29.3/10.7 |
| Diameter (mm)(avg/s.d) | 2.69/0.36 | 2.71/0.42 | 2.67/0.38 | 2.58/0.44 |
| Moisture (%) (avg/s.d) | 12.0/0.5 | 12.2/0.4 | 12.3/0.4 | 12.1/0.4 |
| SKCS distribution | 02-11-30-57-01 | 15-27-29-29-03 | 05-19-25-51-01 | 14-24-25-37-03 |
| Classification | Hard | Mixed | Hard | Mixed |
| **Wheat protein (12% mb)** | 13.7 | 13.6 | 13.4 | 13.3 |
| **Wheat ash (12% mb)** | 1.62 | 1.67 | 1.62 | 1.64 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 73.5 | 74.8 | 76.0 | 71.6 |
| Quadrumat Sr. Mill | 65.1 | 66.4 | 67.1 | 66.0 |
| **Flour moisture (%)** | 12.6 | 12.3 | 12.1 | 11.5 |
| **Flour protein (14% mb)** | 12.4 | 12.2 | 12.2 | 12.0 |
| **Flour ash (14% mb)** | 0.51 | 0.48 | 0.52 | 0.55 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 6.3 | 6.0 | 6.1 | 6.1 |
| Peak viscosity (RVU) | 202.1 | 181.6 | 188.9 | 194.3 |
| Breakdown (RVU) | 72.3 | 78.3 | 73.9 | 65.6 |
| Final viscosity at 13 min (RVU) | 238.4 | 210.1 | 223.1 | 247.8 |
| **Minolta color meter** | | | | |
| L* | 90.55 | 91.10 | 90.56 | 90.64 |
| a* | -1.20 | -1.32 | -1.12 | -1.25 |
| b* | 8.07 | 8.55 | 8.28 | 8.91 |
| **PPO** | 0.689 | 0.721 | 0.760 | 0.657 |
| **Falling number (sec)** | 412 | 389 | 429 | 472 |
| **Damaged Starch** | | | | |
| (AI%) | 98.0 | 97.7 | 98.1 | 97.7 |
| (AACC76-31) | 7.9 | 7.6 | 8.0 | 7.7 |

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

# Northern Growout: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples

| Test Entry Number | 22-2401 | 22-2402 | 22-2403 | 22-2404 |
|---|---|---|---|---|
| Sample Identification | Jagalene_CK | SY Mounment_CK | 19Nord-124_ND | SD15007-11_SD |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 71.0 | 69.4 | 66.2 | 67.8 |
| Flour Abs (14% mb) | 68.1 | 67.1 | 63.2 | 65.8 |
| Mix Time (min) | 5.0 | 9.0 | 3.0 | 6.0 |
| Mix tolerance (0-6) | 4 | 5 | 2 | 5 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 63.3 | 64.4 | 64.0 | 64.9 |
| Flour Abs (14% mb) | 60.4 | 62.0 | 61.1 | 62.8 |
| Peak time (min) | 6.5 | 7.3 | 5.3 | 6.9 |
| Mix stability (min) | 14.8 | 16.3 | 7.3 | 18.6 |
| Mix Tolerance Index (FU) | 19 | 22 | 38 | 16 |
| Breakdown time (min) | 14.1 | 13.9 | 9.5 | 20.1 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 111 | 139 | 91 | 146 |
| L(mm): Extensibility | 58 | 40 | 52 | 37 |
| G(mm): Swelling index | 16.9 | 14.0 | 16.0 | 13.5 |
| W($10^{-4}$ J): strength (curve area) | 277 | 239 | 170 | 239 |
| P/L: curve configuration ratio | 1.91 | 3.48 | 1.75 | 3.95 |
| Ie($P_{200}$/P): elasticity index | 65.7 | 52.0 | 44.0 | 0.0 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 462/555/584 | 633/927/950 | 223/264/322 | 543/778/837 |
| Extensibility (mm at 45/90/135 min) | 156/158/139 | 127/124/105 | 150/164/149 | 157/138/147 |
| Energy ($cm^2$ at 45/90/135 min) | 142/172/142 | 138/175/143 | 60/80/87 | 171/195/218 |
| Resist $_{max}$ (BU at 45/90/135min) | 733/898/839 | 889/1196/1182 | 287/360/440 | 883/1175/1207 |
| Ratio (at 45/90/135 min) | 3.0/3.5/4.2 | 5.0/7.5/9.1 | 1.5/1.6/2.2 | 3.5/5.6/5.7 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 1,2*, 17+18, 5+10 | 2*, 7+9, 5+10 | 2*, 7+9, 5+10 | 2*, 7+9, 5+10 |
| TPP/TMP | 1.11 | 1.00 | 1.01 | 0.95 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 62.1 | 59.1 | 43.2 | 62.2 |

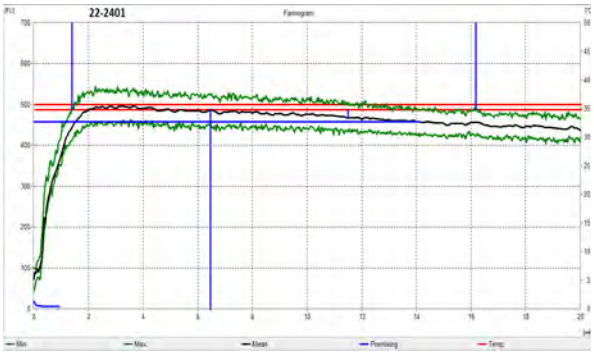
# Northern Growout: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples (continued)

| Test Entry Number | 22-2405 | 22-2406 | 22-2407 | 22-2408 |
|---|---|---|---|---|
| Sample Identification | SD18B025-8_SD | NHH17612_NE | NE17441_NE | WB4727_WB |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 70.1 | 69.4 | 69.7 | 70.3 |
| Flour Abs (14% mb) | 68.3 | 67.2 | 67.5 | 67.6 |
| Mix Time (min) | 5.0 | 5.3 | 5.5 | 3.4 |
| Mix tolerance (0-6) | 5 | 4 | 4 | 2 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 65.3 | 64.9 | 65.0 | 63.7 |
| Flour Abs (14% mb) | 63.5 | 62.7 | 62.7 | 61.0 |
| Peak time (min) | 5.5 | 6.2 | 6.9 | 4.8 |
| Mix stability (min) | 12.3 | 11.4 | 18.6 | 8.1 |
| Mix Tolerance Index (FU) | 21 | 26 | 18 | 34 |
| Breakdown time (min) | 13.0 | 11.6 | 16.0 | 9.7 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 119 | 109 | 139 | 100 |
| L(mm): Extensibility | 78 | 87 | 59 | 64 |
| G(mm): Swelling index | 19.6 | 20.7 | 17.1 | 17.8 |
| W($10^{-4}$ J): strength (curve area) | 336 | 318 | 328 | 214 |
| P/L: curve configuration ratio | 1.53 | 1.25 | 2.36 | 1.56 |
| Ie($P_{200}$/P): elasticity index | 58.1 | 55.4 | 59.1 | 46.3 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 411/525/561 | 390/551/626 | 507/635/808 | 306/359/386 |
| Extensibility (mm at 45/90/135 min) | 147/139/149 | 143/133/132 | 133/110/119 | 149/154/146 |
| Energy ($cm^2$ at 45/90/135 min) | 109/131/151 | 98/124/138 | 117/108/150 | 80/96/99 |
| Resist $_{max}$ (BU at 45/90/135min) | 580/753/821 | 535/738/865 | 690/828/1055 | 399/469/522 |
| Ratio (at 45/90/135 min) | 2.8/3.8/3.8 | 2.7/4.1/4.8 | 3.8/5.8/6.8 | 2.1/2.3/2.6 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 2*, 7+9, 5+10 | 2*, 7+9, 5+10 | 2*, 7+8, 5+10 | 2*,20a+20b,5+10 |
| TPP/TMP | 1.07 | 1.02 | 0.86 | 1.08 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 61.9 | 61.6 | 58.7 | 58.4 |

# Physical Dough Tests – Farino and Mixo

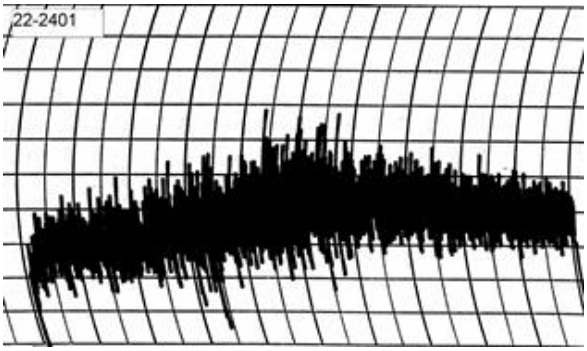
## 2022 (Small Scale) Samples – Northern Growout

### Farinograms



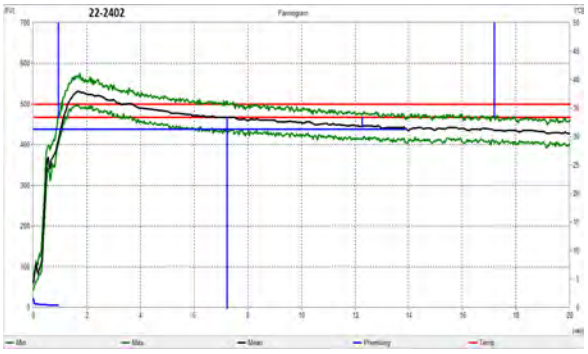

Water abs = 60.4%, Peak time = 6.5 min,
Mix stab = 14.8 min, MTI = 19 FU

### Mixograms

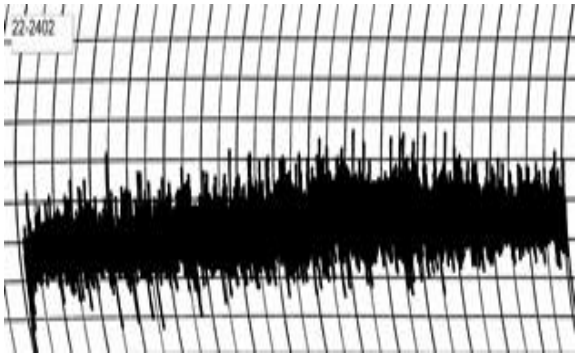



Water abs = 68.1%
Mix time = 5.0 min

### 22-2401, Jagalene_CK




Water abs = 62.0%, Peak time = 7.3 min,
Mix stab = 16.3 min, MTI = 22 FU



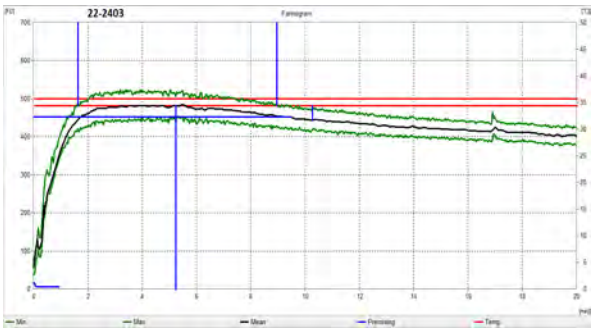

Water abs = 67.1%
Mix time = 9.0 min

### 22-2402, SY Mounment_CK

# Physical Dough Tests – Farino and Mixo

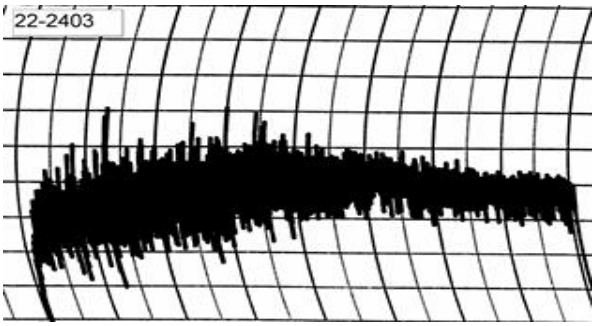
## 2022 (Small Scale) Samples – Northern Growout (Continued)

### Farinograms



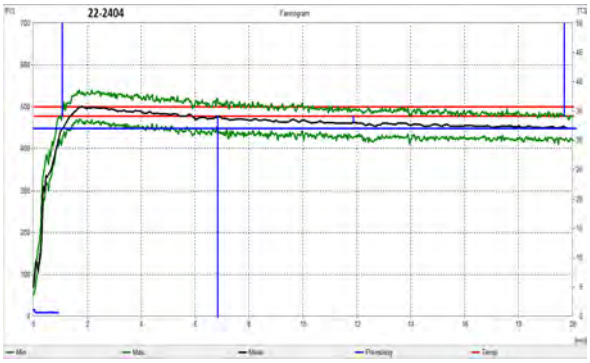

Water abs = 61.1%, Peak time = 5.3 min,
Mix stab = 7.3 min, MTI = 38 FU

### Mixograms

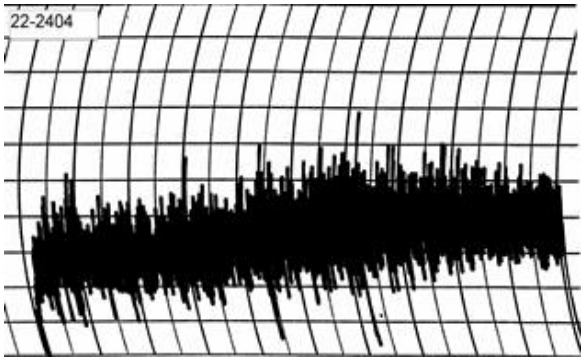



Water abs = 63.2%
Mix time = 3.0 min

**22-2403, 19NORD-124_ND**




Water abs = 62.8%, Peak time = 6.9 min,
Mix stab = 18.6 min, MTI = 16 FU



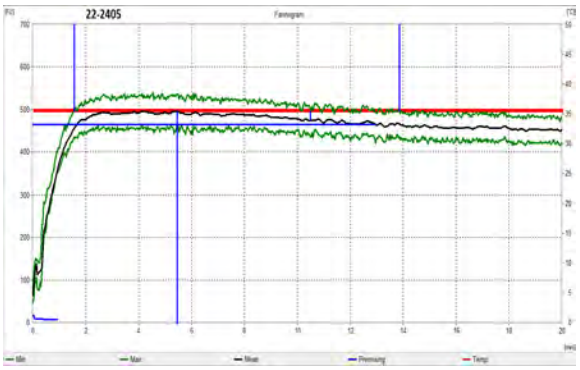

Water abs = 65.8%
Mix time = 6.0 min

**22-2404, SD15007-11_SD**

# Physical Dough Tests – Farino and Mixo

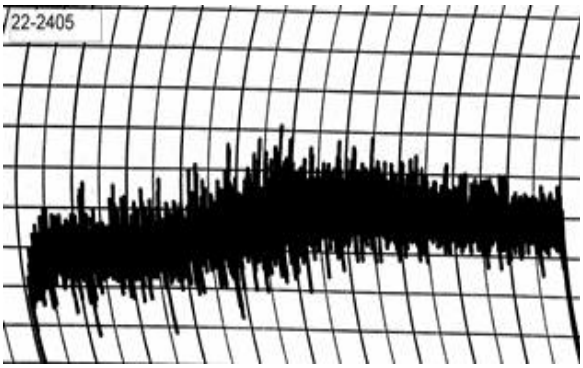
## 2022 (Small Scale) Samples – Northern Growout (Continued)

### Farinograms



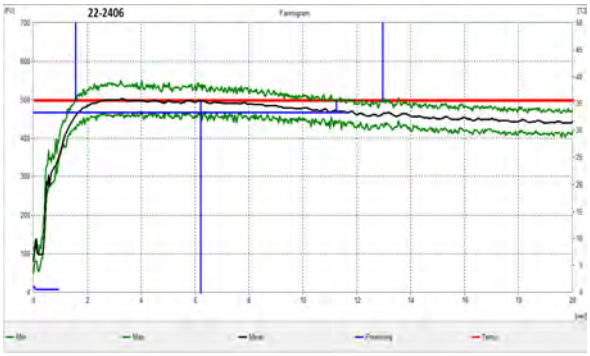

Water abs = 63.5%, Peak time = 5.5 min,
Mix stab = 12.3 min, MTI = 21 FU

### Mixograms

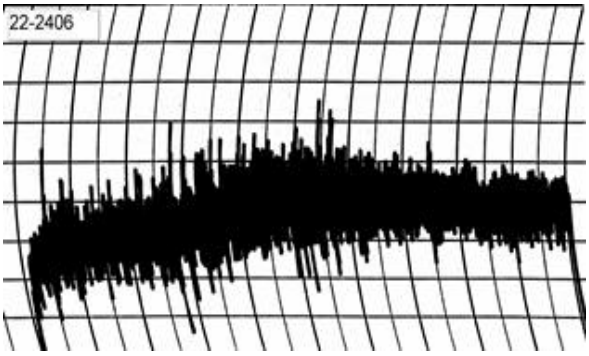



Water abs = 68.3%
Mix time = 5.0 min

**22-2405, SD188025-8_SD**




Water abs = 62.7%, Peak time = 6.2 min,
Mix stab = 11.4 min, MTI = 26 FU



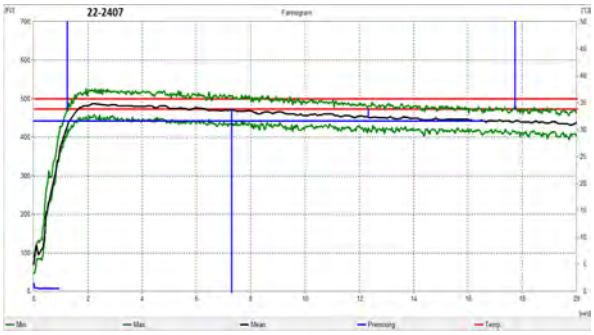

Water abs = 67.2%
Mix time = 5.3 min

**22-2406, NE17441_NE**

# Physical Dough Tests – Farino and Mixo

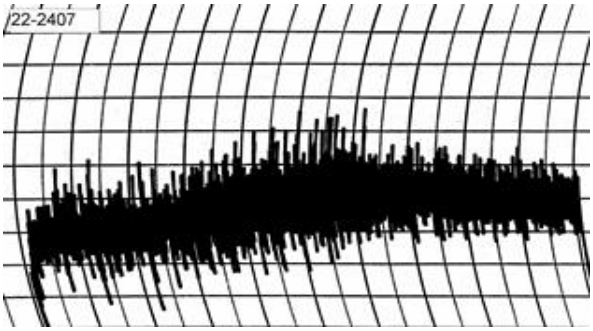
## 2022 (Small Scale) Samples – Northern Growout (Continued)

### Farinograms



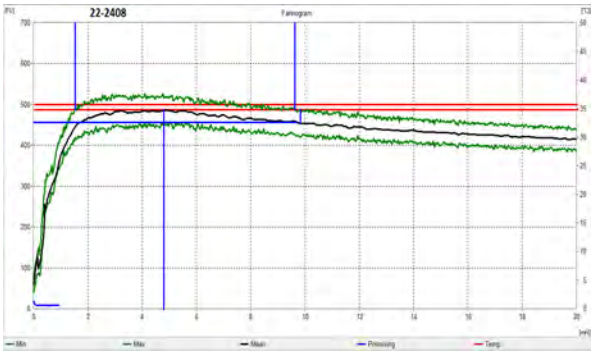

Water abs = 66.9%, Peak time = 7.0 min,
Mix stab = 11.5 min, MTI = 21 FU

### Mixograms

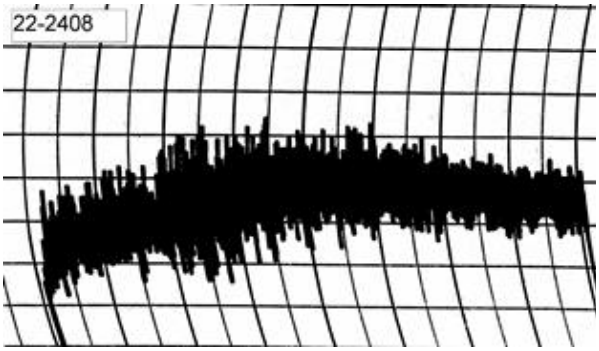



Water abs = 67.5%
Mix time = 5.5 min

**22-2407, NE17441_NE**




Water abs = 61.0%, Peak time = 4.8 min,
Mix stab = 8.1 min, MTI = 34 FU

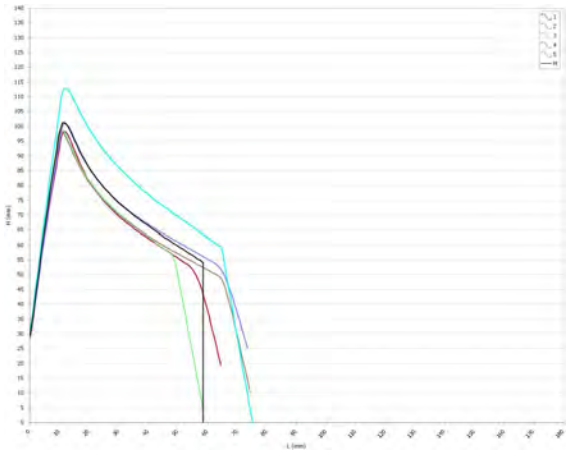



Water abs = 67.6%
Mix time = 3.4 min

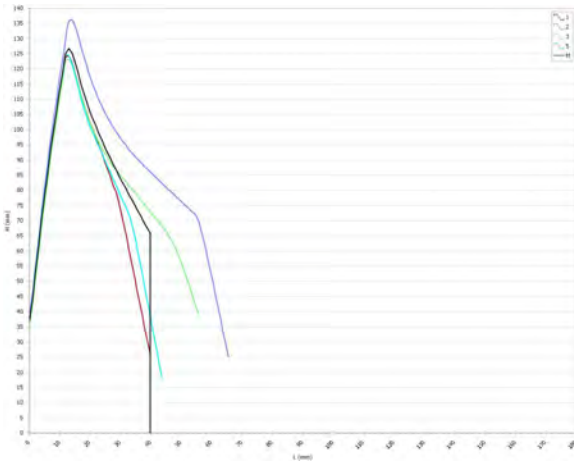
**22-2408, WB4727_WB**

# Physical Dough Tests - Alveograms

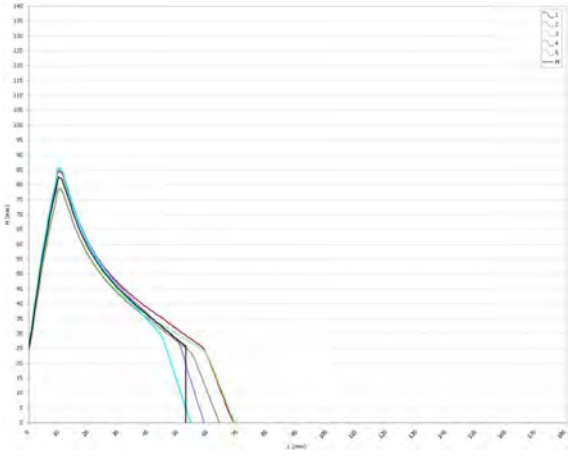
## 2022 (Small Scale) Samples – Northern Growout



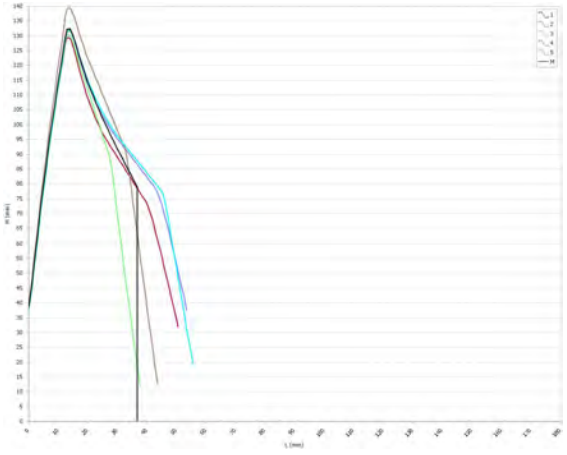
**22-2401, Jagalene_CK**
P(mm $H_20$) =111, L(mm) = 58, W(10E$^{-4}$ J) = 277



**22-2402, SY Monument_CK**
P(mm $H_20$) =139, L(mm) = 40, W(10E$^{-4}$ J) = 239



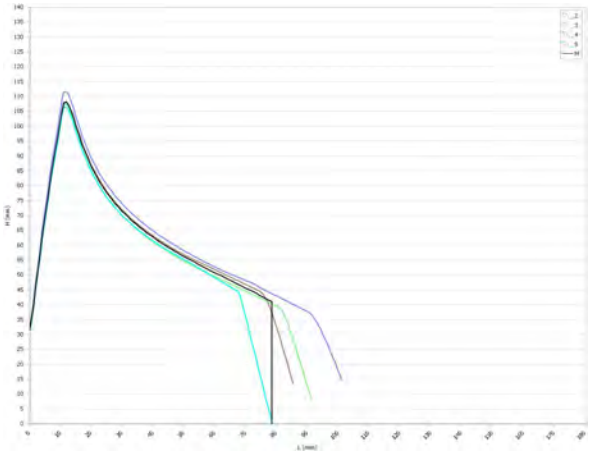
**22-2403, 19NORD-124_ND**
P(mm $H_20$) =91, L(mm) = 52, W(10E$^{-4}$ J) = 170



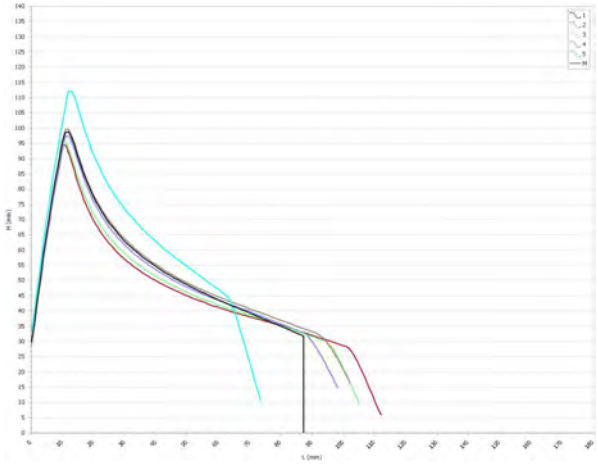
**22-2404, SD15007-11_SD**
P(mm $H_20$) =146, L(mm) = 37, W(10E$^{-4}$ J) = 239

# Physical Dough Tests - Alveograms

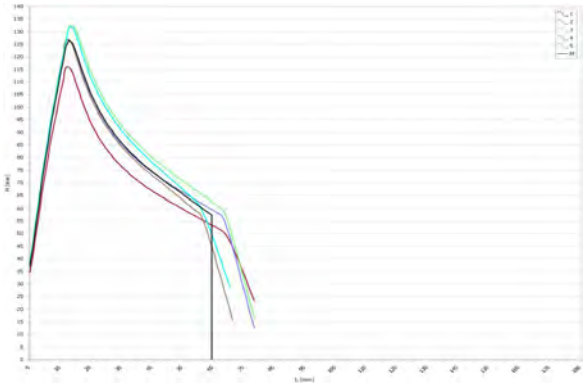
## 2022 (Small Scale) Samples – Northern Growout



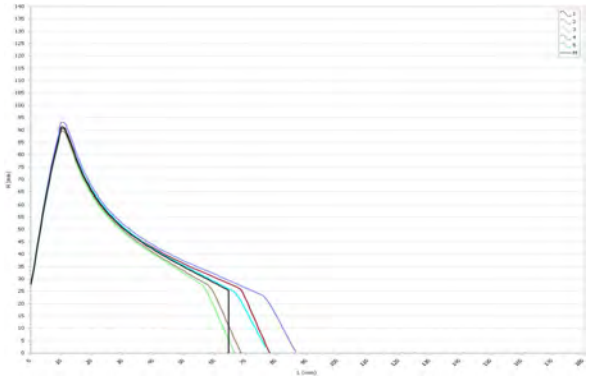
**22-2405, SD18B025-8_SD**
P(mm $H_20$) = 119, L(mm) = 78, W($10E^{-4}$ J) = 336



**22-2406, NE17443_NE**
P(mm $H_20$) = 109, L(mm) = 87, W($10E^{-4}$ J) = 318



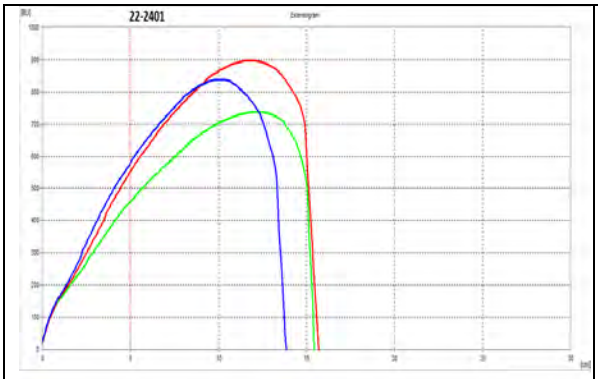
**22-2407, NE17441_NE**
P(mm $H_20$) = 139, L(mm) = 59, W($10E^{-4}$ J) = 328



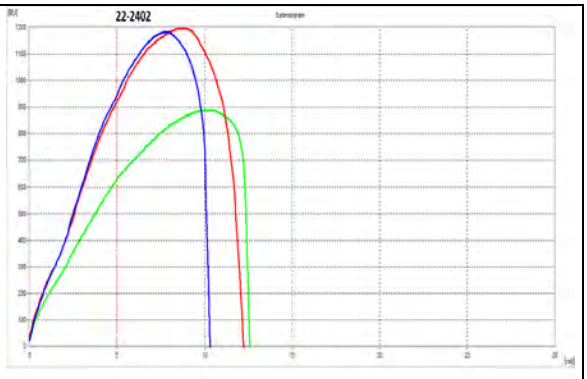
**22-2408, WB4727_WB**
P(mm $H_20$) = 100, L(mm) = 64, W($10E^{-4}$ J) = 214

# Physical Dough Tests - Extensigrams

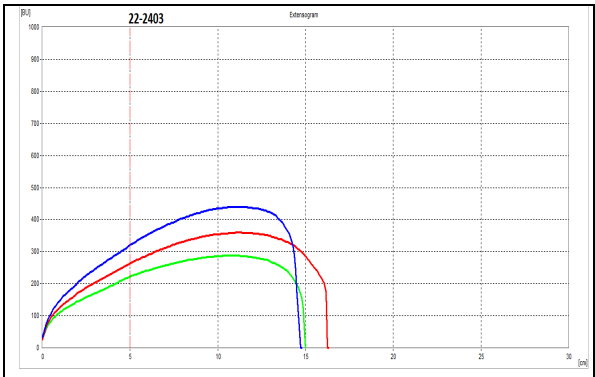
## 2022 (Small Scale) Samples – Northern Growout



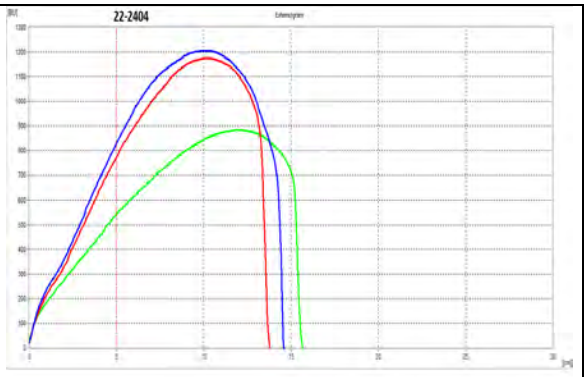

**22-2401, Jagalene_CK**
R (BU) = 555, E (mm) = 158, W ($cm^2$) = 172
Rmax (BU) = 898, Ratio = 3.5 at 90 min




**22-2402, SY Monument_CK**
R (BU) = 927, E (mm) = 124, W ($cm^2$) = 175
Rmax (BU) = 1196, Ratio = 7.5 at 90 min




**22-2403, 19NORD-124_ND**
R (BU) = 264, E (mm) = 164, W ($cm^2$) = 80
Rmax (BU) = 360, Ratio = 1.6 at 90 min

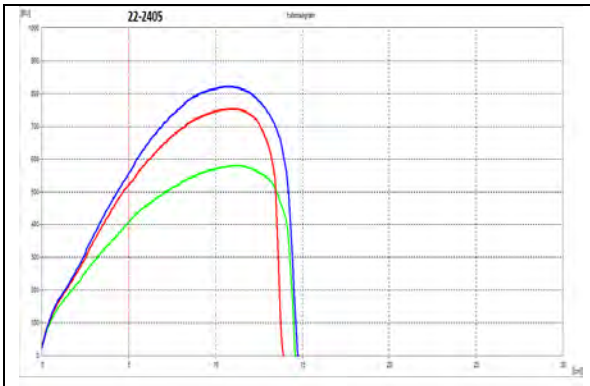



**22-2404, SD15007-11_SD**
R (BU) = 778, E (mm) = 138, W ($cm^2$) = 195
Rmax (BU) = 1175, Ratio = 5.6 at 90 min

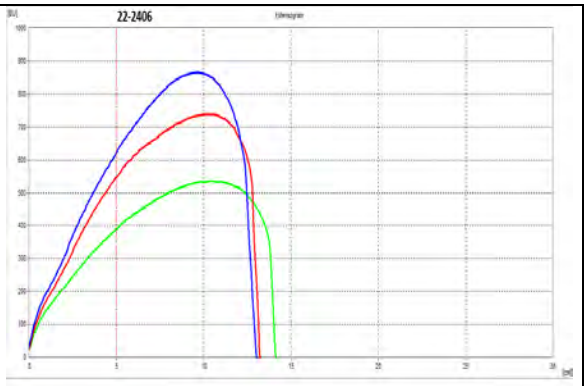
Notes: R (BU) = Resistance; E (mm) = Extensibility; W ($cm^2$) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

# Physical Dough Tests - Extensigrams

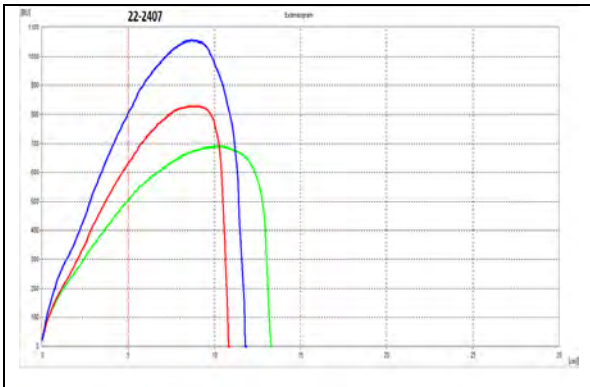
## 2022 (Small Scale) Samples – Northern Growout



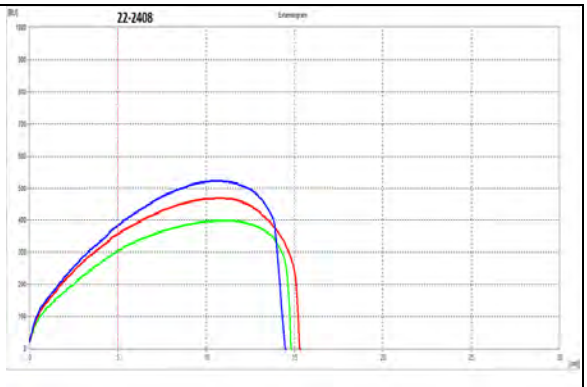

**22-2405, SD18B025-8_SD**
R (BU) = 525, E (mm) = 139, W ($cm^2$) = 131
Rmax (BU) = 753, Ratio = 3.8 at 90 min




**22-2406, NE17443_NE**
R (BU) = 551, E (mm) = 133, W ($cm^2$) = 124
Rmax (BU) = 738, Ratio = 4.3 at 90 min



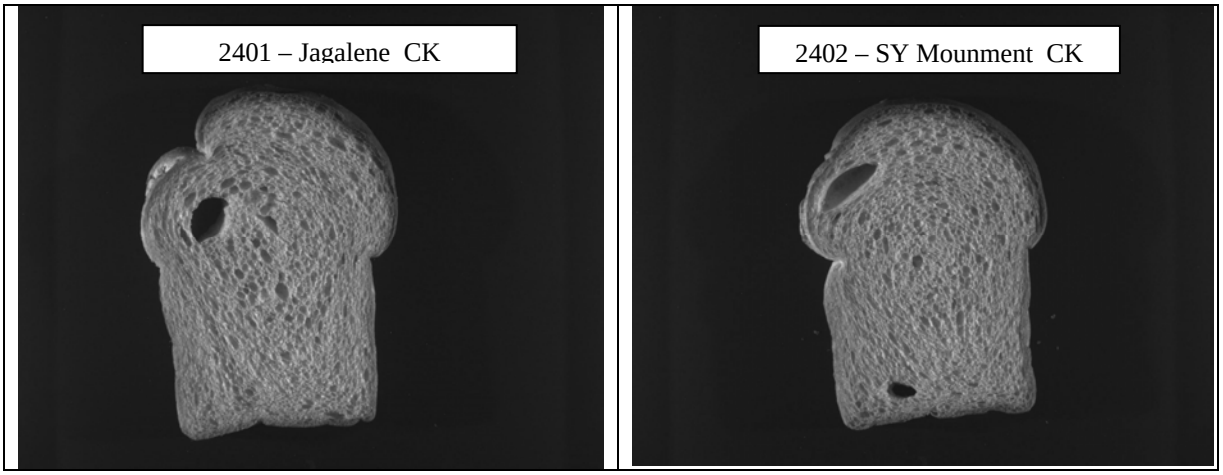

**22-2407, NE17441_NE**
R (BU) = 635, E (mm) = 110, W ($cm^2$) = 108
Rmax (BU) = 828, Ratio = 5.8 at 90 min



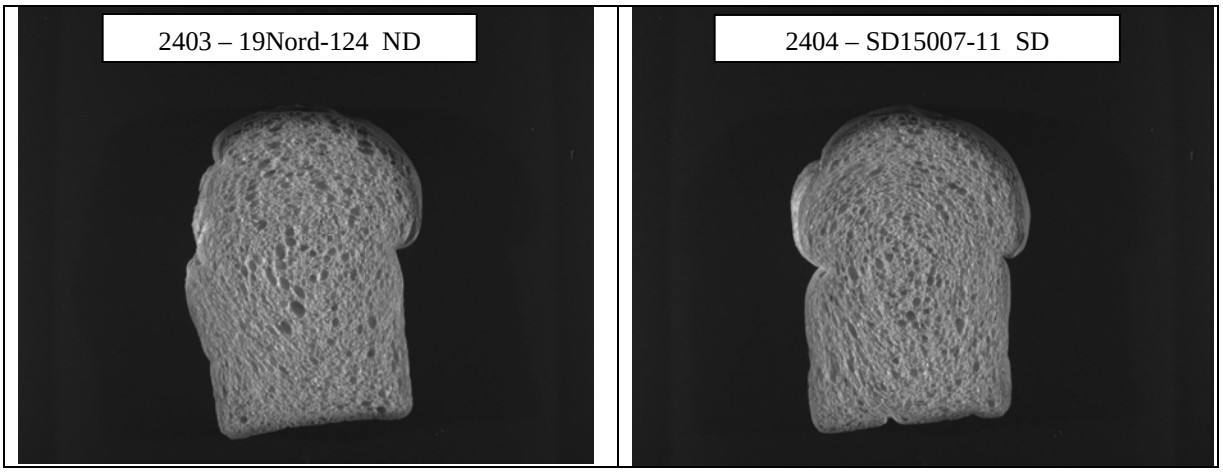

**22-2408, WB4727_WB**
R (BU) = 359, E (mm) = 154, W ($cm^2$) = 96
Rmax (BU) = 469, Ratio = 2.3 at 90 min

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

# Northern Growout: C-Cell Bread Images and Analysis
# 2022 (Small-Scale) Samples

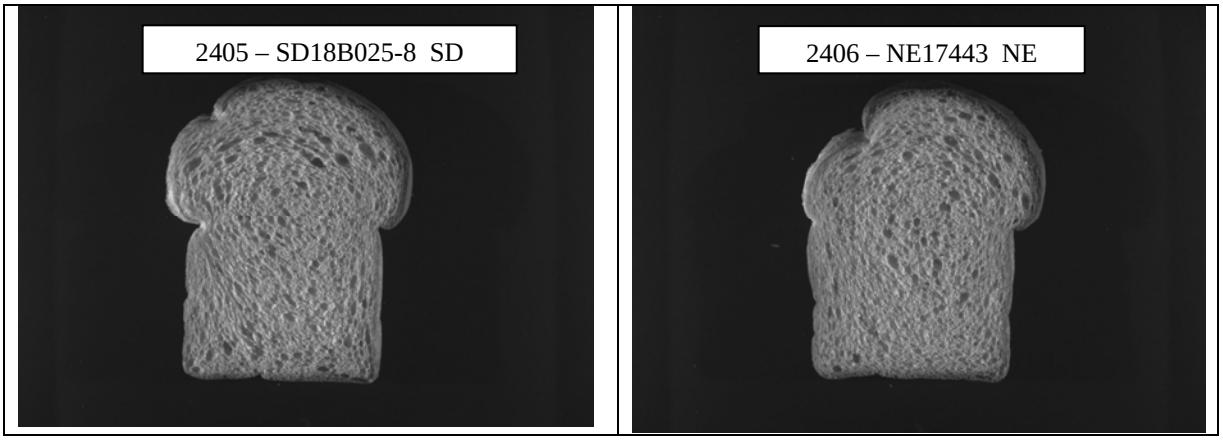



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2401** | 6810 | 111 | 4115 | 0.410 | 1.985 | 8.490 | 1.863 | -3.58 |
| **2402** | 6375 | 111 | 4072 | 0.410 | 1.843 | 6.518 | 1.850 | -1.50 |

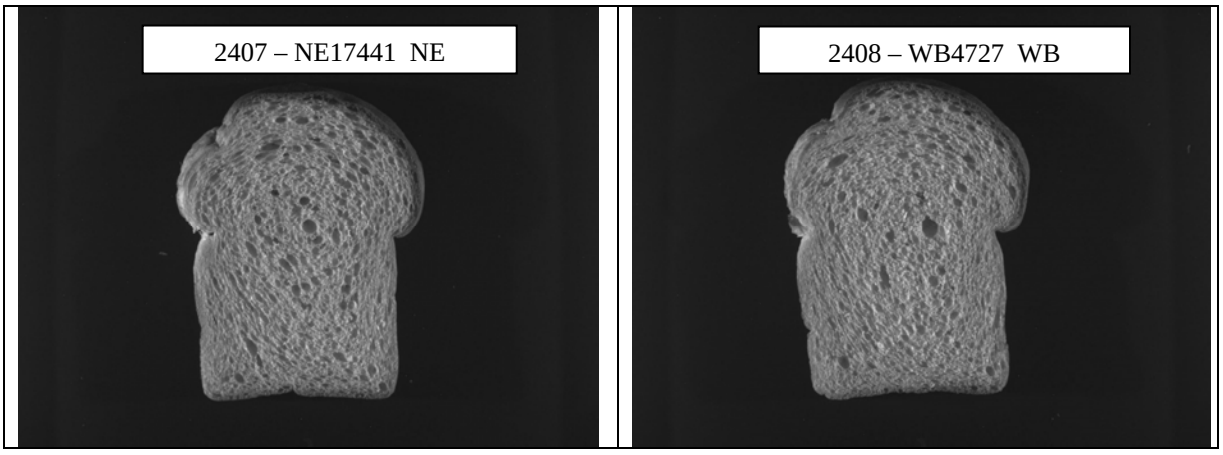



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2403** | 6468 | 115 | 4030 | 0.415 | 1.978 | 4.300 | 1.750 | -0.20 |
| **2404** | 6315 | 114 | 3976 | 0.410 | 1.918 | 6.070 | 1.948 | 3.65 |

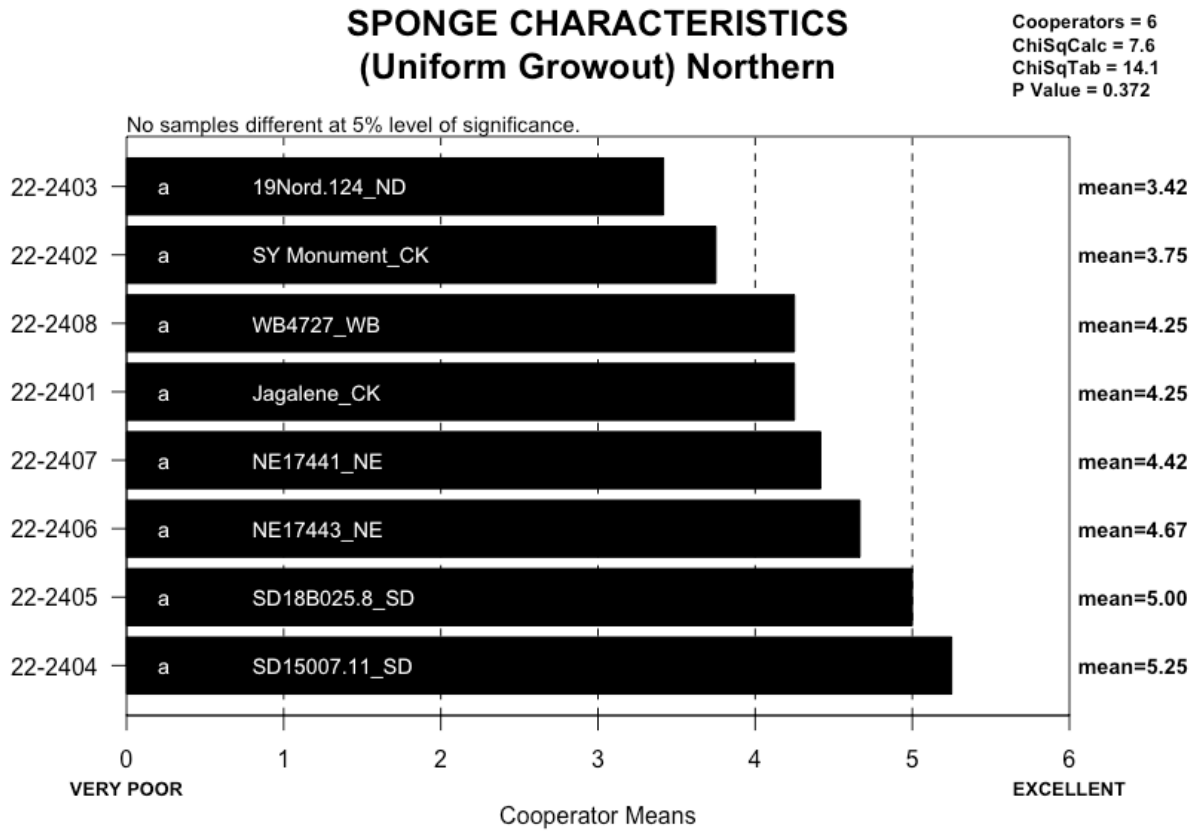
# Northern Growout: C-Cell Bread Images and Analysis
# 2022 (Small-Scale) Samples

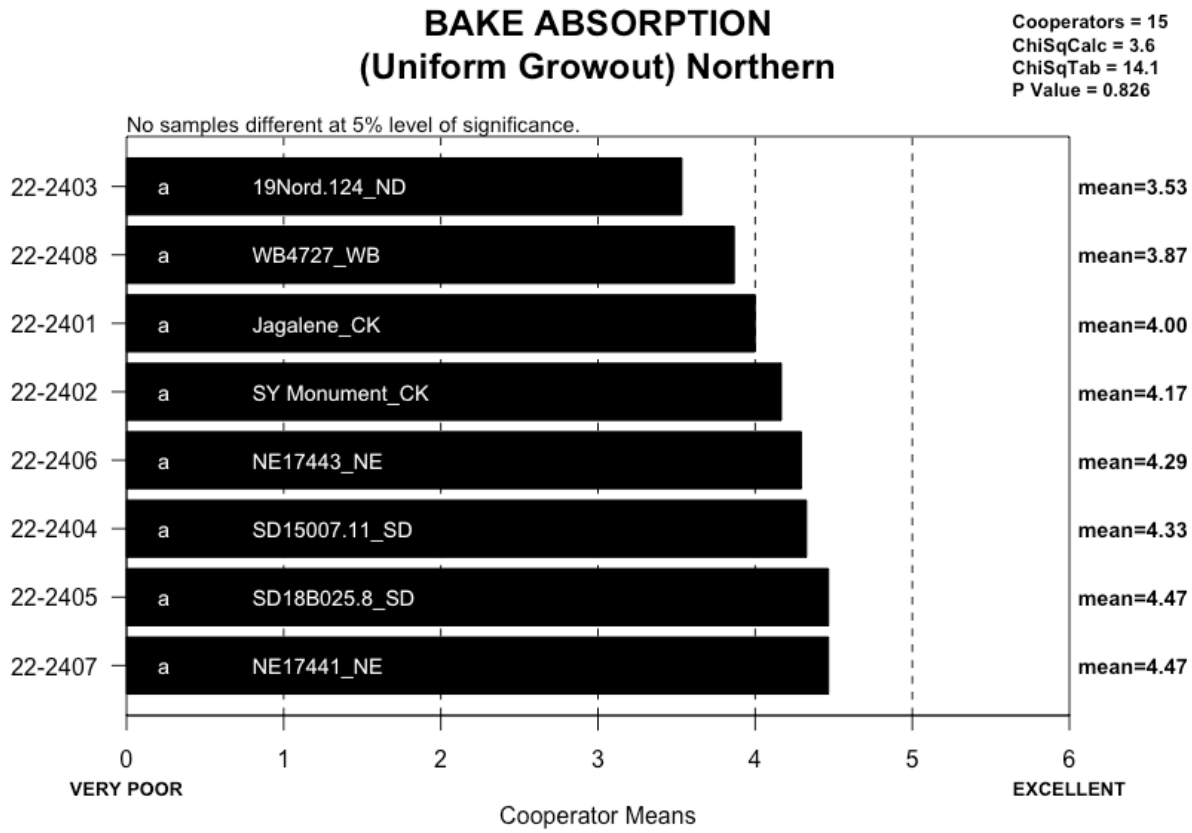



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2405** | 6704 | 113 | 3971 | 0.425 | 2.140 | 8.160 | 1.855 | -7.35 |
| **2406** | 6448 | 115 | 4072 | 0.415 | 1.935 | 5.155 | 1.850 | -6.40 |




| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2407** | 6548 | 113 | 4026 | 0.420 | 2.035 | 2.685 | 1.840 | -8.80 |
| **2408** | 6525 | 113 | 4155 | 0.415 | 1.973 | 1.985 | 1.790 | -5.55 |


SPONGE CHARACTERISTICS
(Uniform Growout) Northern
Cooperators = 6
ChiSqCalc = 7.6
ChiSqTab = 14.1
P Value = 0.372
No samples different at 5% level of significance.
22-2403 a 19Nord.124_ND mean=3.42
22-2402 a SY Monument_CK mean=3.75
22-2408 a WB4727_WB mean=4.25
22-2401 a Jagalene_CK mean=4.25
22-2407 a NE17441_NE mean=4.42
22-2406 a NE17443_NE mean=4.67
22-2405 a SD18B025.8_SD mean=5.00
22-2404 a SD15007.11_SD mean=5.25
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

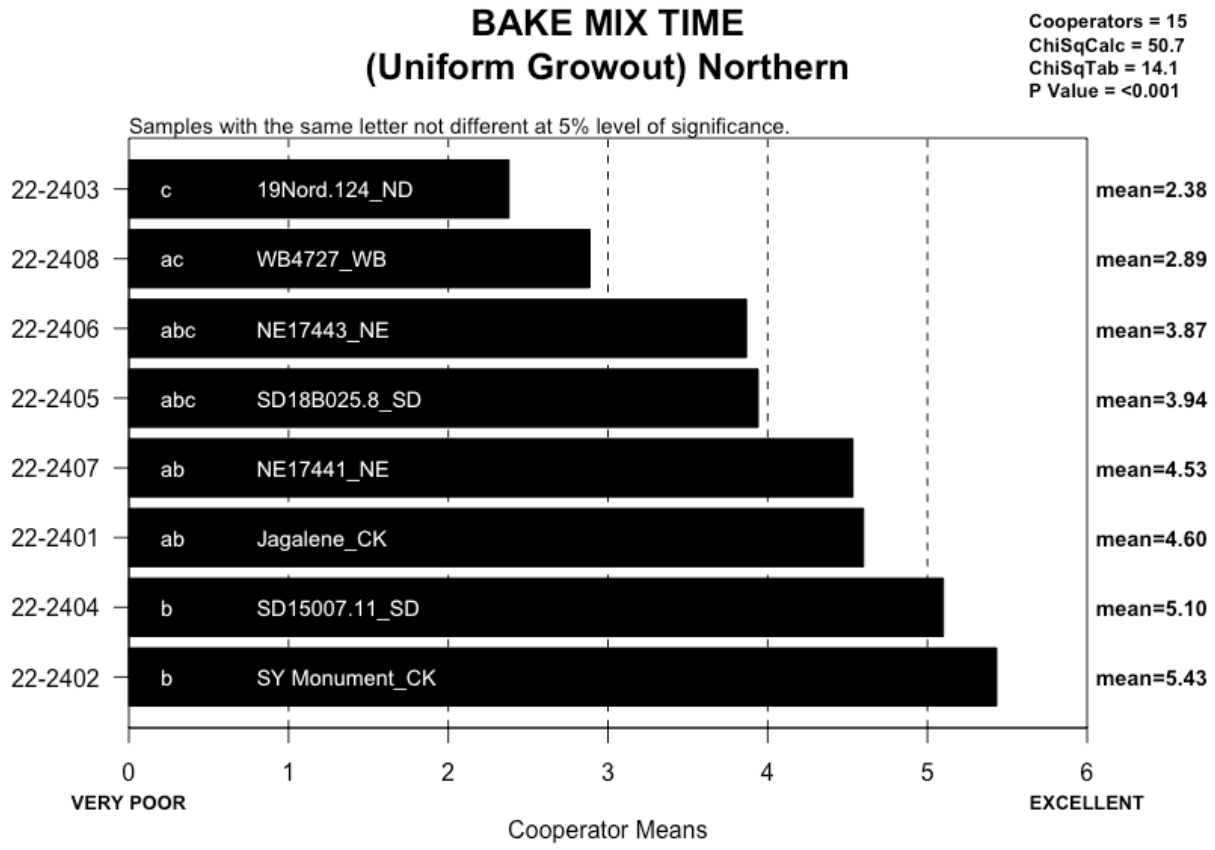

BAKE ABSORPTION
(Uniform Growout) Northern
Cooperators = 15
ChiSqCalc = 3.6
ChiSqTab = 14.1
P Value = 0.826
No samples different at 5% level of significance.
22-2403 a 19Nord.124_ND mean=3.53
22-2408 a WB4727_WB mean=3.87
22-2401 a Jagalene_CK mean=4.00
22-2402 a SY Monument_CK mean=4.17
22-2406 a NE17443_NE mean=4.29
22-2404 a SD15007.11_SD mean=4.33
22-2405 a SD18B025.8_SD mean=4.47
22-2407 a NE17441_NE mean=4.47
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

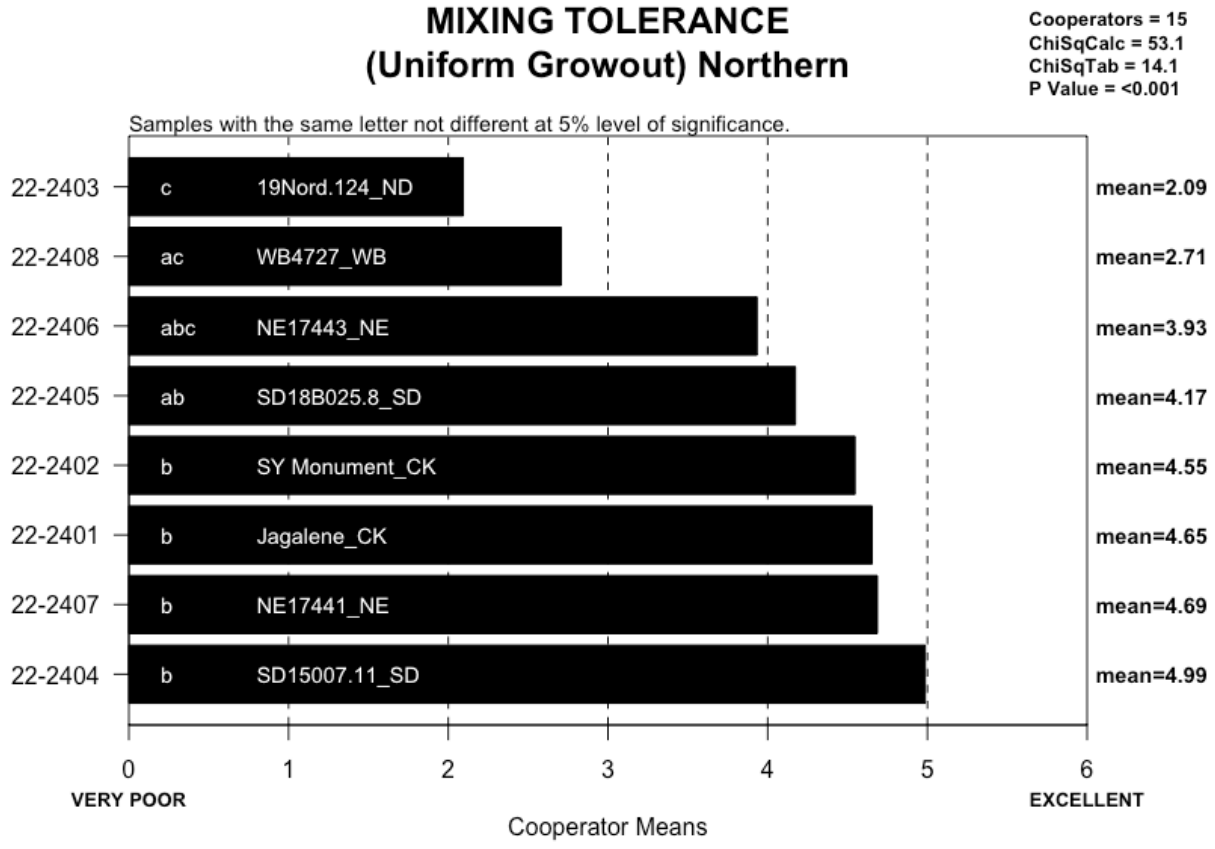
# BAKE ABSORPTION, ACTUAL (14% MB)
# (Uniform Growout) Northern
# Cooperators A – O

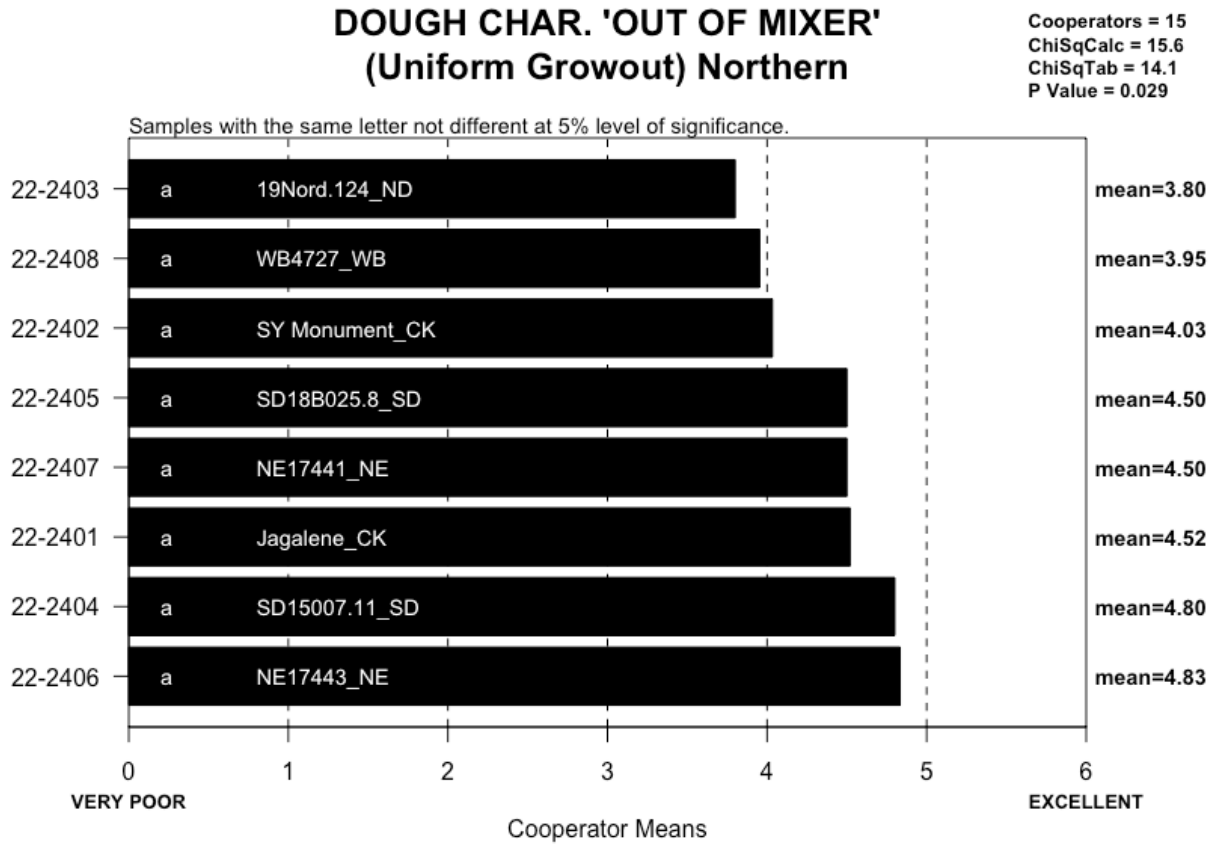
| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 59 | 63.7 | 67.2 | 65.6 | 68.7 | 64.0 | 60.4 | 56.1 | 65.8 | 63.6 | 60.4 | 70.4 | 68.1 | 65.0 | 61 |
| 22-2402 | SY Monument_CK | 58 | 64.5 | 65.4 | 67.1 | 67.8 | 65.0 | 60.2 | 59.7 | 65.4 | 65.0 | 62.0 | 71.4 | 67.1 | 64.3 | 62 |
| 22-2403 | 19Nord.124_ND | 58 | 64.4 | 65.4 | 65.9 | 64.2 | 64.3 | 61.1 | 57.0 | 61.2 | 64.4 | 61.1 | 69.3 | 63.2 | 62.9 | 61 |
| 22-2404 | SD15007.11_SD | 59 | 65.7 | 64.4 | 67.8 | 67.7 | 66.5 | 62.8 | 60.0 | 64.7 | 65.8 | 62.8 | 70.6 | 65.8 | 64.5 | 63 |
| 22-2405 | SD18B025.8_SD | 59 | 65.0 | 66.4 | 68.6 | 67.7 | 68.0 | 63.5 | 60.7 | 65.9 | 66.6 | 63.5 | 69.7 | 68.3 | 64.5 | 64 |
| 22-2406 | NE17443_NE | 59 | 65.3 | 64.9 | 67.8 | 65.6 | 66.2 | 62.7 | 59.8 | 65.5 | 65.6 | 62.7 | 69.5 | 67.2 | 65.3 | 63 |
| 22-2407 | NE17441_NE | 59 | 67.4 | 66.1 | 67.5 | 66.0 | 66.5 | 62.7 | 59.8 | 66.5 | 65.1 | 62.7 | 66.7 | 67.5 | 66.1 | 63 |
| 22-2408 | WB4727_WB | 59 | 64.7 | 65.4 | 65.9 | 65.6 | 65.5 | 61.0 | 57.3 | 65.0 | 64.4 | 61.0 | 70.0 | 67.6 | 62.5 | 61 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 15 | 6.3 | 8.9 | 5.5 | 5.3 | 6.0 | 17 | 6 | 7.4 | 20 | 6.0 | 4.5 | 5.0 | 14 | 19 |
| 22-2402 | SY Monument_CK | 15 | 8.2 | 12.4 | 7.7 | 7.8 | 9.0 | 30 | 7 | 12.8 | 25 | 7.5 | 4.5 | 9.0 | 20 | 22 |
| 22-2403 | 19Nord.124_ND | 5 | 3.5 | 4.2 | 3.1 | 3.3 | 3.3 | 7 | 4 | 3.5 | 8 | 5.0 | 3.5 | 3.0 | 5 | 7 |
| 22-2404 | SD15007.11_SD | 15 | 8.5 | 9.3 | 7.2 | 6.3 | 7.3 | 15 | 7 | 10.3 | 12 | 7.5 | 4.5 | 6.0 | 20 | 24 |
| 22-2405 | SD18B025.8_SD | 10 | 2.7 | 5.1 | 4.7 | 4.5 | 5.3 | 25 | 5 | 5.3 | 12 | 5.5 | 4.8 | 5.0 | 13 | 20 |
| 22-2406 | NE17443_NE | 12 | 4.1 | 6.9 | 4.9 | 4.3 | 5.0 | 11 | 4 | 6.5 | 10 | 6.0 | 4.3 | 5.3 | 8 | 20 |
| 22-2407 | NE17441_NE | 13 | 5.5 | 8.3 | 5.5 | 5.0 | 5.8 | 18 | 6 | 8.0 | 14 | 7.0 | 4.5 | 5.5 | 13 | 27 |
| 22-2408 | WB4727_WB | 7 | 3.5 | 5.3 | 2.6 | 3.5 | 3.5 | 11 | 4 | 4.3 | 8 | 5.0 | 3.5 | 3.4 | 10 | 10 |

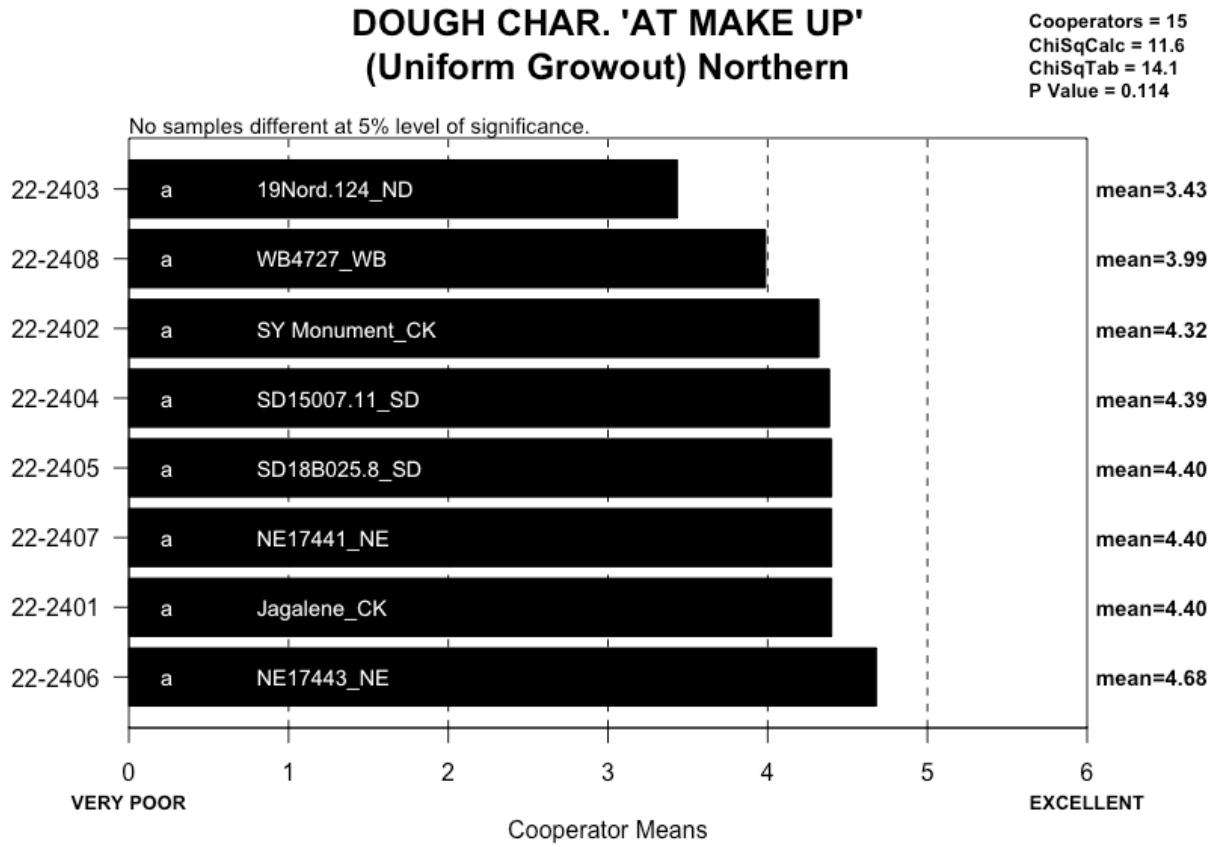

BAKE MIX TIME
(Uniform Growout) Northern
Cooperators = 15
ChiSqCalc = 50.7
ChiSqTab = 14.1
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
22-2403 c 19Nord.124_ND mean=2.38
22-2408 ac WB4727_WB mean=2.89
22-2406 abc NE17443_NE mean=3.87
22-2405 abc SD18B025.8_SD mean=3.94
22-2407 ab NE17441_NE mean=4.53
22-2401 ab Jagalene_CK mean=4.60
22-2404 b SD15007.11_SD mean=5.10
22-2402 b SY Monument_CK mean=5.43
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Uniform Growout) Northern
Cooperators = 15
ChiSqCalc = 53.1
ChiSqTab = 14.1
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
22-2403 c 19Nord.124_ND mean=2.09
22-2408 ac WB4727_WB mean=2.71
22-2406 abc NE17443_NE mean=3.93
22-2405 ab SD18B025.8_SD mean=4.17
22-2402 b SY Monument_CK mean=4.55
22-2401 b Jagalene_CK mean=4.65
22-2407 b NE17441_NE mean=4.69
22-2404 b SD15007.11_SD mean=4.99
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



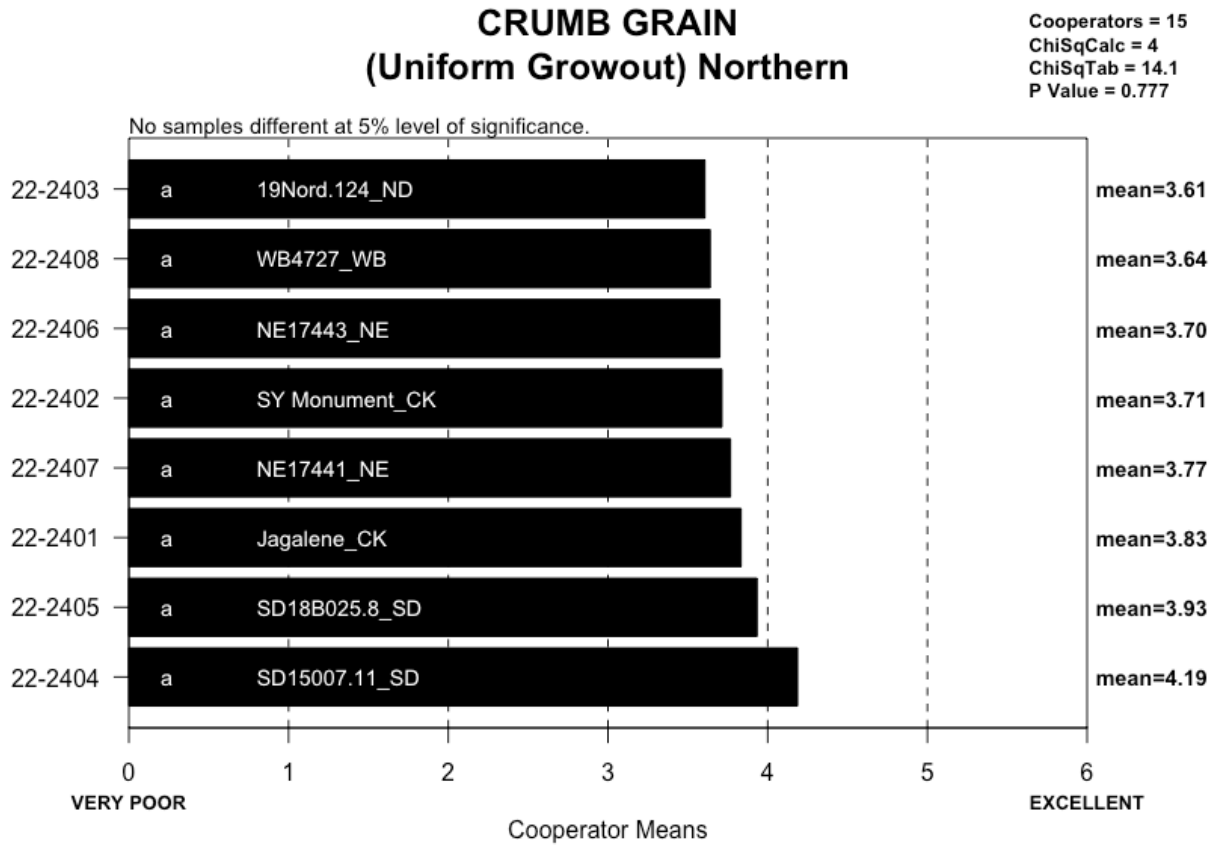

# DOUGH CHAR. 'OUT OF MIXER', DESCRIBED (Uniform Growout) Northern

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 1 | 2 | 2 | 9 | 1 |
| 22-2402 | SY Monument_CK | 3 | 2 | 4 | 6 | 0 |
| 22-2403 | 19Nord.124_ND | 3 | 2 | 0 | 10 | 0 |
| 22-2404 | SD15007.11_SD | 1 | 0 | 2 | 9 | 3 |
| 22-2405 | SD18B025.8_SD | 3 | 0 | 3 | 7 | 2 |
| 22-2406 | NE17443_NE | 0 | 1 | 1 | 11 | 2 |
| 22-2407 | NE17441_NE | 1 | 1 | 3 | 8 | 2 |
| 22-2408 | WB4727_WB | 3 | 2 | 2 | 8 | 0 |




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

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 3 | 1 | 3 | 7 | 1 |
| 22-2402 | SY Monument_CK | 2 | 0 | 5 | 7 | 1 |
| 22-2403 | 19Nord.124_ND | 5 | 4 | 1 | 5 | 0 |
| 22-2404 | SD15007.11_SD | 2 | 0 | 4 | 8 | 1 |
| 22-2405 | SD18B025.8_SD | 1 | 0 | 3 | 8 | 3 |
| 22-2406 | NE17443_NE | 2 | 0 | 1 | 8 | 4 |
| 22-2407 | NE17441_NE | 2 | 0 | 5 | 6 | 2 |
| 22-2408 | WB4727_WB | 4 | 2 | 2 | 4 | 3 |

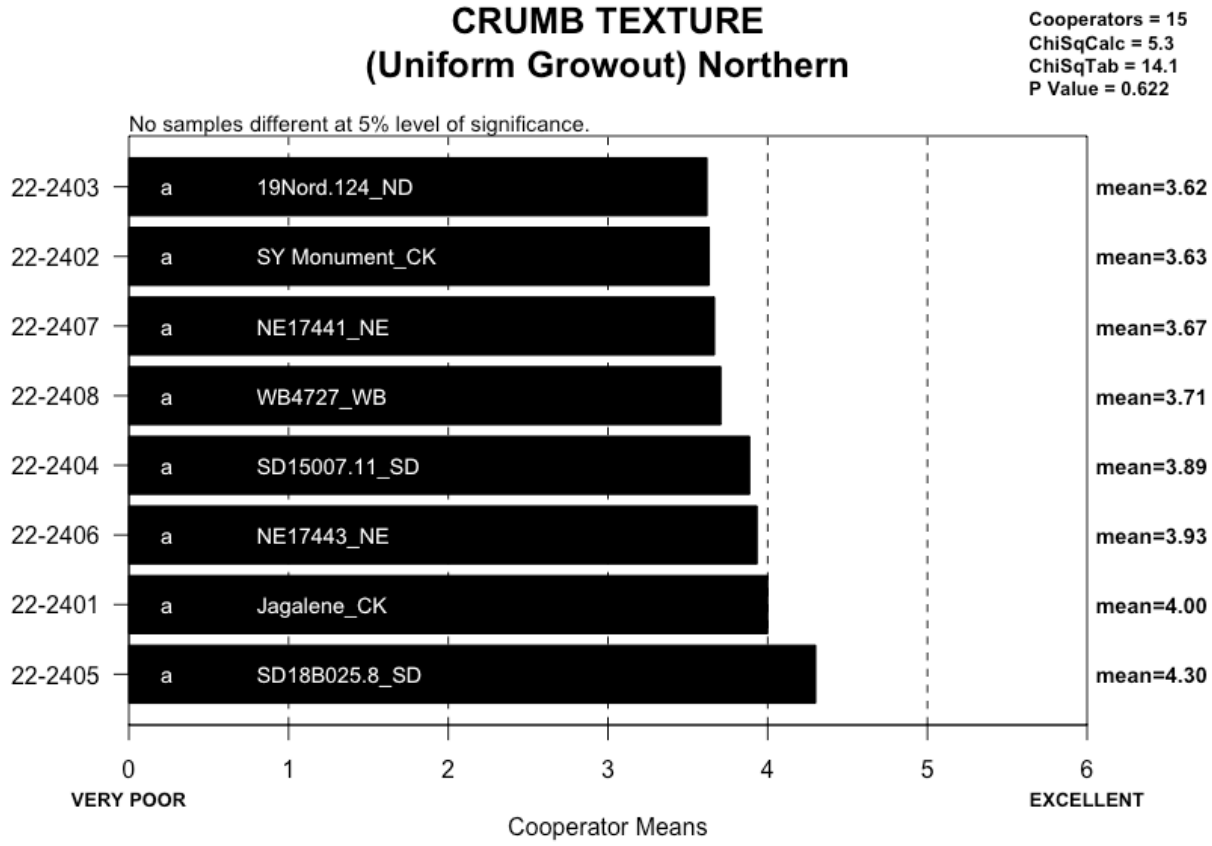



# CRUMB GRAIN, DESCRIBED
# (Uniform Growout) Northern

| IDCODE | ID | Open | Fine | Dense |
|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 9 | 4 | 2 |
| 22-2402 | SY Monument_CK | 5 | 5 | 5 |
| 22-2403 | 19Nord.124_ND | 7 | 5 | 3 |
| 22-2404 | SD15007.11_SD | 6 | 7 | 2 |
| 22-2405 | SD18B025.8_SD | 11 | 2 | 2 |
| 22-2406 | NE17443_NE | 6 | 7 | 2 |
| 22-2407 | NE17441_NE | 7 | 4 | 4 |
| 22-2408 | WB4727_WB | 6 | 3 | 6 |

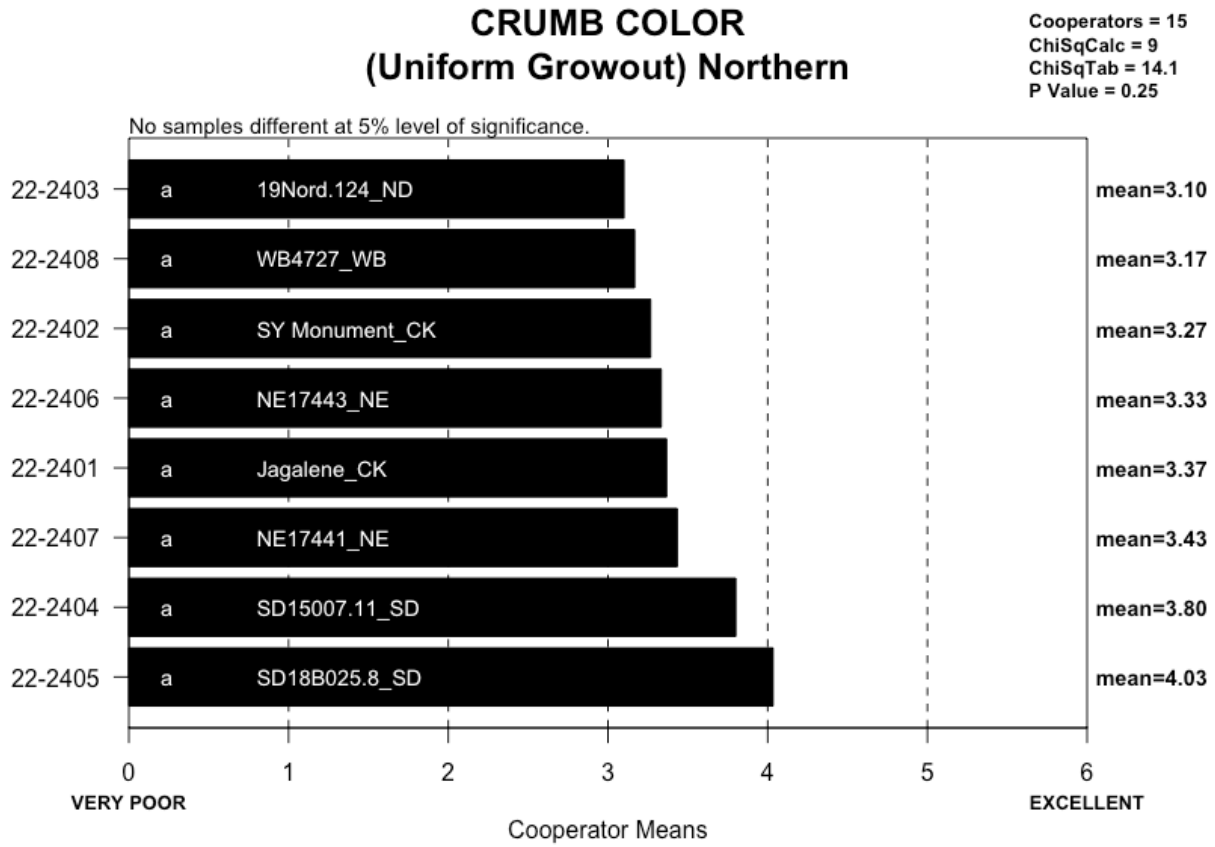
# CELL SHAPE, DESCRIBED
# (Uniform Growout) Northern

| IDCODE | ID | Round | Irregular | Elongated |
|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 8 | 6 | 1 |
| 22-2402 | SY Monument_CK | 8 | 4 | 3 |
| 22-2403 | 19Nord.124_ND | 7 | 4 | 4 |
| 22-2404 | SD15007.11_SD | 4 | 8 | 3 |
| 22-2405 | SD18B025.8_SD | 5 | 7 | 3 |
| 22-2406 | NE17443_NE | 6 | 7 | 2 |
| 22-2407 | NE17441_NE | 7 | 5 | 3 |
| 22-2408 | WB4727_WB | 9 | 4 | 2 |




# CRUMB TEXTURE, DESCRIBED
# (Uniform Growout) Northern

| IDCODE | ID | Harsh | Smooth | Silky |
|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 4 | 8 | 3 |
| 22-2402 | SY Monument_CK | 5 | 6 | 4 |
| 22-2403 | 19Nord.124_ND | 4 | 8 | 3 |
| 22-2404 | SD15007.11_SD | 4 | 8 | 3 |
| 22-2405 | SD18B025.8_SD | 2 | 9 | 4 |
| 22-2406 | NE17443_NE | 4 | 9 | 2 |
| 22-2407 | NE17441_NE | 7 | 5 | 3 |
| 22-2408 | WB4727_WB | 5 | 8 | 2 |




# CRUMB COLOR, DESCRIBED
# (Uniform Growout) Northern

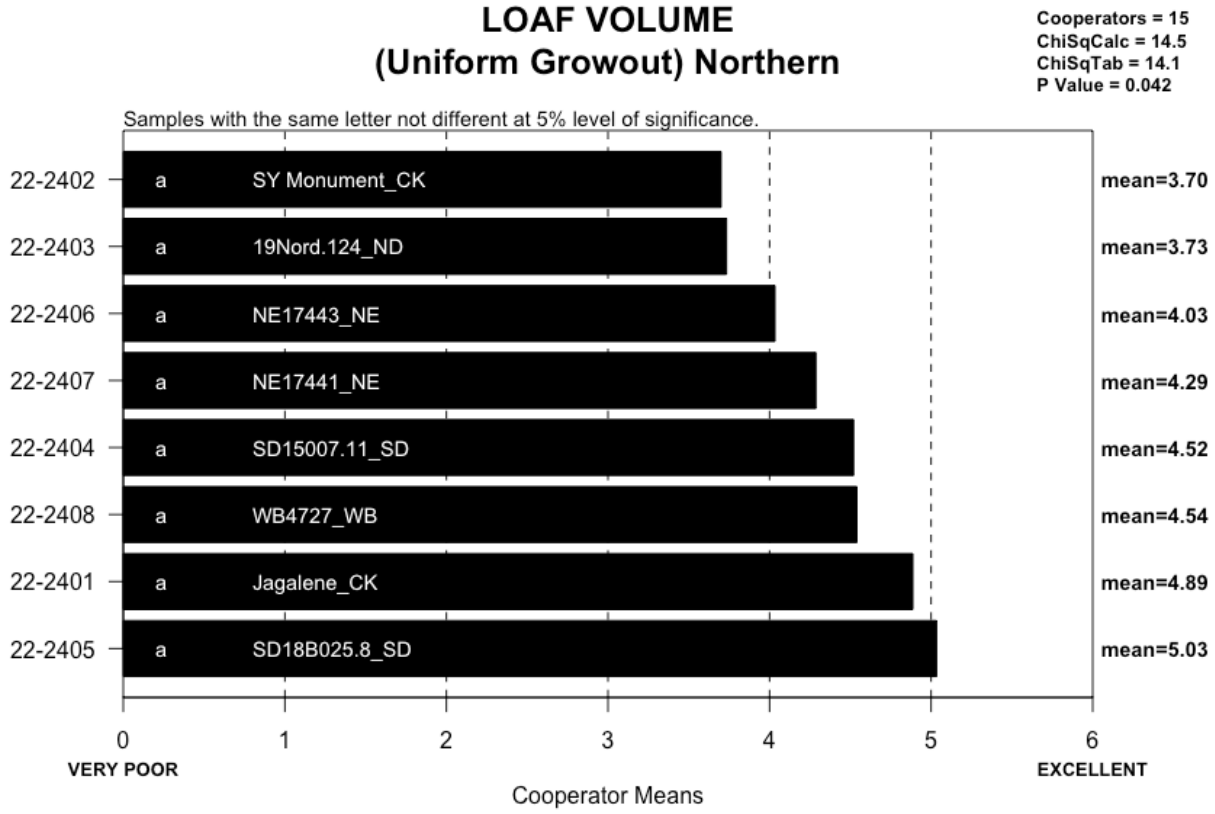
| IDCODE | ID | Gray | Dark_Yellow | Yellow | Dull | Creamy | White | Bright_White |
|---|---|---|---|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 0 | 1 | 1 | 4 | 6 | 3 | 0 |
| 22-2402 | SY Monument_CK | 0 | 0 | 3 | 5 | 5 | 2 | 0 |
| 22-2403 | 19Nord.124_ND | 0 | 1 | 4 | 4 | 5 | 1 | 0 |
| 22-2404 | SD15007.11_SD | 0 | 0 | 3 | 2 | 6 | 4 | 0 |
| 22-2405 | SD18B025.8_SD | 0 | 0 | 2 | 2 | 5 | 6 | 0 |
| 22-2406 | NE17443_NE | 0 | 1 | 2 | 4 | 6 | 2 | 0 |
| 22-2407 | NE17441_NE | 0 | 0 | 2 | 4 | 8 | 1 | 0 |
| 22-2408 | WB4727_WB | 0 | 1 | 3 | 4 | 5 | 2 | 0 |

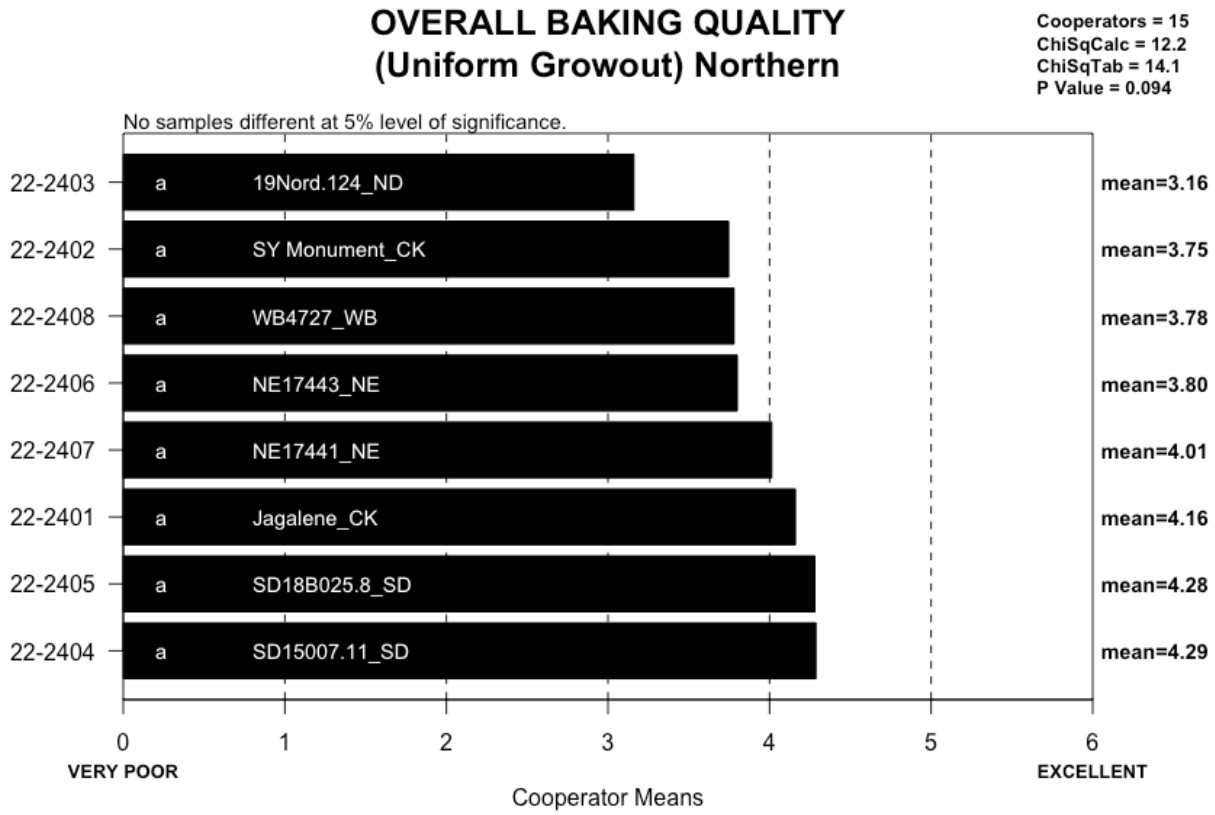
# LOAF WEIGHT, ACTUAL
# (Uniform Growout) Northern
# Cooperators A – O

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 418 | 149.6 | 142.5 | 138.3 | 145.5 | 141.6 | 452.0 | 482.3 | 148.7 | 442 | 451 | 131.4 | 143.8 | 421.6 | 475 |
| 22-2402 | SY Monument_CK | 418 | 152.3 | 138.9 | 138.9 | 143.4 | 145.2 | 457.0 | 484.8 | 149.1 | 443 | 459 | 138.9 | 143.7 | 426.6 | 476 |
| 22-2403 | 19Nord.124_ND | 420 | 149.7 | 142.9 | 138.7 | 141.7 | 141.9 | 444.5 | 483.2 | 149.0 | 432 | 454 | 135.4 | 141.6 | 425.3 | 466 |
| 22-2404 | SD15007.11_SD | 415 | 151.7 | 140.7 | 137.2 | 144.0 | 146.5 | 444.0 | 481.0 | 151.0 | 440 | 456 | 133.5 | 141.2 | 428.4 | 168 |
| 22-2405 | SD18B025.8_SD | 412 | 148.9 | 140.1 | 137.7 | 143.8 | 145.4 | 455.5 | 482.8 | 151.6 | 441 | 454 | 142.7 | 142.7 | 428.4 | 167 |
| 22-2406 | NE17443_NE | 419 | 150.4 | 140.0 | 138.2 | 145.2 | 144.2 | 446.0 | 484.2 | 151.2 | 439 | 455 | 137.6 | 142.8 | 429.6 | 472 |
| 22-2407 | NE17441_NE | 420 | 150.3 | 140.4 | 139.4 | 143.8 | 143.7 | 446.0 | 478.5 | 152.8 | 438 | 455 | 134.6 | 142.5 | 426.5 | 471 |
| 22-2408 | WB4727_WB | 420 | 152.2 | 144.0 | 138.2 | 146.6 | 143.0 | 484.5 | 481.0 | 152.4 | 429 | 458 | 134.5 | 145.1 | 428.2 | 468 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2401 | Jagalene_CK | 2950 | 981 | 885 | 956 | 1150 | 767 | 2164 | 2638 | 1020 | 2427 | 2805 | 855 | 785 | 2675 | 2897 |
| 22-2402 | SY Monument_CK | 2725 | 850 | 905 | 919 | 1025 | 712 | 1925 | 2225 | 915 | 2286 | 2711 | 680 | 720 | 2600 | 2751 |
| 22-2403 | 19Nord.124_ND | 2675 | 869 | 953 | 863 | 925 | 713 | 2006 | 2388 | 935 | 2327 | 2409 | 840 | 825 | 2550 | 2515 |
| 22-2404 | SD15007.11_SD | 2975 | 988 | 870 | 955 | 1070 | 771 | 2136 | 2463 | 920 | 2345 | 2502 | 600 | 805 | 2925 | 2956 |
| 22-2405 | SD18B025.8_SD | 3000 | 998 | 1050 | 966 | 1080 | 796 | 2043 | 2438 | 975 | 2404 | 2583 | 975 | 830 | 2875 | 2956 |
| 22-2406 | NE17443_NE | 2750 | 969 | 928 | 888 | 975 | 761 | 1977 | 2313 | 925 | 2428 | 2490 | 940 | 755 | 2450 | 2751 |
| 22-2407 | NE17441_NE | 2925 | 979 | 1038 | 903 | 990 | 761 | 2055 | 2438 | 925 | 2346 | 2389 | 965 | 755 | 2600 | 2751 |
| 22-2408 | WB4727_WB | 2925 | 959 | 963 | 918 | 880 | 772 | 2212 | 2450 | 975 | 2454 | 2484 | 910 | 900 | 2600 | 2809 |


LOAF VOLUME
(Uniform Growout) Northern
Cooperators = 15
ChiSqCalc = 14.5
ChiSqTab = 14.1
P Value = 0.042
Samples with the same letter not different at 5% level of significance.
22-2402 a SY Monument_CK mean=3.70
22-2403 a 19Nord.124_ND mean=3.73
22-2406 a NE17443_NE mean=4.03
22-2407 a NE17441_NE mean=4.29
22-2404 a SD15007.11_SD mean=4.52
22-2408 a WB4727_WB mean=4.54
22-2401 a Jagalene_CK mean=4.89
22-2405 a SD18B025.8_SD mean=5.03
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Uniform Growout) Northern
Cooperators = 15
ChiSqCalc = 12.2
ChiSqTab = 14.1
P Value = 0.094
No samples different at 5% level of significance.
22-2403 a 19Nord.124_ND mean=3.16
22-2402 a SY Monument_CK mean=3.75
22-2408 a WB4727_WB mean=3.78
22-2406 a NE17443_NE mean=3.80
22-2407 a NE17441_NE mean=4.01
22-2401 a Jagalene_CK mean=4.16
22-2405 a SD18B025.8_SD mean=4.28
22-2404 a SD15007.11_SD mean=4.29
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

# COOPERATOR'S COMMENTS
## (Small Scale) Northern

**COOP. 22-2401 Jagalene_CK**

A. Strong dough, long mix, good volume, slightly open grain.
B. No comment.
C. Very high water absorption, long mix time, sticky & weak dough, high loaf volume, dull crumb grain, open round cells, good resilient and slightly harsh texture.
D. No comment.
E. Excellent loaf externals.
F. Average dough characteristics, poor crumb characteristics.
G. No comment.
H. Low absorption, good mixing tolerance, fine grain, dark yellow crumb, excellent volume.
I. Long mix time, average absorption, good grain, excellent volume.
J. No comment.
K. No comment.
L. Poor color, not well suited for bread.
M. No comment.
N. Good protein and absorption. Fair dough feels and volume.
O. Average absorption and volume, good mix time and stability.

**COOP. 22-2402 SY Monument_CK**

A. Strong dough, long mix, good volume, slightly open grain.
B. No comment.
C. Mid high water abs, very long mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. Excellent loaf externals.
F. Lower than average protein, undesirable mix time, poor crumb characteristics.
G. Sponge felt some what crumbly and weak before and after fermentation, however dough did not reflect this.
H. Good mixing time and tolerance, dense grain, very low volume.
I. Long mix time, average absorption and grain, good mixing tolerance, good volume.
J. No comment.
K. No comment.
L. Small dense crumbed loaf
M. No comment.
N. Fair protein and volume, and absorption. Good dough feels. High mix tolerance.
O. Average absorption, excellent mix time and stability, lacking in volume.

# COOPERATOR'S COMMENTS
## (Small Scale) Northern

**COOP. 22-2403 19NORD-124_ND**

A. Lower protein, soft dough, and lower loaf volume.
B. No comment.
C. Mid high water absorption, medium mix time, slight sticky and weak dough, very high loaf volume, yellow crumb grain, open elongate cells, good resilient and smooth texture.
D. No comment.
E. No comment.
F. Lower than average protein, dough lacked strength at make-up, off crumb color.
G. No comment.
H. Low absorption, low mixing tolerance, wet dough character, open grain, dark yellow crumb, low volume.
I. Low absorption, low mixing tolerance, good volume.
J. No comment.
K. No comment.
L. No comment.
M. No comment.
N. Fair protein, absorption could be improved. Low mix tolerance and volume.
O. Lower absorption, stability, mix time, poor dough handling attributes, unacceptable volume.

**COOP. 22-2404 SD15007-11_SD**

A. Strong dough, long mix, good volume, slightly open grain.
B. No comment.
C. High water absorption, long mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. Slight cap
F. No comment.
G. Good balance of characteristics.
H. Average absorption, good mixing time and tolerance, good grain.
I. Long mix time, good mixing tolerance, average grain, good volume.
J. No comment.
K. No comment.
L. Very small loaf, dense crumb with harsh texture, not well suited for bread.
M. No comment.
N. Fair protein. Good absorption and dough feels. High mix tolerance and volume.
O. Good absorption, excellent mix time and stability, good dough handling and volume.

# COOPERATOR'S COMMENTS
## (Small Scale) Northern

**COOP. 22-2405 SD18B025-8_SD**

A. Good dough out of mixer and make up, average mix time, excellent loaf volume. More open grain.
B. No comment.
C. Very high-water absorption, medium mix time, slight sticky and strong dough, super high loaf volume, yellow crumb gain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. Nice loaf externals, slight cap.
F. High break-and-shred with severe capping.
G. Longest mix time.
H. Average absorption, slightly below average gran and volume.
I. Average absorption and grain, good mixing tolerance, excellent volume.
J. No comment.
K. No comment.
L. Very nice loaf with open, good crumb.
M. No comment.
N. Good protein, absorption, and dough feels. Fair mix tolerance, high volume.
O. Good absorption, excellent mix time and stability, good dough handling and volume.

**COOP. 22-2406 NE17443_NE**

A. Good dough out of mixer and make up, average mix time average loaf volume, more open grain.
B. No comment.
C. High water absorption, long mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. No comment.
F. Good bake absorption, average flour protein, good dough characteristics, high break-and-shred with severe capping.
G. No comment.
H. Low mix time and tolerance, dense grain, dark yellow crumb, low volume, surprisingly good dough character.
I. Average absorption, good dough character, good grain and volume.
J. No comment.
K. No comment.
L. Average crumb loaf.
M. No comment.
N. Good protein and absorption. Low tolerance and volume.
O. Good absorption, mix time and stability, and dough handling, lacking in volume.

# COOPERATOR'S COMMENTS
## (Small Scale) Northern

**COOP. 22-2407 NE17441_NE**

A. Good dough out of mixer and make up, good mix time, good loaf volume.
B. No comment.
C. High water absorption, long mix time, slight sticky and strong dough, super high loaf volume, creamy crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. No comment.
F. Average dough characteristics, stiff crumb.
G. No comment.
H. Good mixing time and tolerance, slightly below average for most other characteristics.
I. Long mix time, average absorption and grain, good volume.
J. No comment.
K. No comment.
L. Nice loaf symmetry, crumb was dense and harsh texture.
M. No comment.
N. Good protein and absorption. Fair mix tolerance and volume.
O. Good absorption, excellent mix time and stability, and dough handling, lacking in volume.

**COOP. 22-2408 WB4727_WB**

A. Shorter mix, slightly soft dough out of mixer but recovered at make up, slightly open grain, good volume.
B. No comment.
C. High water absorption, medium mix time, slightly sticky and weak dough, high loaf volume, dull crumb grain, open round cells, good resilient and slightly harsh texture.
D. No comment.
E. No comment.
F. High, rough break-and-shred.
G. High cell count but irregular.
H. Low absorption, low mixing time and tolerance, open grain, dark yellow crumb.
I. Average absorption, low mixing tolerance, open grain, excellent volume.
J. No comment.
K. No comment.
L. No comment.
M. No comment.
N. Good protein. Fair mix tolerance, volume, and dough feels. Absorption could be improved.
O. Average absorption, low mix time and stability, weak off mix (seemed over absorbed), average volume.

Notes: **A, G, H, J, N and O** conducted sponge and dough bake tests

# MICRO-QUALITY ANALYSIS

| Entry_Code | Entry_ID | Entry_No | Breeding Program | Location* |
|---|---|---|---|---|
| 22-SD2401 | Jagalene | 2401 | Check | SD |
| 22-SD2402 | SY Mounment | 2402 | Check | SD |
| 22-SD2403 | 19Nord-124 | 2403 | NDSU | SD |
| 22-SD2404 | SD15007-11 | 2404 | SDSU | SD |
| 22-SD2405 | SD18B025-8 | 2405 | SDSU | SD |
| 22-SD2406 | NE17443 | 2406 | UNL | SD |
| 22-SD2407 | NE17441 | 2407 | UNL | SD |
| 22-SD2408 | WB4727 | 2408 | WestBred | SD |
| 22-NE2401 | Jagalene | 2401 | Check | NE |
| 22-NE2402 | SY Mounment | 2402 | Check | NE |
| 22-NE2403 | 19Nord-124 | 2403 | NDSU | NE |
| 22-NE2404 | SD15007-11 | 2404 | SDSU | NE |
| 22-NE2405 | SD18B025-8 | 2405 | SDSU | NE |
| 22-NE2406 | NE17443 | 2406 | UNL | NE |
| 22-NE2407 | NE17441 | 2407 | UNL | NE |
| 22-NE2408 | WB4727 | 2408 | WestBred | NE |
| 22-ND2401 | Jagalene | 2401 | Check | ND |
| 22-ND2402 | SY Mounment | 2402 | Check | ND |
| 22-ND2403 | 19Nord-124 | 2403 | NDSU | ND |
| 22-ND2404 | SD15007-11 | 2404 | SDSU | ND |
| 22-ND2405 | SD18B025-8 | 2405 | SDSU | ND |
| 22-ND2406 | NE17443 | 2406 | UNL | ND |
| 22-ND2407 | NE17441 | 2407 | UNL | ND |
| 22-ND2408 | WB4727 | 2408 | WestBred | ND |
| 22-AP2401 | Jagalene | 2401 | Check | AP |
| 22-AP2402 | SY Mounment | 2402 | Check | AP |
| 22-AP2403 | 19Nord-124 | 2403 | NDSU | AP |
| 22-AP2404 | SD15007-11 | 2404 | SDSU | AP |
| 22-AP2405 | SD18B025-8 | 2405 | SDSU | AP |
| 22-AP2406 | NE17443 | 2406 | UNL | AP |
| 22-AP2407 | NE17441 | 2407 | UNL | AP |
| 22-AP2408 | WB4727 | 2408 | WestBred | AP |
| | | | | |
| *SD=South Dakota State Univeristy; NE=University of Nebraska-Lincoln; | | | | |
| ND=North Dakota State University; AP=Agripro. | | | | |

## 1. LOCATIONS AND ENTRIES

A. There are 4 locations:

Nebraska = NE;

North Dakota = ND;

South Dakota = SD.

Agripro = AP

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

Jagalene (Check) = 2401

SY Mounment = 2402

19NORD-124 = 2403

SD15007-11 = 2404

SD18B025-8 = 2405

NE17443 = 2406

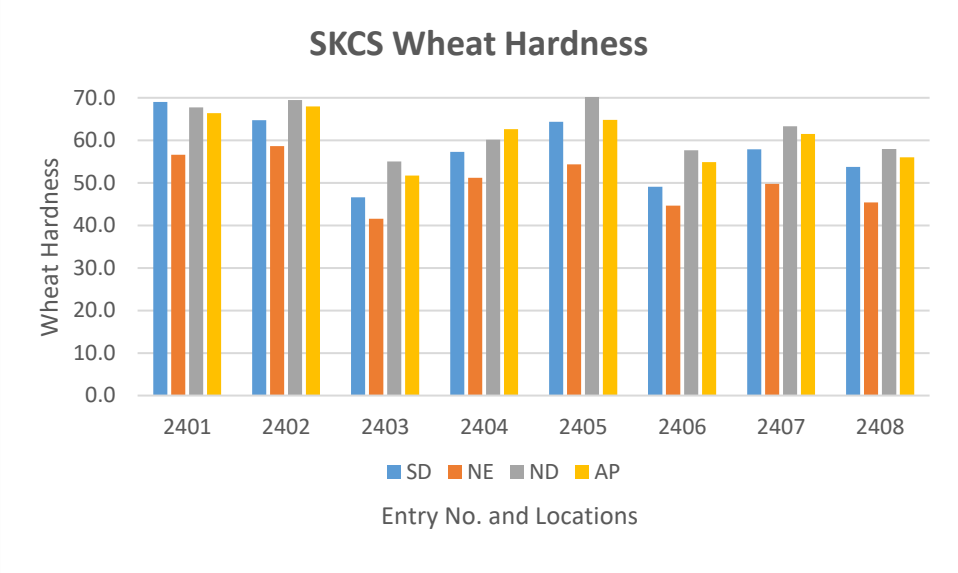
NE17441 = 2407

WB4727 = 2408

## 2. SKCS SINGLE KERNEL INFORMATION

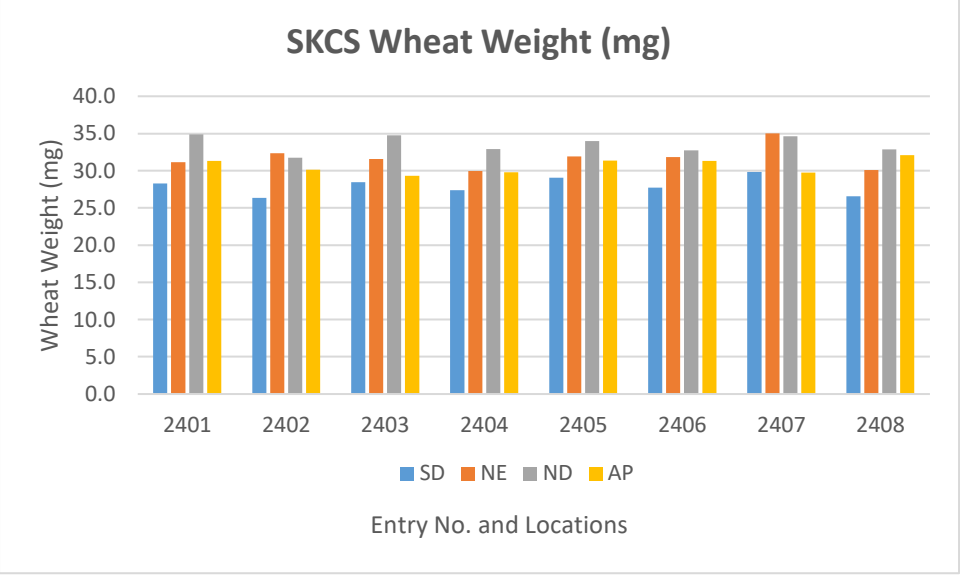
A. Kernel Hardness

| SKCS Wheat Kernel Hardness | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 69.1 | 56.6 | 67.7 | 66.4 | 65.0 | 5.67 |
| 2402 | 64.8 | 58.6 | 69.5 | 68.0 | 65.2 | 4.82 |
| 2403 | 46.7 | 41.6 | 55.1 | 51.8 | 48.8 | 5.91 |
| 2404 | 57.3 | 51.3 | 60.2 | 62.7 | 57.8 | 4.90 |
| 2405 | 64.4 | 54.4 | 70.3 | 64.9 | 63.5 | 6.63 |
| 2406 | 49.2 | 44.7 | 57.7 | 54.9 | 51.6 | 5.84 |
| 2407 | 57.9 | 49.8 | 63.3 | 61.5 | 58.1 | 5.99 |
| 2408 | 53.7 | 45.4 | 58.0 | 56.1 | 53.3 | 5.55 |
| Avg. | 57.9 | 50.3 | 62.7 | 60.8 | | |
| Std | 7.89 | 6.08 | 5.87 | 5.89 | | |



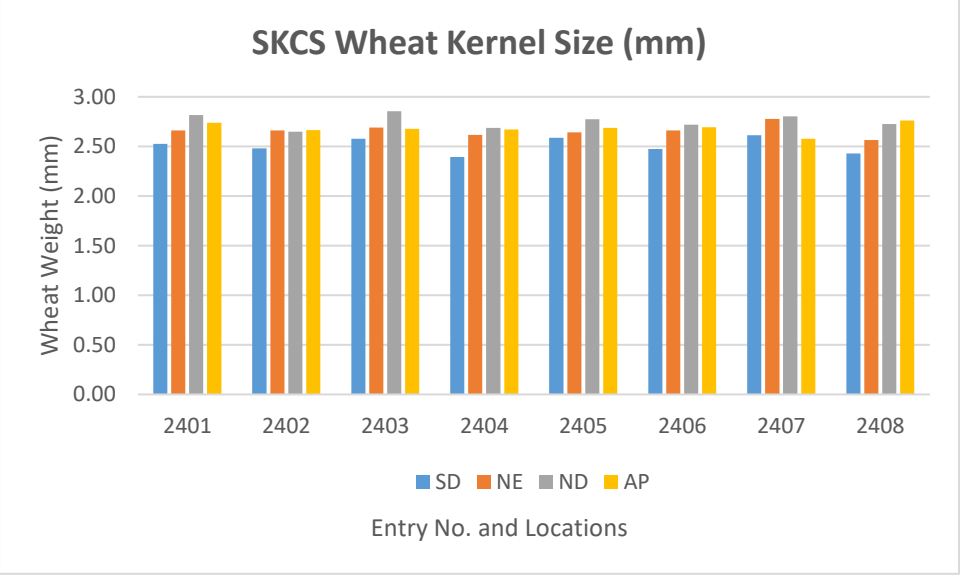
B. Kernel Weight (mg)

| SKCS Wheat Kernel Weight (mg) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 28.3 | 31.1 | 34.9 | 31.3 | 31.4 | 2.71 |
| 2402 | 26.4 | 32.4 | 31.8 | 30.1 | 30.2 | 2.71 |
| 2403 | 28.4 | 31.6 | 34.8 | 29.3 | 31.0 | 2.82 |
| 2404 | 27.4 | 29.9 | 32.9 | 29.8 | 30.0 | 2.28 |
| 2405 | 29.1 | 32.0 | 34.0 | 31.4 | 31.6 | 2.04 |
| 2406 | 27.7 | 31.9 | 32.7 | 31.3 | 30.9 | 2.20 |
| 2407 | 29.8 | 35.0 | 34.6 | 29.7 | 32.3 | 2.91 |
| 2408 | 26.6 | 30.1 | 32.9 | 32.1 | 30.4 | 2.83 |
| Avg. | 28.0 | 31.7 | 33.6 | 30.6 | | |
| Std | 1.20 | 1.59 | 1.16 | 1.01 | | |



C. Kernel Size

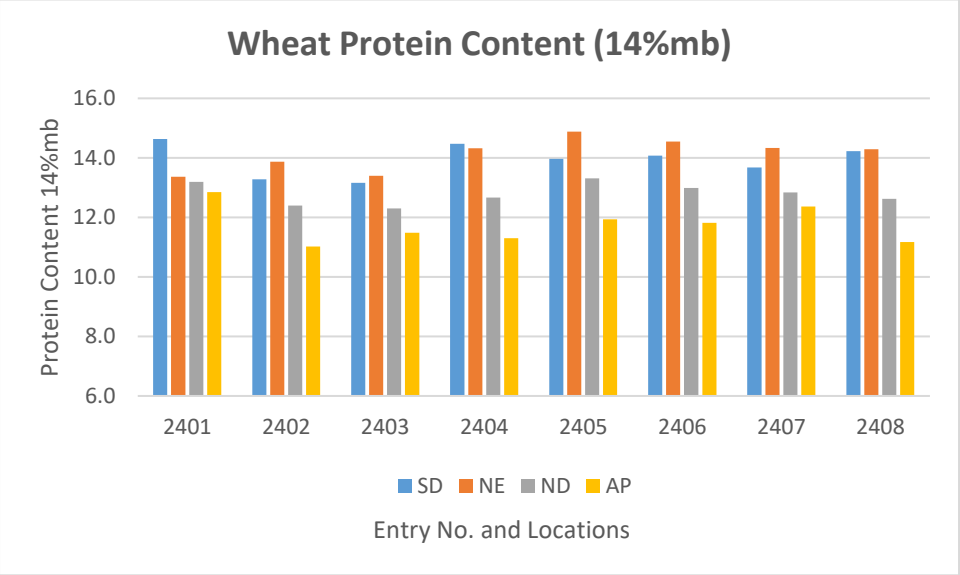
| SKCS Wheat Kernel Size (mm) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 2.53 | 2.66 | 2.82 | 2.74 | 2.69 | 0.12 |
| 2402 | 2.48 | 2.66 | 2.65 | 2.66 | 2.61 | 0.09 |
| 2403 | 2.58 | 2.69 | 2.85 | 2.68 | 2.70 | 0.11 |
| 2404 | 2.39 | 2.61 | 2.69 | 2.67 | 2.59 | 0.14 |
| 2405 | 2.59 | 2.64 | 2.77 | 2.69 | 2.67 | 0.08 |
| 2406 | 2.47 | 2.66 | 2.72 | 2.69 | 2.64 | 0.11 |
| 2407 | 2.61 | 2.78 | 2.80 | 2.58 | 2.69 | 0.11 |
| 2408 | 2.43 | 2.56 | 2.73 | 2.76 | 2.62 | 0.15 |
| Avg. | 2.51 | 2.66 | 2.75 | 2.68 | | |
| Std | 0.08 | 0.06 | 0.07 | 0.05 | | |



## 3. PROTEN CONTENT

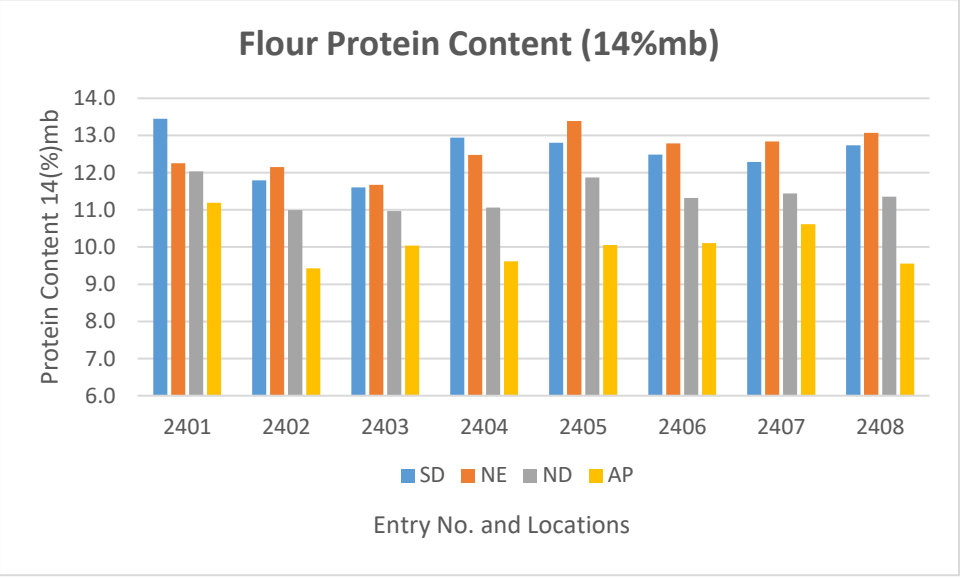
A. Wheat Protein

| Wheat Protein Content (14%mb) | | | | | | |
|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 14.6 | 13.4 | 13.2 | 12.9 | 13.5 | 0.78 |
| 2402 | 13.3 | 13.9 | 12.4 | 11.0 | 12.6 | 1.24 |
| 2403 | 13.2 | 13.4 | 12.3 | 11.5 | 12.6 | 0.87 |
| 2404 | 14.5 | 14.3 | 12.7 | 11.3 | 13.2 | 1.50 |
| 2405 | 14.0 | 14.9 | 13.3 | 11.9 | 13.5 | 1.24 |
| 2406 | 14.1 | 14.5 | 13.0 | 11.8 | 13.4 | 1.21 |
| 2407 | 13.7 | 14.3 | 12.8 | 12.4 | 13.3 | 0.87 |
| 2408 | 14.2 | 14.3 | 12.6 | 11.2 | 13.1 | 1.48 |
| Avg. | 13.9 | 14.1 | 12.8 | 11.7 | | |
| Std | 0.5 | 0.5 | 0.4 | 0.6 | | |



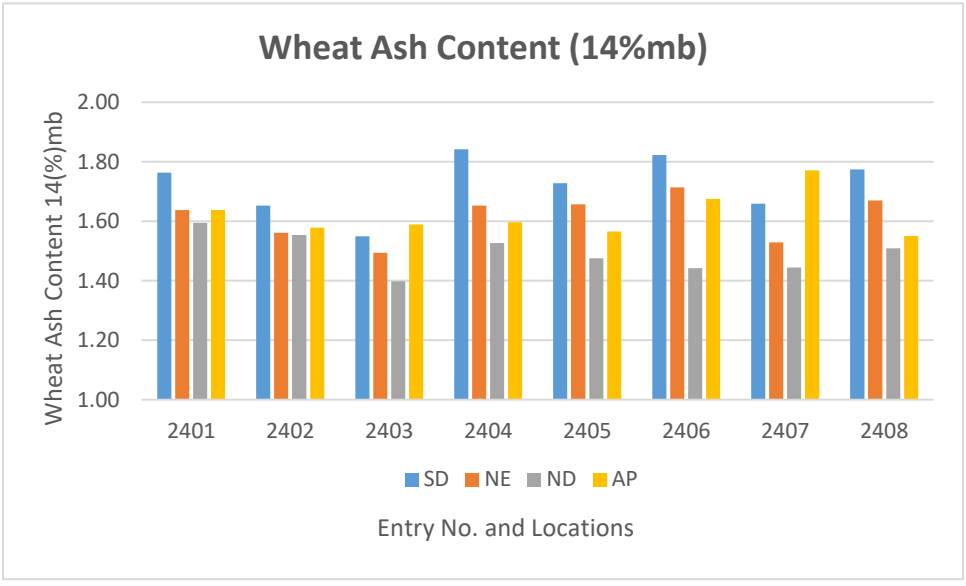
B. Flour Protein

| Flour Protein Content (14%) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 13.4 | 12.3 | 12.0 | 11.2 | 12.2 | 0.93 |
| 2402 | 11.8 | 12.2 | 11.0 | 9.4 | 11.1 | 1.21 |
| 2403 | 11.6 | 11.7 | 11.0 | 10.0 | 11.1 | 0.76 |
| 2404 | 12.9 | 12.5 | 11.1 | 9.6 | 11.5 | 1.51 |
| 2405 | 12.8 | 13.4 | 11.9 | 10.1 | 12.0 | 1.46 |
| 2406 | 12.5 | 12.8 | 11.3 | 10.1 | 11.7 | 1.23 |
| 2407 | 12.3 | 12.8 | 11.4 | 10.6 | 11.8 | 0.97 |
| 2408 | 12.7 | 13.1 | 11.3 | 9.6 | 11.7 | 1.60 |
| Avg. | 12.5 | 12.6 | 11.4 | 10.1 | | |
| Std | 0.61 | 0.55 | 0.40 | 0.59 | | |



## 4. Wheat Ash

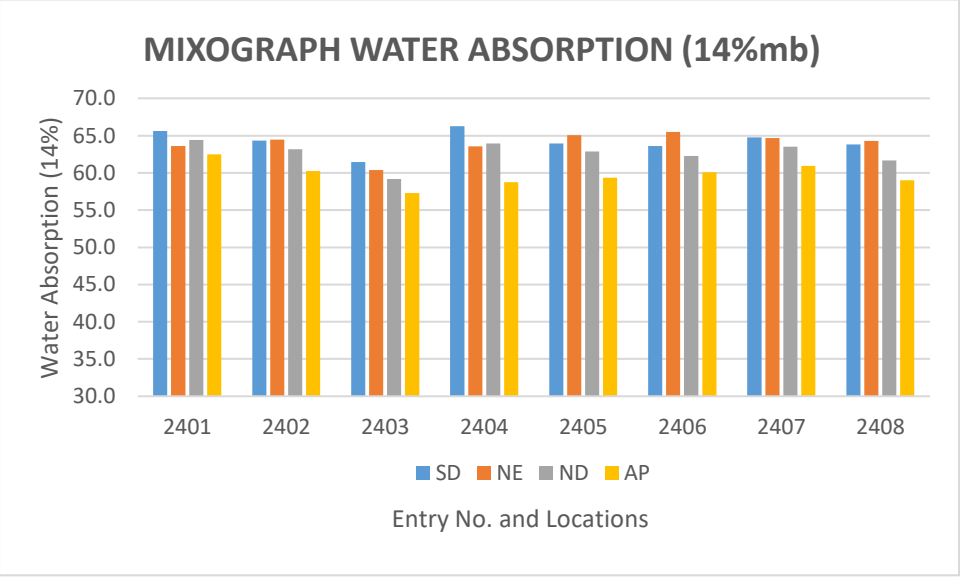
| Wheat Ash Content (14%) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 1.76 | 1.64 | 1.60 | 1.64 | 1.66 | 0.07 |
| 2402 | 1.65 | 1.56 | 1.55 | 1.58 | 1.59 | 0.05 |
| 2403 | 1.55 | 1.49 | 1.40 | 1.59 | 1.51 | 0.08 |
| 2404 | 1.84 | 1.65 | 1.53 | 1.60 | 1.65 | 0.13 |
| 2405 | 1.73 | 1.66 | 1.48 | 1.57 | 1.61 | 0.11 |
| 2406 | 1.82 | 1.71 | 1.44 | 1.68 | 1.66 | 0.16 |
| 2407 | 1.66 | 1.53 | 1.44 | 1.77 | 1.60 | 0.14 |
| 2408 | 1.77 | 1.67 | 1.51 | 1.55 | 1.63 | 0.12 |
| Avg. | 1.72 | 1.61 | 1.49 | 1.62 | | |
| Std | 0.10 | 0.08 | 0.07 | 0.07 | | |



## 5. MIXOGRAPH TEST RESULTS

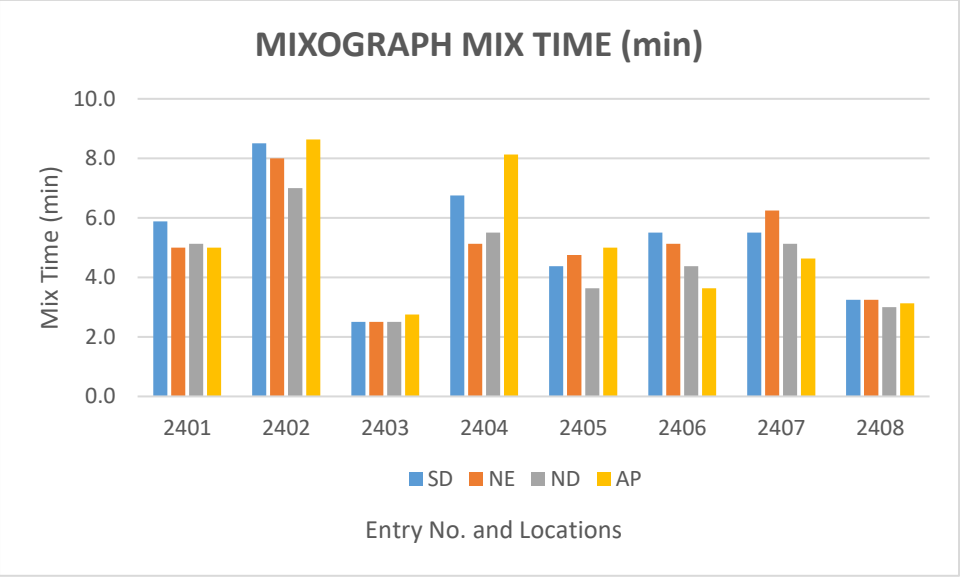
A. Mixograph Water Absorption

| Mixograph Water Absorption (14%mb) | | | | | | |
|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 65.6 | 63.6 | 64.4 | 62.5 | 64.0 | 1.33 |
| 2402 | 64.4 | 64.5 | 63.2 | 60.3 | 63.1 | 1.95 |
| 2403 | 61.5 | 60.4 | 59.2 | 57.3 | 59.6 | 1.79 |
| 2404 | 66.3 | 63.6 | 64.0 | 58.7 | 63.1 | 3.17 |
| 2405 | 63.9 | 65.1 | 62.9 | 59.4 | 62.8 | 2.47 |
| 2406 | 63.6 | 65.5 | 62.3 | 60.1 | 62.9 | 2.28 |
| 2407 | 64.8 | 64.7 | 63.5 | 61.0 | 63.5 | 1.78 |
| 2408 | 63.8 | 64.3 | 61.7 | 59.0 | 62.2 | 2.41 |
| Avg. | 64.2 | 64.0 | 62.6 | 59.8 | | |
| Std | 1.46 | 1.59 | 1.66 | 1.57 | | |



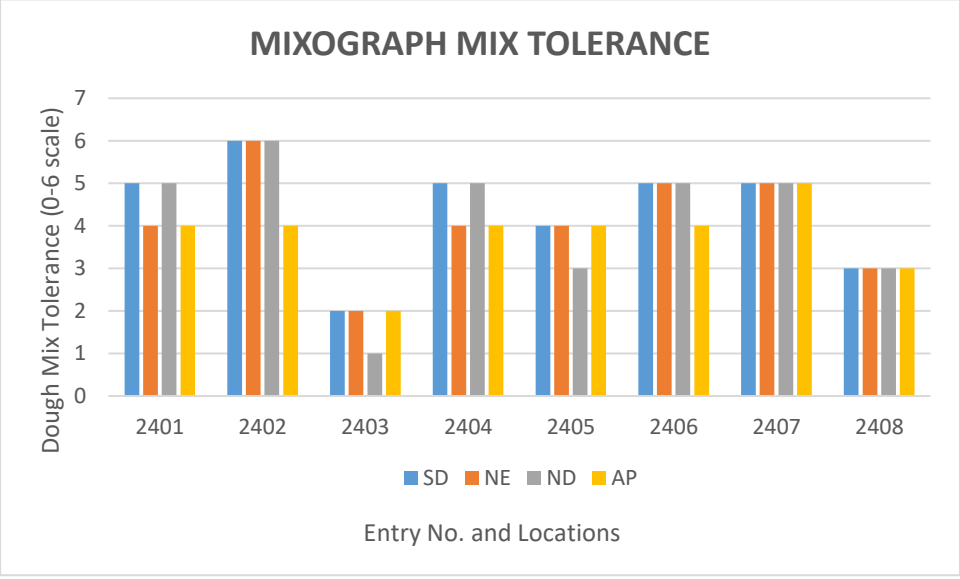
B. Mixograph Mix Time

| Mixograph Mix Time (min) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 5.9 | 5.0 | 5.1 | 5.0 | 5.3 | 0.42 |
| 2402 | 8.5 | 8.0 | 7.0 | 8.6 | 8.0 | 0.74 |
| 2403 | 2.5 | 2.5 | 2.5 | 2.8 | 2.6 | 0.13 |
| 2404 | 6.8 | 5.1 | 5.5 | 8.1 | 6.4 | 1.36 |
| 2405 | 4.4 | 4.8 | 3.6 | 5.0 | 4.4 | 0.60 |
| 2406 | 5.5 | 5.1 | 4.4 | 3.6 | 4.7 | 0.83 |
| 2407 | 5.5 | 6.3 | 5.1 | 4.6 | 5.4 | 0.68 |
| 2408 | 3.3 | 3.3 | 3.0 | 3.1 | 3.2 | 0.12 |
| Avg. | 5.3 | 5.0 | 4.5 | 5.1 | | |
| Std | 1.91 | 1.69 | 1.47 | 2.19 | | |



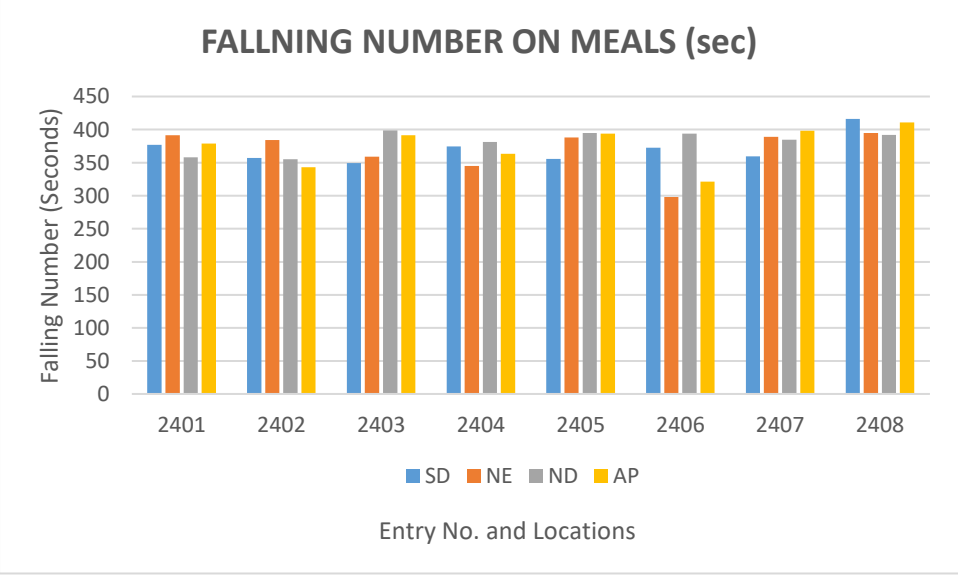
C. Mixograph Mix Tolerance

| Mixograph Mix Tolerance | | | | | | |
|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 5 | 4 | 5 | 4 | 4.5 | 0.58 |
| 2402 | 6 | 6 | 6 | 4 | 5.5 | 1.00 |
| 2403 | 2 | 2 | 1 | 2 | 1.8 | 0.50 |
| 2404 | 5 | 4 | 5 | 4 | 4.5 | 0.58 |
| 2405 | 4 | 4 | 3 | 4 | 3.8 | 0.50 |
| 2406 | 5 | 5 | 5 | 4 | 4.8 | 0.50 |
| 2407 | 5 | 5 | 5 | 5 | 5.0 | 0.00 |
| 2408 | 3 | 3 | 3 | 3 | 3.0 | 0.00 |
| Avg. | 4.4 | 4.1 | 4.1 | 3.8 | | |
| Std | 1.30 | 1.25 | 1.64 | 0.89 | | |



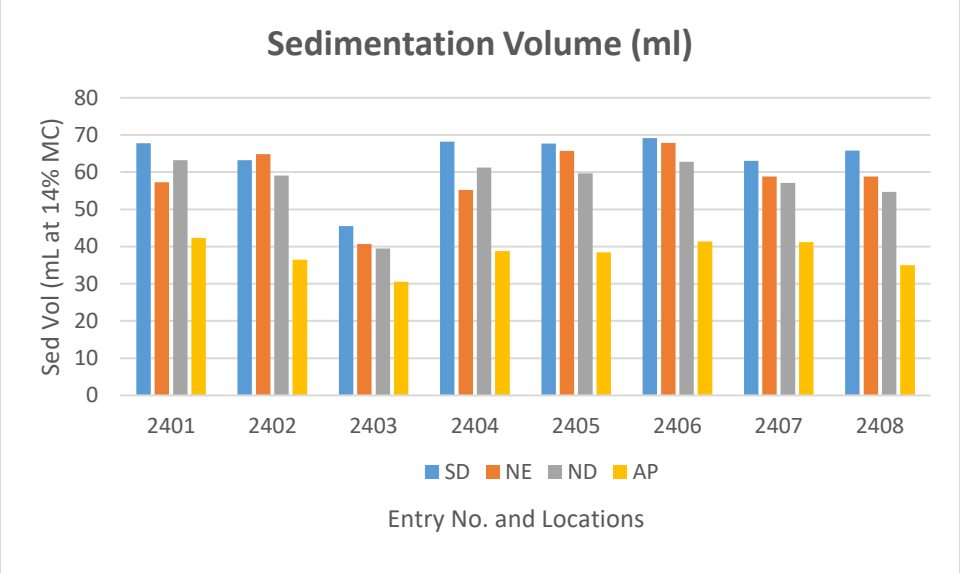
## 6. FALLING NUMBER TEST

| Falling Number on Meals (sec) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 377 | 392 | 358 | 379 | 376 | 14 |
| 2402 | 357 | 384 | 355 | 343 | 360 | 17 |
| 2403 | 350 | 359 | 399 | 392 | 375 | 24 |
| 2404 | 375 | 345 | 382 | 364 | 366 | 16 |
| 2405 | 356 | 388 | 395 | 394 | 383 | 19 |
| 2406 | 373 | 298 | 394 | 322 | 347 | 44 |
| 2407 | 360 | 389 | 385 | 398 | 383 | 16 |
| 2408 | 416 | 395 | 392 | 411 | 404 | 12 |
| Avg. | 370 | 369 | 382 | 375 | | |
| Std | 21 | 34 | 17 | 30 | | |



## 7. SEDIMENTATION TEST

| Sedimentation Volume (ml) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | LOCATIONS | | | | | |
| Entry No. | SD | NE | ND | AP | Avg | Std |
| 2401 | 67.8 | 57.3 | 63.2 | 42.3 | 57.6 | 11.08 |
| 2402 | 63.2 | 64.9 | 59.0 | 36.4 | 55.9 | 13.19 |
| 2403 | 45.5 | 40.7 | 39.5 | 30.6 | 39.1 | 6.22 |
| 2404 | 68.2 | 55.2 | 61.2 | 38.8 | 55.9 | 12.54 |
| 2405 | 67.6 | 65.7 | 59.6 | 38.4 | 57.9 | 13.39 |
| 2406 | 69.2 | 67.8 | 62.8 | 41.3 | 60.3 | 12.93 |
| 2407 | 63.0 | 58.8 | 57.1 | 41.2 | 55.0 | 9.54 |
| 2408 | 65.8 | 58.9 | 54.7 | 35.0 | 53.6 | 13.23 |
| Avg. | 63.8 | 58.7 | 57.2 | 38.0 | | |
| Std | 7.74 | 8.52 | 7.69 | 3.93 | | |



# SOUTHERN GROWOUT

| | |
|---|---|
| 22-2409 | SY Monument_CK |
| 22-2410 | Jagalene_CK |
| 22-2411 | LCH18-9027_LM |
| 22-2412 | TX16M9216_TC |
| 22-2413 | BASF7_BF |
| 22-2414 | BASF12_BF |
| 22-2415 | WB4523_WB |
| 22-2416 | WB0433004_WB |
| 22-2417 | OK18510_OK |
| 22-2418 | OK16107125C-17HR-2_OK |
| 22-2419 | OKP17D101A666_OK |
| 22-2420 | KS18H111-3_KH |
| 22-2421 | CO16SF027_CO |
| 22-2422 | CO18D297R_CO |
| 22-2423 | KS13DH0041-35_KM |

**CK=Check; LM=Limagrain; TC=Texas A&M College Station; BF=BASF; WB=Westbred (Bayer); OK=Oklahoma; KH=KSU Hays; CO=Colorado; TB=Texas A&M Bushland; KM=KSU Manhattan.**

# Description of Test Plots and Breeder Entries

## Southern Growout (LM, TC, BF, WB, OK, KH, CO, and KM)

## LIMAGRAIN by Marla Barnett

### Growing Location & Conditions

The 2022 hard winter Wheat Quality Council samples from Limagrain Cereal Seeds originated from strip increases grown in Wichita, KS located in south central Kansas. The WQC strips were planted on October 28th, 2022 into good soil moisture with good fall stands and decent growth. The field received 120 lbs 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 43.0 bushels/acre with an average grain protein content of 12.8% (Table 1). Drought was the most persistent stress factor. Temperatures ranged from 2°F on February 4th, 2022 to 104°F on June 15th, 2022 during the growing season at the location. The field received 14.01 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 Wichita, KS 2022, Limagrain Cereal Seeds.

| | Grain Yield (bu/ac) | Test Weight (lbs/bu) | Grain Protein (%) |
|---|---|---|---|
| **SYMonument** | 44.27 | 62.1 | 12.1 |
| **Jagalene** | 34.59 | 62.4 | 12.7 |
| **LCH18-9027** | 54.08 | 62.9 | 13.1 |
| **TX16M9216** | 37.69 | 61.2 | 13.2 |
| **TX14A001249** | 37.30 | 62.4 | 13.7 |
| **BASF 7** | 42.65 | 61.5 | 13.4 |
| **BASF 12** | 50.08 | 63.2 | 12.8 |
| **WB4523** | 42.85 | 59.8 | 12.6 |
| **WB4401** | 42.66 | 60.2 | 11.9 |
| **OK18510** | 41.04 | 62.0 | 12.4 |
| **OK16107125C-17HR-2** | 51.69 | 62.2 | 13.8 |
| **OKP17D101A666** | 38.91 | 60.8 | 13.1 |
| **KS18H111-3** | 39.17 | 60.9 | 12.2 |
| **CO16SF027** | 33.75 | 61.5 | 13.2 |
| **CO18D297R** | 45.81 | 61.6 | 11.9 |
| **KS13DH0041-35** | 51.30 | 61.1 | 12.7 |
| **Mean** | 43.0 | 61.61 | 12.8 |

### LCH18-9027

LCH18-9027 is a medium maturing hard-white winter wheat with an excellent disease package and huge kernels. The pedigree of LCH18-9027 is LCI13-069 / KS090120*C-25. Tolerance to Fusarium head blight 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. 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 acceptable milling quality and desirable dough properties and baking quality. Thousand kernel weight of LCH18-9027 typically exceeds 40 grams with a kernel diameter averaging 2.8 mm. Protein content and strength are noted as exceptional with very good absorption. LCH18-9027 was released as LCS White Lightning in August 2022 to replace LCS Yeti acres with improved yield.

## OKLAHOMA by Brett Carver

The North Central Agronomy Research Station at Lahoma (12 miles west of Enid) provided the Oklahoma site for the southern uniform WQC growout. The WQC growout has occurred at this same location, and in the same pair of alternating fields, for more than 20 years. Grain yield in 2022, though limited by season-long drought stress at Lahoma, averaged 79 bu/ac in the growout. Test weight averaged 60.0 lb/bu. Wheat protein concentration in an adjacent breeder seed increase nursery was well above the historical mean of 12% for this site and averaged 14.2%. Harvest occurred on time (June 12, 2022), and mean falling number in the adjacent seed increase was 406 sec. No shortcomings are expected beyond genetics in the outcome of this uniform growout.

**OK18510 (22-2417)**

OK18510 originated from the three-way cross, *TCI982345/Ruby Lee//OK10415*. Tracing back three breeding cycles leads to the common ancestor on both sides of the pedigree, 2180, which originated in the Pioneer Hi-Bred HRW wheat breeding program and was released by Kansas State University in 1987. This is the first progeny of Ruby Lee in the OSU breeding program, but OK18510 and Ruby Lee bear little resemblance in quality except for a softer endosperm.

In 2-yr, multi-site comparisons with Smith's Gold, OK18510 was 0.5 percentage units lower for wheat protein (11.6%), 14 units lower in SKCS hardness index (mid-50s), 1.5 g lower in TKW (34.5 g), and lower in NIRT-predicted flour ash (0.45). OK18510 resembles Smith's Gold in all mixograph parameters (moderately tolerant), though OK18510 may at times exhibit a steeper post-peak decline based on slightly higher stability index values. Baking quality is acceptable to more than acceptable for absorption, loaf volume, and crumb score. OK18510 does not scream for quality like Ruby Lee, but nowadays silence in the quality lab can be golden.

Multi-year yield performance puts OK18510 in high cotton. From 2018 to 2022, OK18510 has exceeded Gallagher by an average of 12 bu/ac, Bentley by 7 bu/ac, Smith's Gold by 6 bu/ac, and Showdown by 5 bu/ac. During the same period, test weight of OK18510 has equaled Smith's Gold and exceeded Gallagher and Showdown by 1 lb/bu. These differentials are reminiscent of the Duster era. Indeed, OK18510 was the highest-ranking experimental line in the OSU wheat breeding program over the past five years, with an average rank of 2.4 of about 40 entries.

OK18510 exhibits an intermediate growth habit, excellent vegetative persistence and grazing recovery, and delayed dormancy release with intermediate heading date – a recipe for success in a dual-purpose system. OK18510 can build a wall against common foliar diseases in Oklahoma, with the possible exception of powdery mildew.

OK18510 is in its second year of foundation seed production and purification, awaiting a release hearing in spring 2023.

**OK16107125C-17HR-2 (22-2418)**

Another 2-gene Clearfield candidate cut from the same cloth as Doublestop CL+ and Strad CL+, this one comes hemmed with BYD immunity. This Doublestop CL+ offspring, and half-sib to the non-Clearfield variety Uncharted, did not perform any better than Doublestop CL+ in the drought year of 2022. Otherwise, it is a step up in yield potential. OK16107125C-17HR-2 prefers a wetter environment and can withstand the common foliar diseases that come with it. OK16107125C-17HR-2 has even shown resistance to various leaf spotting diseases in Oklahoma, including spot blotch. OK16107125C-17HR-2 lies between Strad CL+ and Doublestop CL+ in milling and baking quality (good to outstanding), except with lower protein amounting to about one percentage unit. Now in its second year of foundation seed production, a decision to release will be delayed until after the 2023 harvest to allow one final comparison with another Doublestop CL+ offspring named OK198417C. OK16107125C-17HR-2 drew the straw for entry into the 2022 WQC.

**OKP17D101A666 (22-2419)**

More of a daredevil than just straight devil, OKP17D101A666 does an outright sprint to the finish line at harvest. Its maturity pattern seems better fit as a short-season variety, that is, planted much later than most HRW varieties, around mid to late November in Oklahoma. OSU is currently testing it that way, along with Butler's Gold. OKP17D101A666 offers a bastion of resistance to multiple disease devils, including wheat soilborne mosaic/spindle streak mosaic complex, leaf rust, stripe rust, powdery mildew, tan spot, and spot blotch. It also provides Hessian fly resistance. Milling and baking quality run average to above average, though its protein concentration is nothing unordinary. Curious is the wheat breeder regarding water absorption of OKP17D101A666 in the current WQC evaluation.

OKP17D101A666 has the pedigree, *HV9W07-1031/Gallagher //OK09429*, in which OK09429 is 50% Cutter. The doubled haploid was produced in collaboration with Corteva, formerly Pioneer Hi-Bred International, Inc., from a single-head selection of an $F_4$ bulk population following three consecutive generations of bulk selection in a grazed system.

## KSU-HAYS by Guorong Zhang

The 14 lines and two checks (SY Monument and Jagalene) were grown at Hays experimental station in 2022. They were planted with a seeding rate of 60 lb/a on Oct. 8, 2021 in a field with sandy-loam soil. The field had good soil moisture at planting and the plots had good stands. The field was fertilized with 60 lb/a N before planting. Plots were not irrigated, and were not treated with fungicide. The 2022 crop year at Hays was dry in most of the growing season and no disease

was observed. Plots were harvested on June 24, 2022. The average yield of these plots was 53 bu/a with a range from 42 to 64.

KS18H111-3 (KS Territory)

KS18H111-3 was released as KS Territory in August 2022. It is a hard red winter wheat with medium maturity and medium height. KS18H111-3 has good grain yield potential and good drought tolerance, which is similar to KS Dallas and KS Hamilton. KS18H111-3 has a very good disease resistance package for western Kansas, which has been greatly improved when comparing to our previously released varieties. It has resistances to wheat streak mosaic virus, stem rust, and Hessian fly; moderate resistances to stripe and leaf rusts; and intermediate resistances to *Triticum* mosaic virus, Barley yellow dwarf virus, and scab. KS18H111-3 has resistance to grain shattering and very good straw strength. Its test weight is about average (~60 lb/bu). Based on our lab tests, its milling and baking qualities are acceptable.

## COLORADO by Esten Mason

**Growing Location & Conditions**
The Wheat Quality Council samples from Colorado originated from strip increases grown under irrigated conditions at the Agricultural Research, Development and Education Center. The field with the strip increases, including adjacent breeding and extension trials, was fertilized with a pre-plant application of 130 lbs N/acre (applied as 46-0-0) and 45 lbs S/acre. The planting date was September 22, 2021 and the harvest date was July 20, 2022. The trial was planted into moisture with good stands and good fall growth. No diseases noted. The winter and spring were extremely dry. Irrigation started in late April with ~5" total applied. Station estimates showed the trial received 2.8" of precipitation from Jan. 1st through July 25th, which was well below normal.

CO16SF027
CO16SF027 is a hard red winter wheat (HRW) breeding line developed at Colorado State University. CO16SF027 is derived from the single backcross Bearpaw/Antero//Antero and was developed using a modified bulk breeding procedure. Antero is a hard white winter (HWW) wheat release (2012) from CSU with excellent medium height and maturity, good test weight, fair straw strength, good resistance to stripe rust, with average mixing and baking characteristics. Bearpaw is a Montana State University release (2011) and carries the solid stem trait conferring protection against wheat stem sawfly damage. Over several years of testing, CO16SF027 has shown average milling, below average mixing, and average bake loaf volume. CO16SF027 carries the solid stem trait and was released in 2021 and marketed as Amplify SF under the PlainsGold Brand (Certified Seed Only)

CO18D297R
CO18D297R is a HRW breeding line developed at Colorado State University. CO18D297R is a doubled haploid line derived from a cross between the F1 of two CSU breeding lines (CO12D906/CO11D1353) and Monarch. Monarch is a HWW with excellent straw strength and

very high irrigated yield potential, good stripe rust resistance with good quality and very low PPO. Both CO12D906 and CO11D1353 were tested over multiple year in Colorado and showed good milling, mixing, and baking characteristics. CO18D297 has shown average milling and mixing with a good loaf volume over multiple years of testing.

## TEXAS A&M College Station by Amir Ibrahim and Jackie Rudd

**Texas A&M AgriLife Research Test Plots**

Bushland, TX. Located in the Texas Panhandle west of Amarillo. The Bushland location was irrigated with a 60 bu $ac^{-1}$ average grain yield due to dry conditions and limited irrigation. The fall 2021 planting conditions were poor at Bushland. There was minimal winter precipitation through the Texas High Plains resulting in another dry winter. The few, dry snowfall events provided little moisture, and as a result, much of the region received less than one inch of moisture from October through mid-April. Fungal disease pressure was minimal due to the dry weather.

**Texas A&M AgriLife Research Entries**

TX16M9216 hard red winter wheat has been developed and proposed and released by Texas A&M AgriLife Research Wheat Improvement Program in 2022. Licensing under negotiation. TX16M9216 is an $F_4$-derived line from the cross 'X09A440S [=TX07A001482/TAM 401] /'Duster' (PI 644016) made in Amarillo, TX, in 2010. TX16M9216 is an awned, medium-maturing, semi-dwarf wheat with white glumes. It was released primarily for its high grain yield potential under both irrigated and dryland conditions across a wide range of environments in Texas. It is resistant to leaf, stripe, and stem rusts. It carries *Lr34*, *Lr37* and *Lr68,* or leaf rust, *Yr17* for stripe rust, and *Sr38* for stem rust resistance. It is resistant to Hessian fly but susceptible to greenbug. It has large seeds, high grain volume weight, and excellent grain characteristics and milling and bread-baking quality attributes. It is later in maturity, similar in height to most recent and popular TAM wheat cultivars in Texas with strong straw. TX16M9216 will provide a good complement to other hard red winter wheat cultivars for wheat producers across the state, particularly in Texas Rolling Plains, Blacklands, South and Central Texas, and under dryland and irrigated conditions in Texas High Plains and similar adaptation zones.

## BASF by Bill Berzonsky

The 2022 Hard Winter Wheat samples for the WQC Trial from BASF were grown in a strip increase in Beaver Crossing, NE. The strips were planted into adequate soil moisture on, or near to 25 Sept. 2021. The lines and hybrid entries emerged well and had decent fall growth before winter. The soil was sampled and recommendations matching our expected yield goal were established. The portion of the field where the strips were grown received 150lbs of N (actual). A broadleaf herbicide application was made in March and Nexicor® and Caramba® fungicides were applied in May prior to and at flowering to prevent foliar disease and FHB infection. Upon

ripening, the strips were harvested on 14 July 2022 without receiving any significant pre-harvest rains.

**BASF-7** is an experimental hard red winter wheat hybrid developed by BASF. The $F_1$ is the result of combining female and male parents that are well-adapted to a specific winter wheat area that spans the predominant production regions of Nebraska, Kansas, and north-central Oklahoma. Three years of internal yield test data suggest it is better adapted to the northern part of the region, i.e., NE and northern portions of KS. It was tested in the 2022 Southern Regional Performance Nursery (SRPN). It is a medium-maturity hybrid that is medium-tall. Its straw strength is average; and it should be managed to mitigate any risk of lodging late in the growing season. It is rated as susceptible to WSMV, but moderate in resistance to the prevalent races of stripe rust and leaf rust. BASF-7 is moderate in its resistance to FHB. As a hybrid, its grain yield is expected to be an average of 5 to 10% higher than most pure line varieties. Internal evaluations have typically characterized its milling, mix, and bake qualities as acceptable-good for the hard winter wheat class.

**BASF-12** is an experimental hard red winter wheat hybrid developed by BASF. The $F_1$ is the result of combining female and male parents that are well-adapted to a specific winter wheat area that spans the predominant production regions of Nebraska, Kansas, and north-central Oklahoma. Three years of internal yield test data suggest that it is well adapted to the entire region, and in comparison to BASF-7, it is slightly better adapted to the southern part of the region (i.e., KS and north-central OK). It was tested in the 2022 Southern Regional Performance Nursery (SRPN). It is a medium-maturity hybrid that is tall, but despite its height, its straw strength is excellent, making it resistant to lodging. It tested as moderately susceptible to WSMV, and moderately resistant-to-resistance to the prevalent races of stripe rust. However, it is moderately susceptible-to-susceptible to the prevalent races of leaf rust; and it is susceptible to FHB. In comparison to BASF-7, its overall disease package provides a lower level of resistance, but on average, it has performed better for yield than BASF-7 across the region and exhibits higher test weight. Internal evaluations have typically characterized its milling and mix qualities as good-excellent and its bake qualities as good for the hard winter wheat class.

## WESTBRED (Bayer) by Adam Bray

# WB4523

WB4523 is a hard red winter wheat, with medium maturity, excellent straw strength, and high yield potential with good milling and baking quality. It has good leaf health and is well adapted to the central and southern plains. It has strong resistance to Stripe Rust, Powdery Mildew, and moderate resistance to Wheat Streak Mosaic Virus. It is moderately resistant to FHB, Stem Rust, and Leaf Rust. Internal quality testing indicates very good mixing and baking quality for hard red winter wheat class. WB4523 was released in 2021 targeting broad acres across the central and southern plains.

## 0433004 (Out-license)

The out-license line 0433004 is a hard red winter wheat, with medium-early maturity, good straw strength, average protein, and high yield potential. It has good winterhardiness and is broadly adapted to the central and northern plains. It has strong resistance to Stripe Rust and Powdery Mildew, with moderate resistance to FHB and Leaf Rust. It may have some tolerance to Wheat Stem Sawfly. Internal quality testing indicates good mixing and baking quality for the eastern central plains and northern plains region. 0433004 was offered for out-licensing in 2020 in the central plains.

## KSU-MANHATTAN by Allan Fritz

KS13DH0041-35 was released as KS Providence in August of 2022 with the pedigree of KS060634K-8/KS040640K-1. The expanded pedigree is KS89180B-2-1-1/CMSW89Y267//X921025-A-3-2/3/Karl 92 *2/Kakatsi/5/SERI.1B//KAUZ/HEVO/3/AMAD/4/Tarkio. KS Providence is a medium maturity, medium-tall semi-dwarf hard red winter wheat with excellent yield potential. It is resistant to soil-borne mosaic virus, stem rust, leaf rust and tan spot. It has an intermediate reaction to stripe rust, Fusarium head blight, wheat streak mosaic virus and acid soils and is susceptible to Hessian fly. Paired t-tests from central Kansas over a minimum of 22 site-years indicates KS Providence has a yield advantage over KS Hatchett, Showdown, SY Monument, SY Wolverine and WB 4699 ($p<0.05$). It has excellent yield potential but some of that advantage over site-years is exceptional yield stability across its primary area of adaptation. KS Providence is best adapted to areas along and east of US Highway 183. It's performance becomes more variable west of that line and the lack of stronger resistance to the wheat streak mosaic virus complex will likely limit expansion west of US-183.

KS Providence carries the 1B.1R wheat-rye translocation. Quality data from the 2020 and 2021 SRPN would indicate that it meets HRWW quality targets for most traits including loaf volume. Its primary quality shortcoming is less than desired stability due, in part, to more variable responses to environment for stability. It does have a positive protein deviation indicating that it holds its protein well for its yield performance. For clarity, that does not mean that it is a high protein line, just that protein is diluted less in KS Providence than most other materials at high yield levels.

Data collected during development of KS Providence would indicate that it has outstanding agronomic performance in is area of adaptation due to excellent yield potential and excellent stability of yield across environments. It will benefit from a fungicide application when stripe rust is present but does possess enough stripe rust resistance to allow delay of fungicide application to target Fusarium in most environments. The quality is not as good as we would aspire to but it does perform as well or better than other varieties in the highest yielding category. Additional information can be found at https://kswheatalliance.org/seed/ks-providence/ and https://www.youtube.com/watch?v=qfiaWvdutBc

# Southern Growout: 2022 (Small-Scale) Samples

| Test entry number | 22-2409 | 22-2410 | 22-2411 | 22-2412 |
|---|---|---|---|---|
| **Sample identification** | **SY Monument_CK** | **Jagalene_CK** | **LCH18-9027_LM** | **TX16M9216_TC** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HDWH | 1 HRW |
| **Test weight (lb/bu)** | 60.2 | 62.2 | 61.6 | 60.9 |
| **Hectoliter weight (kg/hl)** | 79.2 | 81.8 | 81.0 | 80.1 |
| **1000 kernel weight (gm)** | 30.4 | 33.6 | 39.2 | 30.5 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 67.0 | 74.7 | 87.5 | 54.6 |
| Over 9 wire (%) | 32.3 | 24.8 | 12.5 | 45.1 |
| Through 9 wire (%) | 0.7 | 0.5 | 0.0 | 0.3 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 75.7/20.2 | 74.1/18.5 | 59.9/16.6 | 79.5/19.9 |
| Weight (mg) (avg/s.d) | 30.4/9.7 | 33.6/9.9 | 39.2/12.0 | 30.5/11.6 |
| Diameter (mm)(avg/s.d) | 2.67/0.42 | 2.81/0.39 | 2.87/0.41 | 2.62/0.39 |
| Moisture (%) (avg/s.d) | 11.1/1.3 | 10.9/1.1 | 11.0/1.0 | 10.6/1.1 |
| SKCS distribution | 03-04-12-81-01 | 01-06-15-78-01 | 05-16-27-52-01 | 01-04-13-82-01 |
| Classification | Hard | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 13.2 | 13.5 | 14.2 | 14.0 |
| **Wheat ash (12% mb)** | 1.52 | 1.50 | 1.53 | 1.55 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 76.1 | 75.3 | 75.4 | 72.9 |
| Quadrumat Sr. Mill | 66.5 | 67.7 | 66.9 | 66.8 |
| **Flour moisture (%)** | 12.1 | 11.9 | 11.7 | 11.8 |
| **Flour protein (14% mb)** | 11.9 | 12.5 | 12.8 | 12.6 |
| **Flour ash (14% mb)** | 0.53 | 0.53 | 0.49 | 0.51 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 5.9 | 6.1 | 6.0 | 6.1 |
| Peak viscosity (RVU) | 183.4 | 180.8 | 195.3 | 169.5 |
| Breakdown (RVU) | 76.8 | 66.2 | 99.9 | 65.3 |
| Final viscosity at 13 min (RVU) | 212.0 | 213.5 | 166.3 | 196.8 |
| **Minolta color meter** | | | | |
| L* | 90.65 | 90.83 | 91.26 | 90.62 |
| a* | -1.07 | -1.20 | -1.15 | -1.10 |
| b* | 8.63 | 8.82 | 8.02 | 8.81 |
| **PPO** | 0.292 | 0.487 | 0.648 | 0.611 |
| **Falling number (sec)** | 438 | 445 | 373 | 439 |
| **Damaged Starch** | | | | |
| (AI%) | 98.8 | 99.3 | 97.0 | 98.7 |
| (AACC76-31) | 8.7 | 9.1 | 7.0 | 8.5 |

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

# Southern Growout: 2022 (Small-Scale) Samples (continued)

| Test entry number | 22-2413 | 22-2414 | 22-2415 | 22-2416 |
|---|---|---|---|---|
| **Sample identification** | **BASF7_BF** | **BASF12_BF** | **WB4523_WB** | **WB0433004_WB** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW | 1 HRW |
| **Test weight (lb/bu)** | 60.9 | 61.8 | 60.3 | 60.2 |
| **Hectoliter weight (kg/hl)** | 80.1 | 81.3 | 79.3 | 79.2 |
| **1000 kernel weight (gm)** | 37.1 | 33.7 | 30.9 | 36.8 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 79.6 | 72.3 | 63.0 | 76.9 |
| Over 9 wire (%) | 20.1 | 27.2 | 35.8 | 22.6 |
| Through 9 wire (%) | 0.3 | 0.5 | 1.2 | 0.5 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 59.2/17.5 | 67.7/18.3 | 81.7/17.4 | 65.6/21.6 |
| Weight (mg) (avg/s.d) | 37.1/12.0 | 33.7/11.4 | 30.9/9.6 | 36.8/11.1 |
| Diameter (mm)(avg/s.d) | 2.82/0.39 | 2.69/0.38 | 2.60/0.38 | 2.65/0.38 |
| Moisture (%) (avg/s.d) | 11.0/0.9 | 11.3/1.0 | 10.9/1.0 | 10.8/1.1 |
| SKCS distribution | 08-15-29-48-01 | 02-12-19-67-01 | 01-03-06-90-01 | 01-10-24-65-01 |
| Classification | Hard | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 14.2 | 13.2 | 12.0 | 12.9 |
| **Wheat ash (12% mb)** | 1.58 | 1.59 | 1.45 | 1.50 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 75.2 | 75.2 | 73.7 | 73.6 |
| Quadrumat Sr. Mill | 65.7 | 66.8 | 62.6 | 63.7 |
| **Flour moisture (%)** | 12.3 | 12.7 | 11.4 | 11.4 |
| **Flour protein (14% mb)** | 13.0 | 11.9 | 11.0 | 11.8 |
| **Flour ash (14% mb)** | 0.50 | 0.52 | 0.57 | 0.54 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 6.1 | 6.1 | 6.1 | 6.3 |
| Peak viscosity (RVU) | 180.8 | 185.3 | 183.9 | 193.9 |
| Breakdown (RVU) | 64.6 | 65.9 | 68.3 | 68.8 |
| Final viscosity at 13 min (RVU) | 217.1 | 225.4 | 216.3 | 223.4 |
| **Minolta color meter** | | | | |
| L* | 91.36 | 91.06 | 90.61 | 90.64 |
| a* | -1.17 | -1.29 | -1.54 | -1.35 |
| b* | 8.44 | 8.63 | 10.32 | 9.49 |
| **PPO** | 0.522 | 0.533 | 0.209 | 0.484 |
| **Falling number (sec)** | 414 | 451 | 406 | 400 |
| **Damaged Starch** | | | | |
| (AI%) | 98.1 | 98.5 | 99.2 | 99.0 |
| (AACC76-31) | 8.0 | 8.4 | 9.0 | 8.8 |

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

# Southern Growout: 2022 (Small-Scale) Samples (continued)

| Test entry number | 22-2417 | 22-2418 | 22-2419 | 22-2420 |
|---|---|---|---|---|
| **Sample identification** | **OK18510_OK** | **OK16107125C-17HR-2_OK** | **OKP17D101A666_OK** | **KS18H111-3_KH** |
| **Wheat Data** | | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW | 1 HRW |
| **Test weight (lb/bu)** | 62.1 | 61.7 | 61.8 | 61.2 |
| **Hectoliter weight (kg/hl)** | 81.7 | 81.1 | 81.3 | 80.5 |
| **1000 kernel weight (gm)** | 33.8 | 30.5 | 31.1 | 32.4 |
| **Wheat kernel size (Rotap)** | | | | |
| Over 7 wire (%) | 78.4 | 70.6 | 74.0 | 71.6 |
| Over 9 wire (%) | 21.4 | 29.2 | 25.7 | 27.8 |
| Through 9 wire (%) | 0.2 | 0.2 | 0.3 | 0.6 |
| **Single kernel (skcs)[a]** | | | | |
| Hardness (avg /s.d) | 61.3/18.1 | 81.8/17.6 | 75.8/17.1 | 73.4/17.9 |
| Weight (mg) (avg/s.d) | 33.8/11.0 | 30.5/9.3 | 31.1/9.0 | 32.4/10.3 |
| Diameter (mm)(avg/s.d) | 2.82/0.34 | 2.71/0.35 | 2.71/0.34 | 2.79/0.41 |
| Moisture (%) (avg/s.d) | 10.7/1.2 | 10.7/1.1 | 10.7/1.1 | 10.8/1.1 |
| SKCS distribution | 07-13-26-54-01 | 00-03-09-88-01 | 00-04-14-82-01 | 01-06-16-77-01 |
| Classification | Hard | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 13.6 | 14.4 | 14.4 | 13.1 |
| **Wheat ash (12% mb)** | 1.57 | 1.70 | 1.63 | 1.57 |
| **Milling and Flour Quality Data** | | | | |
| **Flour yield (%, str. grade)** | | | | |
| Miag Multomat Mill | 74.4 | 74.8 | 75.5 | 74.4 |
| Quadrumat Sr. Mill | 65.1 | 66.2 | 66.4 | 65.5 |
| **Flour moisture (%)** | 12.1 | 11.8 | 11.6 | 12.2 |
| **Flour protein (14% mb)** | 12.2 | 13.0 | 13.3 | 11.8 |
| **Flour ash (14% mb)** | 0.48 | 0.56 | 0.56 | 0.53 |
| **Rapid Visco-Analyser** | | | | |
| Peak time (min) | 6.2 | 6.2 | 5.9 | 6.2 |
| Peak viscosity (RVU) | 182.2 | 182.5 | 156.3 | 194.3 |
| Breakdown (RVU) | 63.,0 | 62.6 | 72.6 | 67.3 |
| Final viscosity at 13 min (RVU) | 223.1 | 214.7 | 172.6 | 237.2 |
| **Minolta color meter** | | | | |
| L* | 90.72 | 89.96 | 90.11 | 90.22 |
| a* | -1.30 | -1.45 | -1.19 | -1.43 |
| b* | 8.61 | 10.09 | 8.83 | 9.58 |
| **PPO** | 0.510 | 0.539 | 0.530 | 0.483 |
| **Falling number (sec)** | 414 | 517 | 419 | 471 |
| **Damaged Starch** | | | | |
| (AI%) | 98.7 | 99.0 | 99.1 | 99.0 |
| (AACC76-31) | 8.6 | 8.8 | 8.9 | 8.8 |

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

# Southern Growout: 2022 (Small-Scale) Samples (continued)

| Test entry number | 22-2421 | 22-2422 | 22-2423 |
|---|---|---|---|
| **Sample identification** | **CO16SF027_CO** | **CO18D297R_CO** | **KS13DH0041-35_KM** |
| **Wheat Data** | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW |
| **Test weight (lb/bu)** | 61.2 | 62.2 | 60.9 |
| **Hectoliter weight (kg/hl)** | 80.5 | 81.8 | 80.1 |
| **1000 kernel weight (gm)** | 32.9 | 30.9 | 34.0 |
| **Wheat kernel size (Rotap)** | | | |
| Over 7 wire (%) | 62.2 | 55.7 | 74.0 |
| Over 9 wire (%) | 37.2 | 43.3 | 25.7 |
| Through 9 wire (%) | 0.6 | 1.0 | 0.3 |
| **Single kernel (skcs)[a]** | | | |
| Hardness (avg /s.d) | 69.0/19.8 | 70.0/18.0 | 67.9/18.0 |
| Weight (mg) (avg/s.d) | 32.9/11.4 | 30.9/11.2 | 34.0/10.1 |
| Diameter (mm)(avg/s.d) | 2.63/0.36 | 2.54/0.36 | 2.72/0.34 |
| Moisture (%) (avg/s.d) | 10.8/1.1 | 11.2/0.9 | 11.0/1.1 |
| SKCS distribution | 02-12-20-66-01 | 01-09-17-73-01 | 02-09-20-69-01 |
| Classification | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 13.6 | 12.9 | 13.1 |
| **Wheat ash (12% mb)** | 1.56 | 1.46 | 1.59 |
| **Milling and Flour Quality Data** | | | |
| **Flour yield (%, str. grade)** | | | |
| Miag Multomat Mill | 75.5 | 74.7 | 74.3 |
| Quadrumat Sr. Mill | 67.4 | 67.0 | 66.0 |
| **Flour moisture (%)** | 12.0 | 11.3 | 11.9 |
| **Flour protein (14% mb)** | 12.3 | 11.7 | 12.0 |
| **Flour ash (14% mb)** | 0.51 | 0.49 | 0.54 |
| **Rapid Visco-Analyser** | | | |
| Peak time (min) | 6.1 | 6.2 | 6.2 |
| Peak viscosity (RVU) | 225.8 | 186.2 | 166.7 |
| Breakdown (RVU) | 98.2 | 55.1 | 56.4 |
| Final viscosity at 13 min (RVU) | 221.9 | 238.0 | 206.1 |
| **Minolta color meter** | | | |
| L* | 90.73 | 90.78 | 90.83 |
| a* | -1.34 | -1.07 | -1.43 |
| b* | 8.69 | 7.97 | 9.12 |
| **PPO** | 0.619 | 0.599 | 0.173 |
| **Falling number (sec)** | 455 | 454 | 388 |
| **Damaged Starch** | | | |
| (AI%) | 98.1 | 99.2 | 98.8 |
| (AACC76-31) | 8.0 | 9.0 | 8.6 |

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

# Southern Growout: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples

| Test Entry Number | 22-2409 | 22-2410 | 22-2411 | 22-2412 |
|---|---|---|---|---|
| Sample Identification | SY Monument_CK | Jagalene_CK | LCH18-9027_LM | TX16M9216_TC |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 70.5 | 71.8 | 72.7 | 73.0 |
| Flour Abs (14% mb) | 68.4 | 69.4 | 70.1 | 70.6 |
| Mix Time (min) | 8.0 | 4.1 | 3.9 | 4.5 |
| Mix tolerance (0-6) | 5 | 4 | 4 | 4 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 66.3 | 69.4 | 69.5 | 71.5 |
| Flour Abs (14% mb) | 64.1 | 67.0 | 66.9 | 69.1 |
| Peak time (min) | 10.8 | 6.3 | 7.0 | 6.2 |
| Mix stability (min) | 22.6 | 11.9 | 11.5 | 11.3 |
| Mix Tolerance Index (FU) | 19 | 18 | 21 | 24 |
| Breakdown time (min) | 20.3 | 13.6 | 13.5 | 12.3 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 151 | 160 | 134 | 170 |
| L(mm): Extensibility | 48 | 64 | 69 | 57 |
| G(mm): Swelling index | 15.4 | 17.8 | 18.4 | 16.8 |
| W($10^{-4}$ J): strength (curve area) | 300 | 396 | 348 | 374 |
| P/L: curve configuration ratio | 3.15 | 2.50 | 1.94 | 2.98 |
| Ie($P_{200}$/P): elasticity index | 57.4 | 58.5 | 57.6 | 54.5 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 526/1093/1154 | 480/557/641 | 358/417/431 | 376/457/470 |
| Extensibility (mm at 45/90/135 min) | 124/103/94 | 139/122/122 | 158/155/160 | 130/135/132 |
| Energy ($cm^2$ at 45/90/135 min) | 106/146/127 | 113/111/128 | 105/126/132 | 82/109/106 |
| Resist $_{max}$ (BU at 45/90/135min) | 666/1225/1218 | 614/736/856 | 515/665/655 | 480/640/644 |
| Ratio (at 45/90/135 min) | 4.23/10.6/12.3 | 3.5/4.6/5.3 | 2.3/2.7/2.7 | 2.9/3.4/3.6 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 2*, 7+9, 5+10 | 1,2*, 17+18, 5+10 | 2*, 7+9, 5+10 | 2*, 7+9, 5+10 |
| TPP/TMP | 0.90 | 1.09 | 0.96 | 1.04 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 59.2 | 61.5 | 64.3 | 54.7 |

# Southern Growout: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples (continued)

| Test Entry Number | 22-2413 | 22-2414 | 22-2415 | 22-2416 |
|---|---|---|---|---|
| Sample Identification | BASF7_BF | BASF12_BF | WB4523_WB | WB0433004_WB |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 73.5 | 72.1 | 73.2 | 73.8 |
| Flour Abs (14% mb) | 71.3 | 70.6 | 69.7 | 70.8 |
| Mix Time (min) | 4.1 | 3.9 | 4.4 | 3.4 |
| Mix tolerance (0-6) | 3 | 3 | 3 | 2 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 67.7 | 67.4 | 71.9 | 72.6 |
| Flour Abs (14% mb) | 65.5 | 65.9 | 68.4 | 69.5 |
| Peak time (min) | 7.0 | 5.0 | 6.1 | 5.2 |
| Mix stability (min) | 12.3 | 9.1 | 8.3 | 7.5 |
| Mix Tolerance Index (FU) | 20 | 23 | 33 | 31 |
| Breakdown time (min) | 16.4 | 11.2 | 10.3 | 9.8 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 140 | 152 | 188 | 172 |
| L(mm): Extensibility | 56 | 52 | 31 | 45 |
| G(mm): Swelling index | 16.6 | 16.0 | 12.4 | 14.9 |
| W($10^{-4}$ J): strength (curve area) | 299 | 304 | 259 | 312 |
| P/L: curve configuration ratio | 2.50 | 2.92 | 6.06 | 3.82 |
| Ie($P_{200}$/P): elasticity index | 52.7 | 49.8 | 0.0 | 46.5 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 379/438/434 | 337/435/469 | 395/445/443 | 336/385/444 |
| Extensibility (mm at 45/90/135 min) | 139/156/139 | 145/141/141 | 117/118/114 | 124/124/125 |
| Energy ($cm^2$ at 45/90/135 min) | 88/128/103 | 84/108/117 | 70/81/76 | 66/75/86 |
| Resist $_{max}$ (BU at 45/90/135min) | 489/670/585 | 430/594/645 | 433/535/508 | 393/458/529 |
| Ratio (at 45/90/135 min) | 2.7/2.8/3.1 | 2.3/3.1/3.3 | 3.4/3.8/3.9 | 2.7/3.1/3.6 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 1,2* 7+9, 5+10 | 1,2*, 17+18, 2+12 | 2*, 7+9, 5+10 | 2*, 7+9 (poss $7^{OE}$), 5+10 |
| TPP/TMP | 0.83 | 1.02 | 1.02 | 0.99 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 64.1 | 52.2 | 48.3 | 52.4 |

# Southern Growout: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples

| Test Entry Number | 22-2417 | 22-2418 | 22-2419 | 22-2420 |
|---|---|---|---|---|
| Sample Identification | OK18510_OK | OK16107125C-17HR-2_OK | OKP17D101A666_OK | KS18H111-3_KH |
| **MIXOGRAPH** | | | | |
| Flour Abs (% as-is) | 71.2 | 74.8 | 75.0 | 71.1 |
| Flour Abs (14% mb) | 68.9 | 71.9 | 72.4 | 69.3 |
| Mix Time (min) | 3.0 | 3.8 | 5.1 | 3.4 |
| Mix tolerance (0-6) | 2 | 4 | 5 | 2 |
| **FARINOGRAPH** | | | | |
| Flour Abs (% as-is) | 69.9 | 73.6 | 73.6 | 72.4 |
| Flour Abs (14% mb) | 67.6 | 70.8 | 71.0 | 70.6 |
| Peak time (min) | 6.2 | 5.2 | 6.2 | 6.7 |
| Mix stability (min) | 7.8 | 6.2 | 11.7 | 8.1 |
| Mix Tolerance Index (FU) | 32 | 42 | 27 | 32 |
| Breakdown time (min) | 11.0 | 8.7 | 11.7 | 10.7 |
| **ALVEOGRAPH** | | | | |
| P(mm): Tenacity | 151 | 169 | 218 | 175 |
| L(mm): Extensibility | 53 | 48 | 36 | 39 |
| G(mm): Swelling index | 16.2 | 15.4 | 13.3 | 13.9 |
| W($10^{-4}$ J): strength (curve area) | 295 | 316 | 356 | 282 |
| P/L: curve configuration ratio | 2.85 | 3.52 | 3.06 | 4.49 |
| Ie($P_{200}$/P): elasticity index | 46.6 | 46.1 | 0.0 | 0.0 |
| **EXTENSIGRAPH** | | | | |
| Resist (BU at 45/90/135 min) | 303/333/383 | 295/324/365 | 464/534/527 | 261/345/317 |
| Extensibility (mm at 45/90/135 min) | 148/146/152 | 147/153/153 | 133/137/131 | 145/140/142 |
| Energy ($cm^2$ at 45/90/135 min) | 78/84/105 | 76/86/97 | 100/130/115 | 65/83/79 |
| Resist $_{max}$ (BU at 45/90/135min) | 389/433/508 | 382/424/491 | 590/799/756 | 329/445/425 |
| Ratio (at 45/90/135 min) | 2.1/2.3/2.5 | 2.0/2.1/2.4 | 3.5/3.9/4.0 | 1.8/2.5/2.2 |
| **PROTEIN ANALYSIS** | | | | |
| HMW-GS Composition | 2*, 7+8, 5+10 | 2*, 7+8, 5+10 | 2*, 17+18, 5+10 | 2*, 7+9, 5+10 |
| TPP/TMP | 0.96 | 0.94 | 1.02 | 0.98 |
| **SEDIMENTATION TEST** | | | | |
| Volume (ml) | 55.7 | 55.4 | 58.4 | 51.5 |

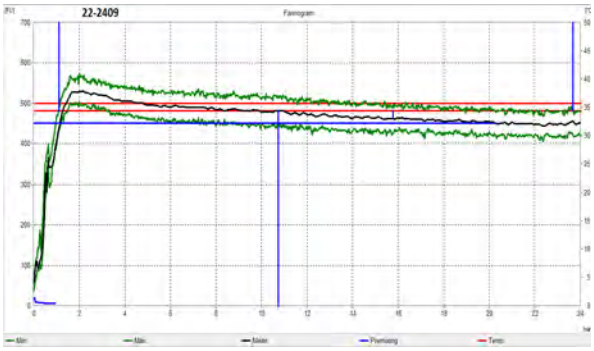
# Southern Growout: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples (continued)

| Test Entry Number | 22-2421 | 22-2422 | 22-2423 |
|---|---|---|---|
| Sample Identification | CO16SF027_CO | CO18D297R_CO | KS13DH0041-35_KM |
| **MIXOGRAPH** | | | |
| Flour Abs (% as-is) | 71.2 | 72.3 | 68.7 |
| Flour Abs (14% mb) | 69.2 | 69.7 | 66.1 |
| Mix Time (min) | 2.9 | 4.9 | 2.9 |
| Mix tolerance (0-6) | 3 | 4 | 2 |
| **FARINOGRAPH** | | | |
| Flour Abs (% as-is) | 73.0 | 71.2 | 70.4 |
| Flour Abs (14% mb) | 70.9 | 68.6 | 67.8 |
| Peak time (min) | 5.8 | 7.5 | 7.3 |
| Mix stability (min) | 6.8 | 15.2 | 11.4 |
| Mix Tolerance Index (FU) | 36 | 17 | 15 |
| Breakdown time (min) | 9.9 | 15.8 | 14.8 |
| **ALVEOGRAPH** | | | |
| P(mm): Tenacity | 167 | 158 | 159 |
| L(mm): Extensibility | 36 | 42 | 43 |
| G(mm): Swelling index | 13.3 | 14.4 | 14.6 |
| W($10^{-4}$ J): strength (curve area) | 246 | 272 | 281 |
| P/L: curve configuration ratio | 4.64 | 3.76 | 3.70 |
| Ie($P_{200}$/P): elasticity index | 0.0 | 48.6 | 46.4 |
| **EXTENSIGRAPH** | | | |
| Resist (BU at 45/90/135 min) | 240/283/351 | 374/560/590 | 286/346/386 |
| Extensibility (mm at 45/90/135 min) | 141/145/135 | 127/129/124 | 129/122/126 |
| Energy ($cm^2$ at 45/90/135 min) | 57/70/78 | 75/118/118 | 60/67/79 |
| Resist $_{max}$ (BU at 45/90/135min) | 294/367/442 | 450/731/785 | 354/432/489 |
| Ratio (at 45/90/135 min) | 1.7/2.0/2.6 | 3.0/4.4/4.7 | 2.2/2.9/3.1 |
| **PROTEIN ANALYSIS** | | | |
| HMW-GS Composition | 2*, 7+9, 5+10 | 2*, 7+9, 5+10 | 2*, 7+8, 5+10 |
| TPP/TMP | 0.79 | 0.84 | 0.71 |
| **SEDIMENTATION TEST** | | | |
| Volume (ml) | 43.1 | 54.6 | 46.3 |

# Physical Dough Tests – Farino and Mixo

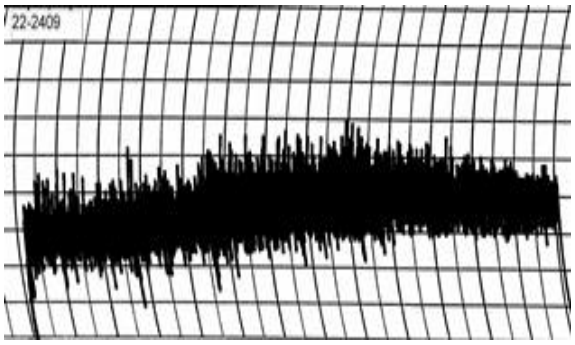
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms



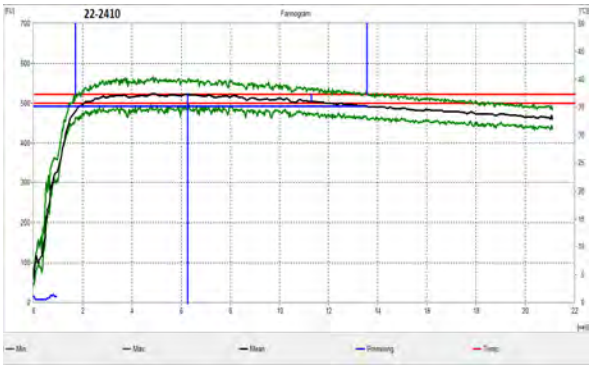

Water abs = 64.1%, Peak time = 10.8 min,
Mix stab = 22.6 min, MTI = 19 FU

### Mixograms

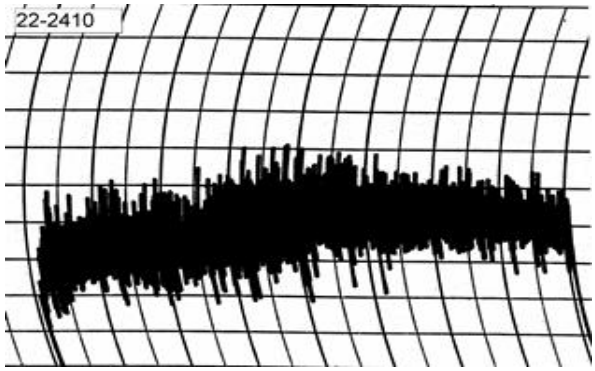



Water abs = 68.4%
Mix time = 8.0 min

### 22-2409, SY Mounment_CK




Water abs = 67.0%, Peak time = 6.3 min,
Mix stab = 11.9 min, MTI = 18 FU



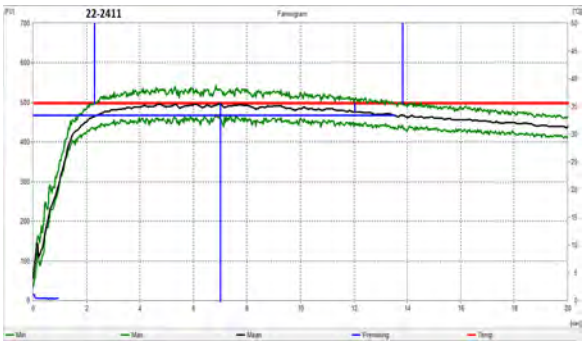

Water abs = 69.4%
Mix time = 4.1 min

### 22-2410, Jagalene_CK

# Physical Dough Tests – Farino and Mixo

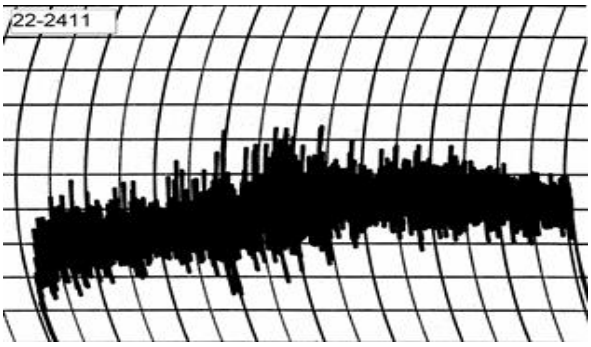
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms



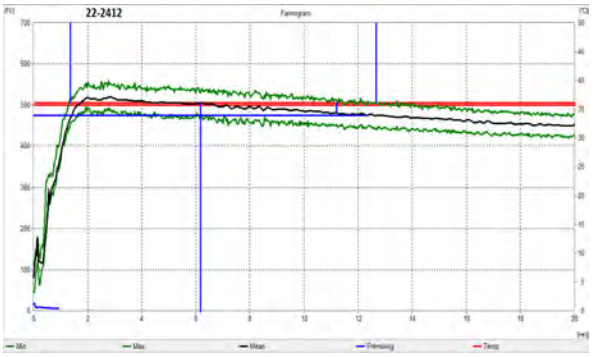

Water abs = 66.9%, Peak time = 7.0 min,
Mix stab = 11.5 min, MTI = 21 FU

### Mixograms

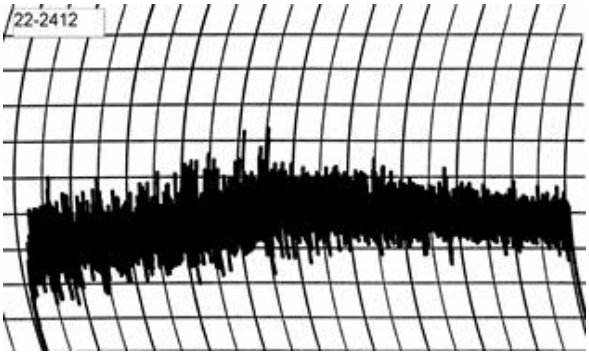



Water abs = 70.1%
Mix time = 3.9 min

**22-2411, LCH18-9027_LM**




Water abs = 69.1%, Peak time = 6.2 min,
Mix stab = 11.3 min, MTI = 24 FU



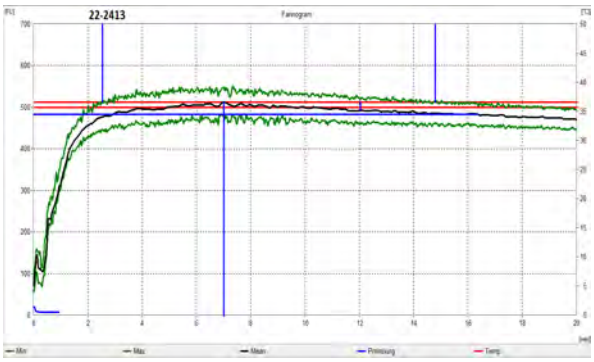

Water abs = 70.6%
Mix time = 4.5 min

**22-2412, TX16M9216_TC**

# Physical Dough Tests - Farino and Mixo

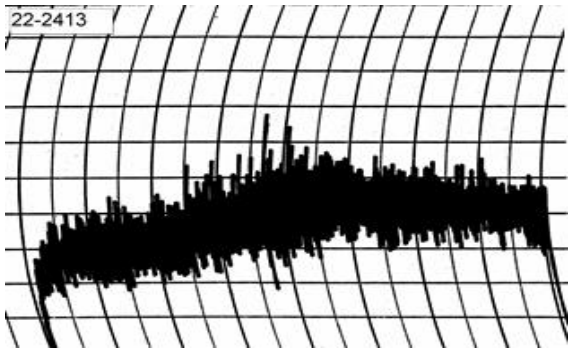
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms



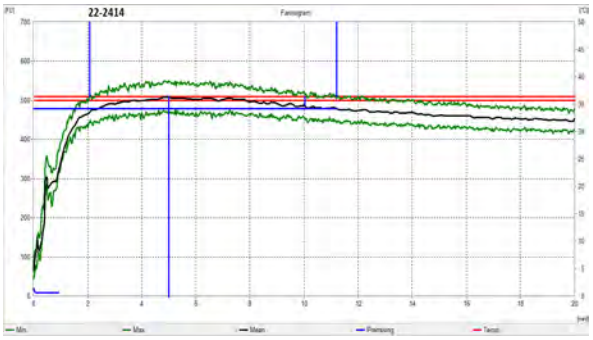

Water abs = 65.5%, Peak time = 7.0 min,
Mix stab = 12.3 min, MTI = 20 FU

### Mixograms

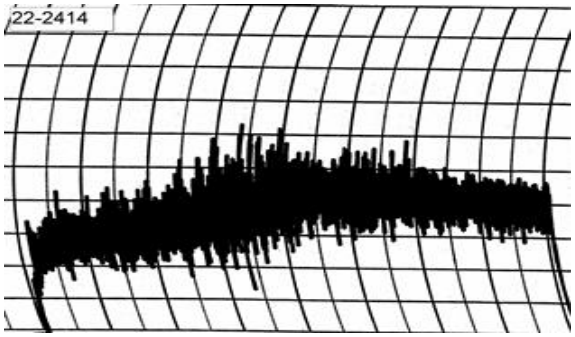



Water abs = 71.3%
Mix time = 4.1 min

## 22-2413, BASF7_BF




Water abs = 65.9%, Peak time = 5.0 min,
Mix stab = 9.1 min, MTI = 23 FU



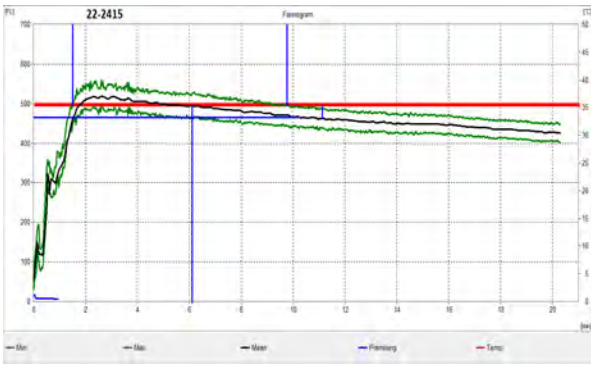

Water abs = 70.6%
Mix time = 3.9 min

## 22-2414, BASF12_BF

# Physical Dough Tests- Farino and Mixo

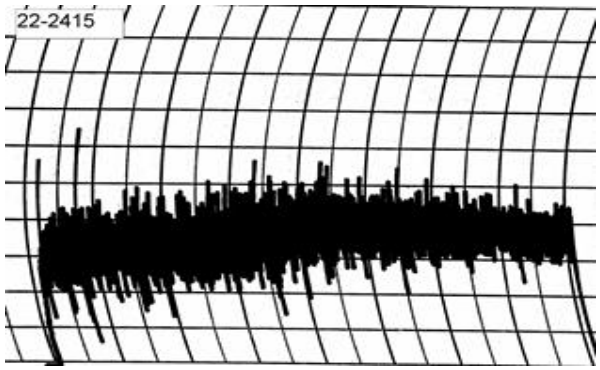
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms



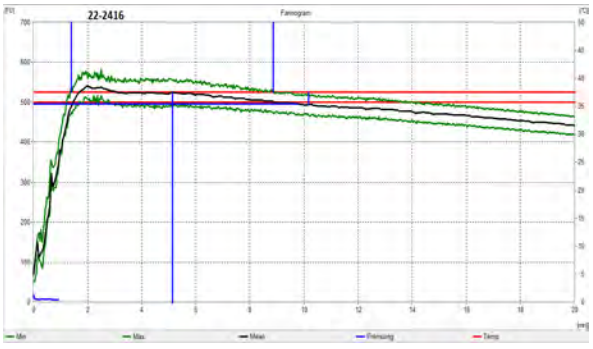

Water abs = 68.4%, Peak time = 6.1 min,
Mix stab = 8.3 min, MTI = 33 FU

### Mixograms

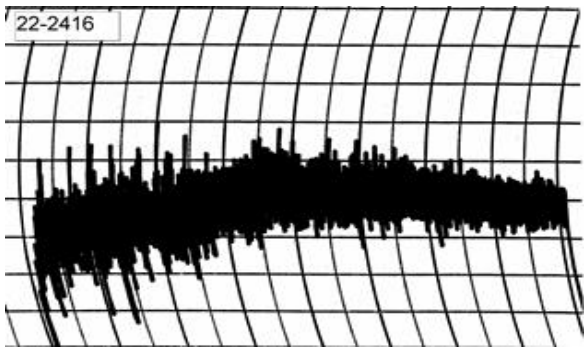



Water abs = 69.7%
Mix time = 4.4 min

### 22-2415, WB4523_WB




Water abs = 69.5%, Peak time = 5.2 min,
Mix stab = 7.5 min, MTI = 31 FU



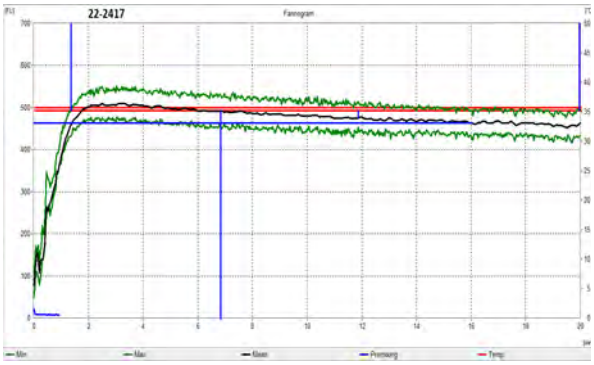

Water abs = 70.8%
Mix time = 3.4 min

### 22-2416, WB0433004_WB

# Physical Dough Tests- Farino and Mixo

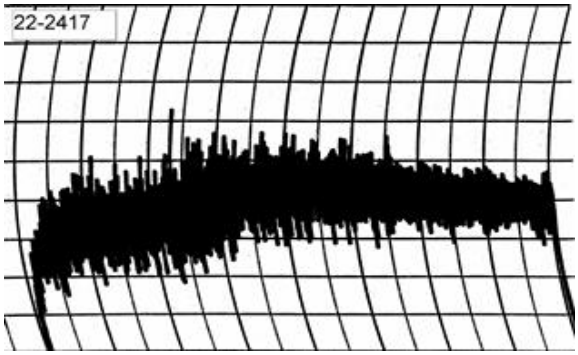
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms



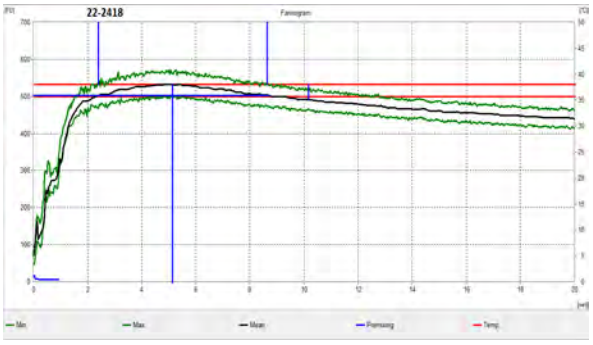

Water abs = 67.6%, Peak time = 6.2 min,
Mix stab = 7.8 min, MTI = 32 FU

### Mixograms

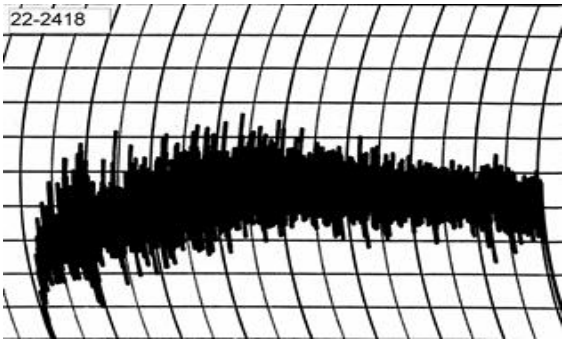



Water abs = 68.9%
Mix time = 3.0 min

## 22-2417, OK18510_OK




Water abs = 70.8%, Peak time = 5.2 min,
Mix stab = 6.2 min, MTI = 42 FU



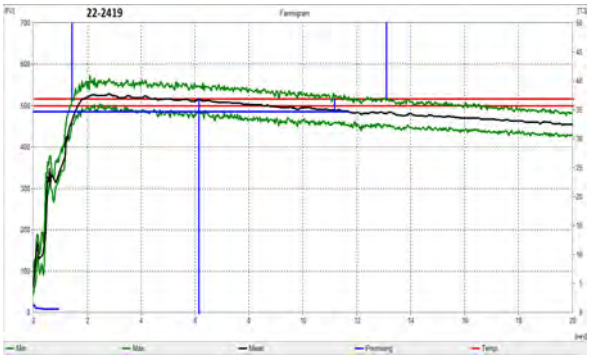

Water abs = 71.9%
Mix time = 3.8 min

## 22-2418, OK16107125C-17HR-2_OK

# Physical Dough Tests- Farino and Mixo

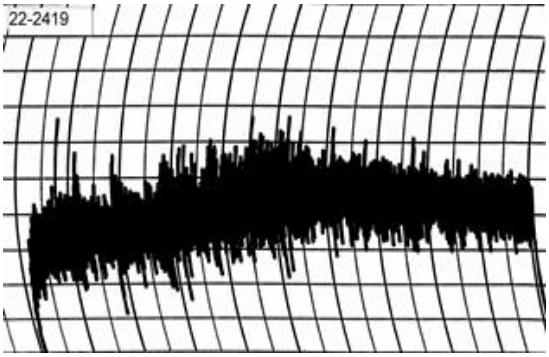
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms



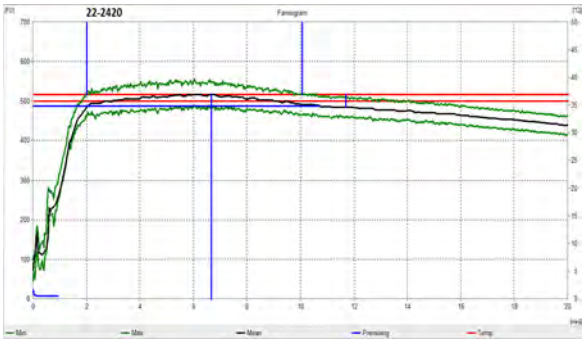

Water abs = 71.0%, Peak time = 6.2 min,
Mix stab = 11.7 min, MTI = 27 FU

### Mixograms

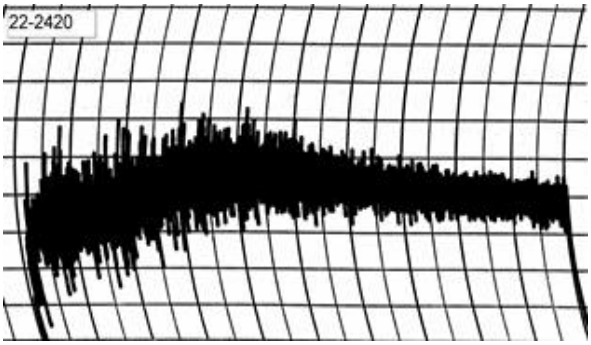



Water abs = 72.4%
Mix time = 5.1 min

### 22-2419, OKP17D101A666_OK




Water abs = 70.6%, Peak time = 6.7 min,
Mix stab = 8.1 min, MTI = 32 FU



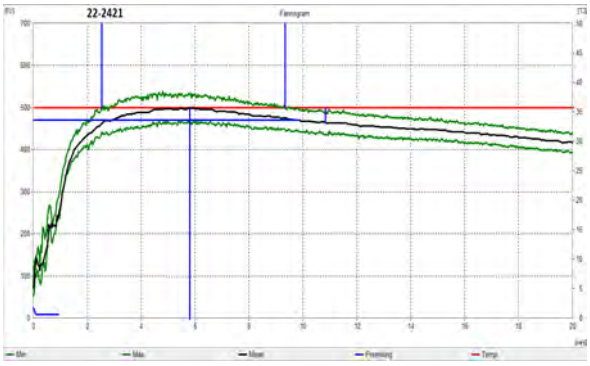

Water abs = 69.3%
Mix time = 3.4 min

### 22-2420, KS18H111-3_KH

# Physical Dough Tests- Farino and Mixo

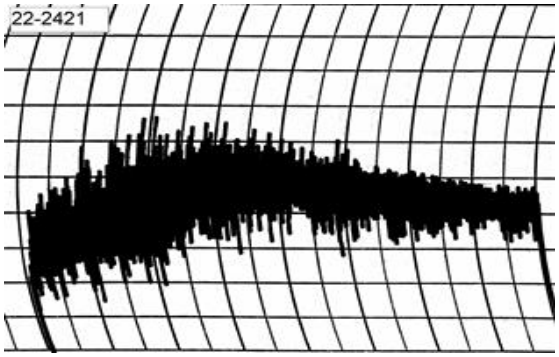
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms



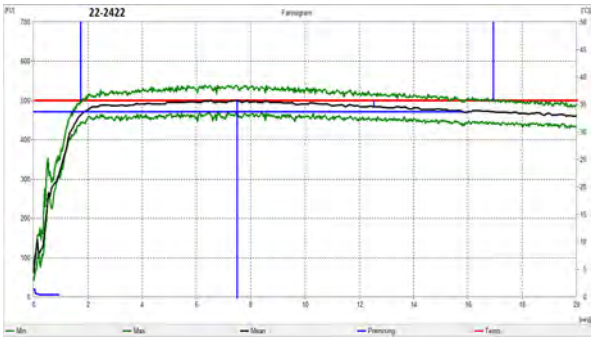

Water abs = 70.9%, Peak time = 5.8 min,
Mix stab = 6.8 min, MTI = 36 FU

### Mixograms

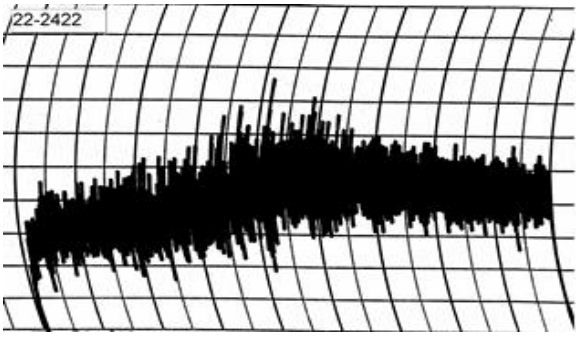



Water abs = 69.2%
Mix time = 2.9 min

## 22-2421, CO16SF027_CO




Water abs = 68.6%, Peak time = 7.5 min,
Mix stab = 15.2 min, MTI = 17 FU



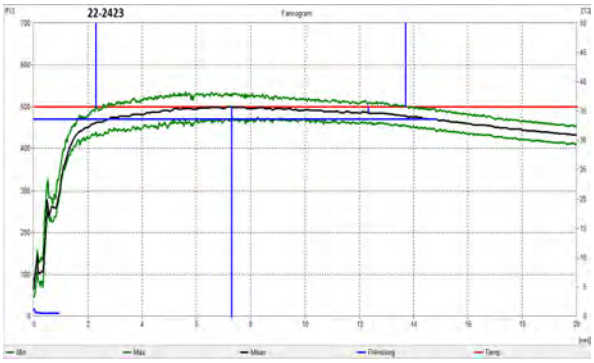

Water abs = 69.7%
Mix time = 4.9 min

## 22-2422, CO18D297R_CO

# Physical Dough Tests- Farino and Mixo

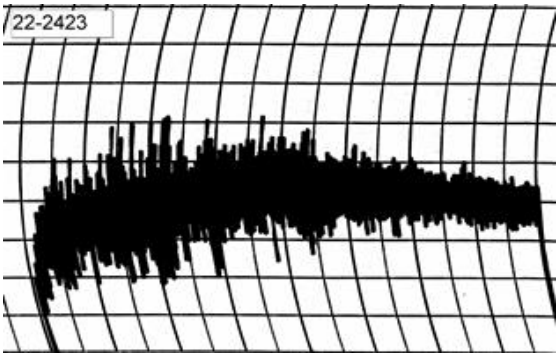
## 2022 (Small Scale) Samples – Southern Growout

### Farinograms




Water abs = 767.8%, Peak time = 7.3 min,
Mix stab = 11.4 min, MTI = 15 FU

### Mixograms

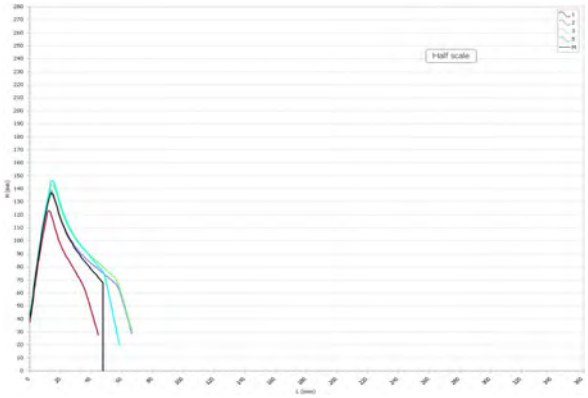



Water abs = 66.1%
Mix time = 2.9 min

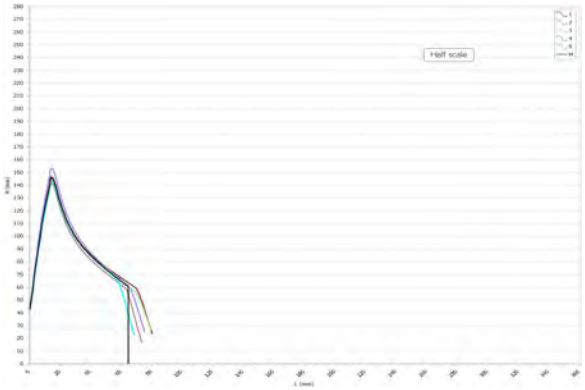
**22-2423, KS13DH0041-35_KM**

# Physical Dough Tests - Alveograms

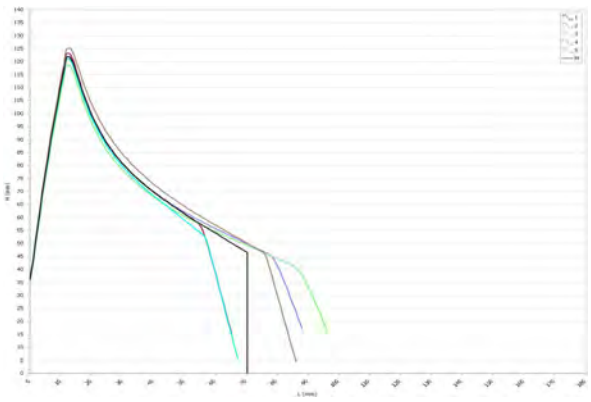
## 2022 (Small Scale) Samples – Southern Growout



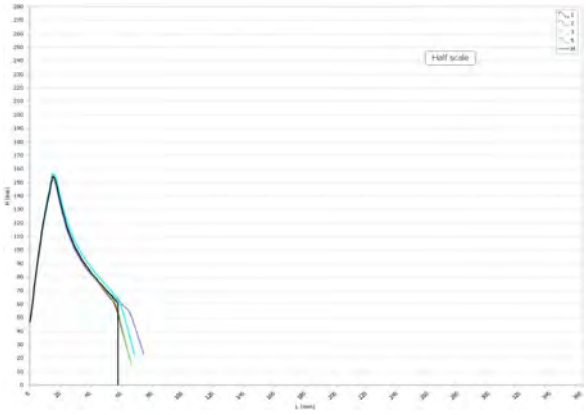

**22-24109, SY Monument_CK**
P(mm $H_20$) = 151, L(mm) = 48, W($10E^{-4}$ J) = 300




**22-2410, Jagalene_CK**
P(mm $H_20$) = 160, L(mm) = 64, W($10E^{-4}$ J) = 396



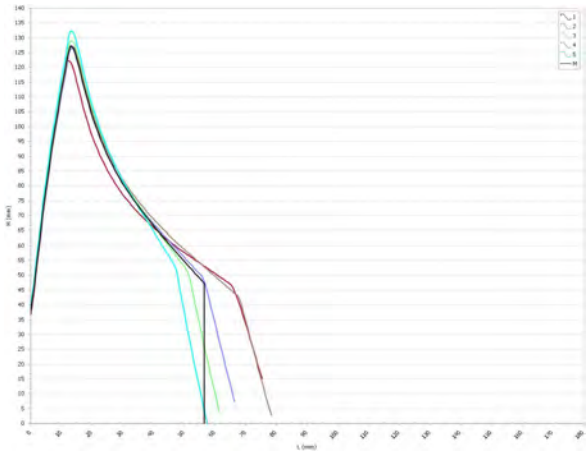
**22-2411, LCH18-9027_LM**
P(mm $H_20$) = 134, L(mm) = 69, W($10E^{-4}$ J) = 348



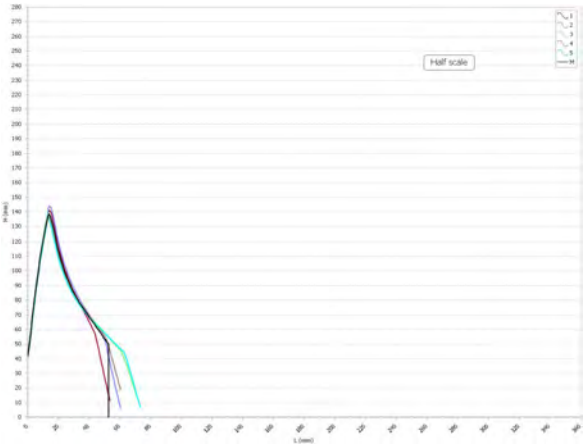

**22-2412, TX16M9216_TC**
P(mm $H_20$) = 170, L(mm) = 57, W($10E^{-4}$ J) = 374

# Physical Dough Tests - Alveograms

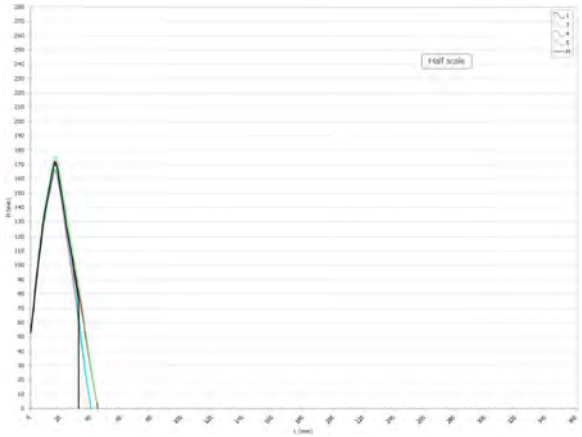
## 2022 (Small Scale) Samples – Southern Growout



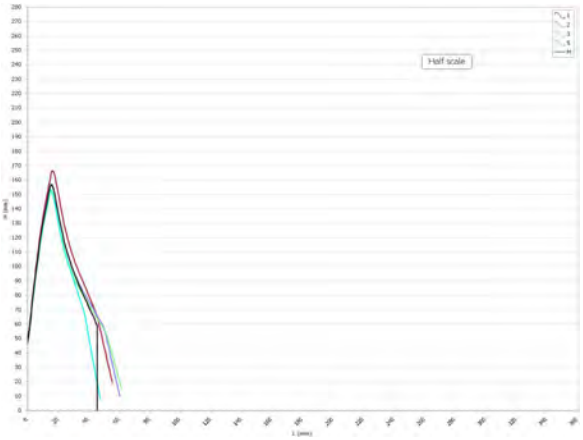
**22-2413, BASF7_BF**
P(mm $H_20$) = 140, L(mm) = 56, W(10E$^{-4}$ J) = 299




**22-2414, BASF12_BF**
P(mm $H_20$) = 152, L(mm) = 52, W(10E$^{-4}$ J) = 304



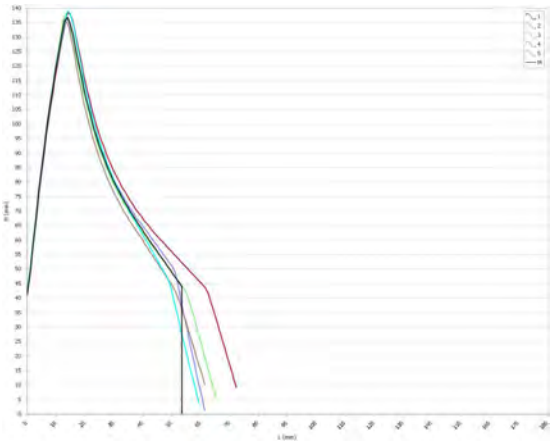

**22-2415, WB4523_WB**
P(mm $H_20$) = 188, L(mm) = 31, W(10E$^{-4}$ J) = 259



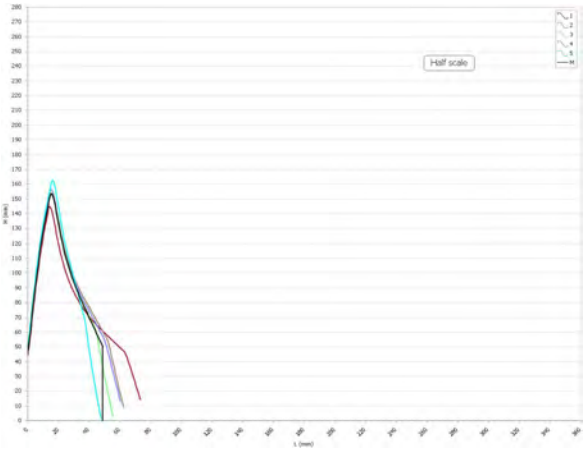

**22-2416, WB0433004_WB**
P(mm $H_20$) = 172, L(mm) = 45, W(10E$^{-4}$ J) = 312

# Physical Dough Tests - Alveograms

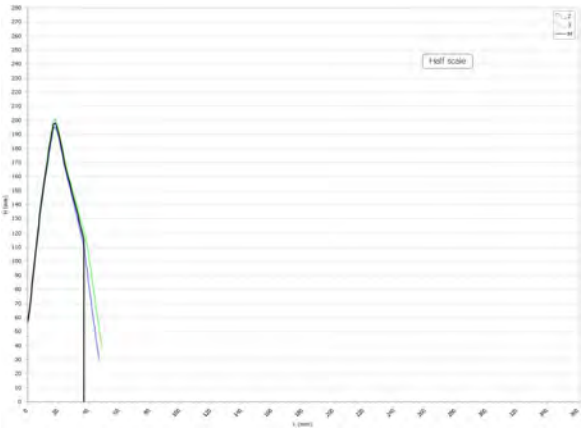
## 2022 (Small Scale) Samples – Southern Growout



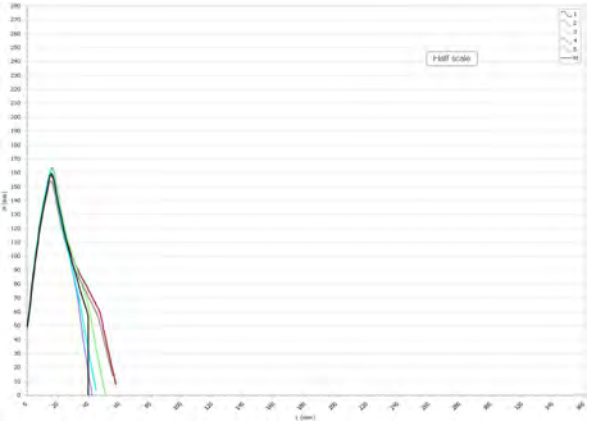
**22-2417, OK18510_OK**
P(mm $H_20$) = 151, L(mm) = 53, W(10E$^{-4}$ J) = 295




**22-2418, OK16107125C-17HR-2_OK**
P(mm $H_20$) = 169 L(mm) = 48, W(10E$^{-4}$ J) = 316



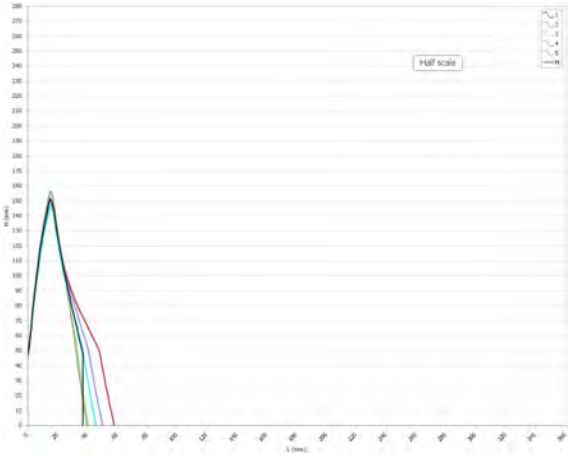

**22-2419, OKP17D101A666_OK**
P(mm $H_20$) = 218, L(mm) = 36, W(10E$^{-4}$ J) = 356



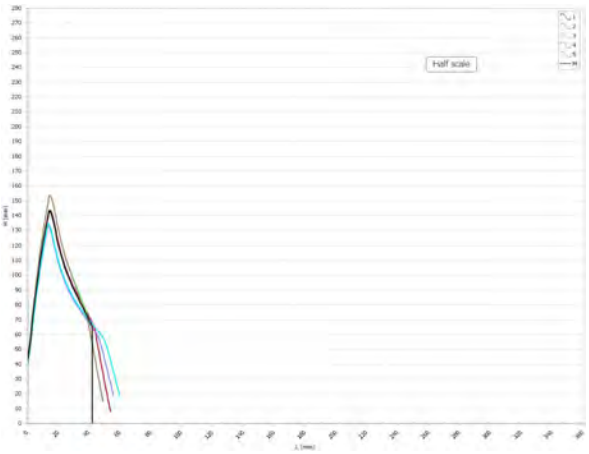

**22-2420, KS18HH111-3_KH**
P(mm $H_20$) = 175, L(mm) = 39, W(10E$^{-4}$ J) = 282

# Physical Dough Tests - Alveograms

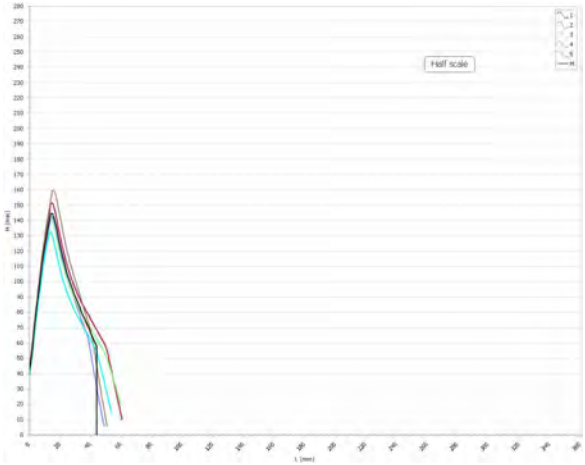
## 2022 (Small Scale) Samples – Southern Growout




**22-2421, CO16SF027_CO**
P(mm $H_20$) = 167, L(mm) = 36, W($10E^{-4}$ J) = 246



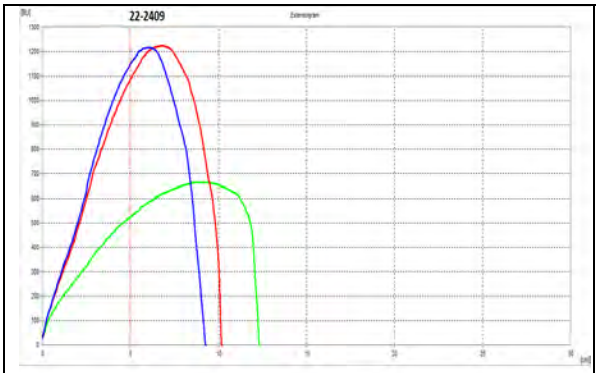

**22-2422, CO18D297R_CO**
P(mm $H_20$) = 158, L(mm) = 42, W($10E^{-4}$ J) = 272



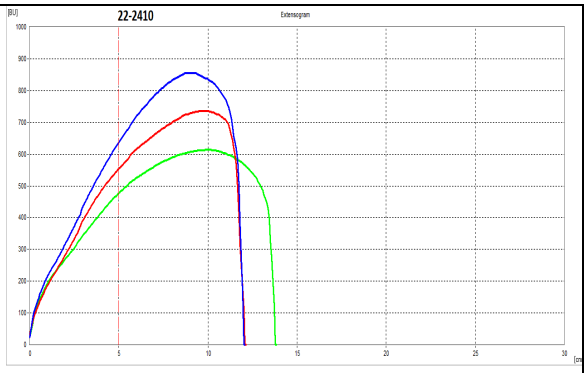

**22-2423, KS13DH0041-35_KM**
P(mm $H_20$) = 159, L(mm) = 43, W($10E^{-4}$ J) = 281

# Physical Dough Tests - Extensigrams

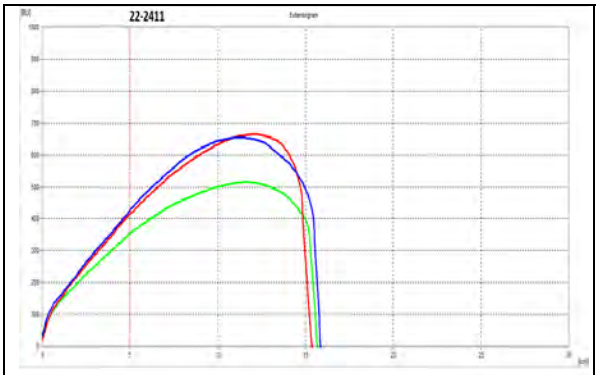
## 2022 (Small Scale) Samples – Southern Growout



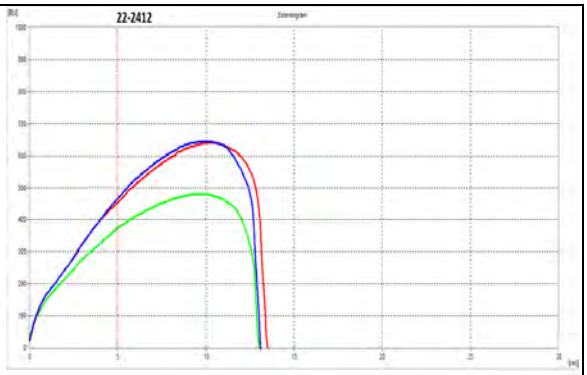

**22-2409, SY Monument_CK**
R (BU) =1093, E (mm) = 103, W ($cm^2$) = 146
Rmax (BU) = 1225, Ratio = 10.6 at 90 min




**22-2410, Jagalene_CK**
R (BU) = 557, E (mm) = 122, W ($cm^2$) = 111
Rmax (BU) = 736, Ratio = 4.6 at 90 min




**22-2411, LCH18-9027_LM**
R (BU) = 417, E (mm) = 155, W ($cm^2$) = 126
Rmax (BU) = 665, Ratio = 2.7 at 90 min

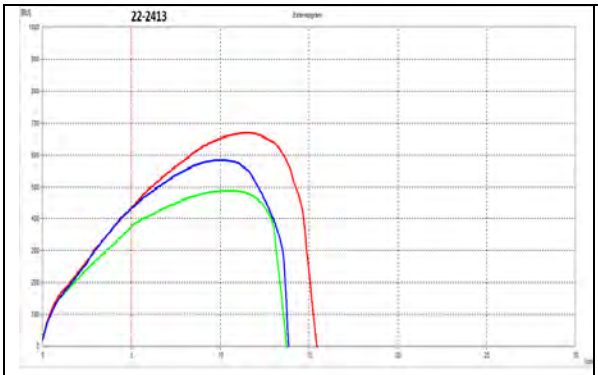



**22-2412, TX16M9216_TC**
R (BU) = 457, E (mm) = 135, W ($cm^2$) = 109
Rmax (BU) = 640, Ratio = 3.4 at 90 min

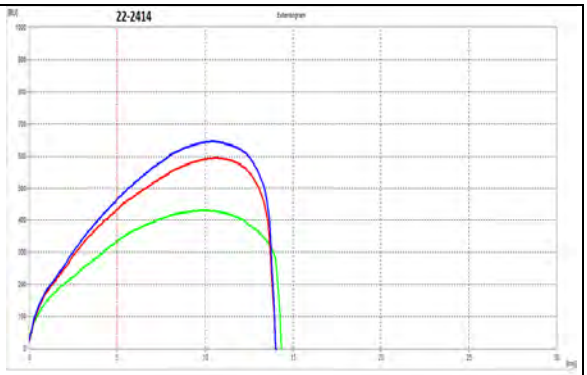
Notes: R (BU) = Resistance; E (mm) = Extensibility; W ($cm^2$) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

# Physical Dough Tests - Extensigrams

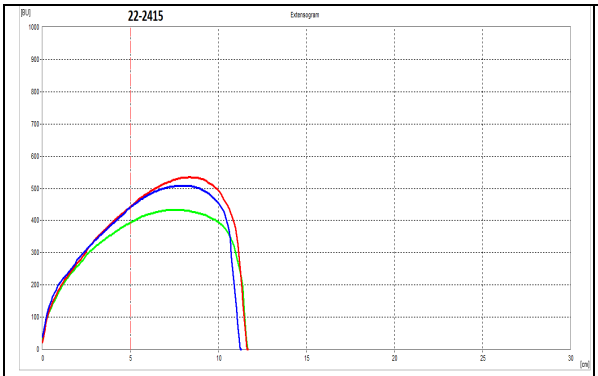
## 2022 (Small Scale) Samples – Southern Growout



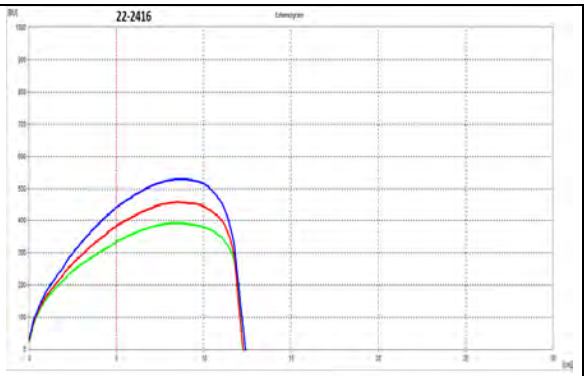

**22-2413, BASF7_BF**
R (BU) = 435, E (mm) = 156, W ($cm^2$) = 128
Rmax (BU) = 670, Ratio = 2.8 at 90 min




**22-2414, BASF12_BF**
R (BU) = 435, E (mm) = 141, W ($cm^2$) = 108
Rmax (BU) = 594, Ratio = 3.1 at 90 min




**22-2415, WB4523_WB**
R (BU) = 445, E (mm) = 118, W ($cm^2$) = 81
Rmax (BU) = 535, Ratio = 3.8 at 90 min

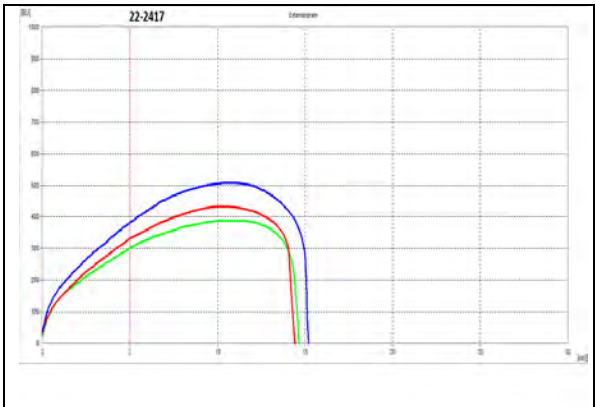



**22-2416, WB0433004_WB**
R (BU) = 385, E (mm) = 123, W ($cm^2$) = 75
Rmax (BU) = 458, Ratio = 3.1 at 90 min

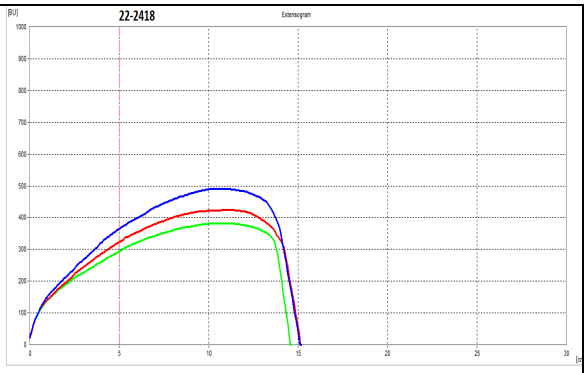
Notes: R (BU) = Resistance; E (mm) = Extensibility; W ($cm^2$) = Energy; Rmax (BU) = Maximum resistance. Green = 45 min, Red = 90 min, and Blue = 135 min.

# Physical Dough Tests - Extensigrams

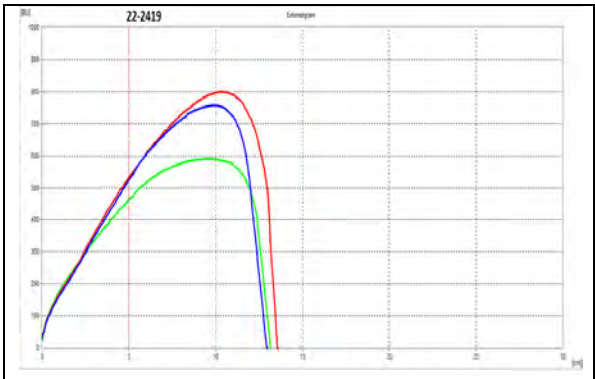
## 2022 (Small Scale) Samples – Southern Growout



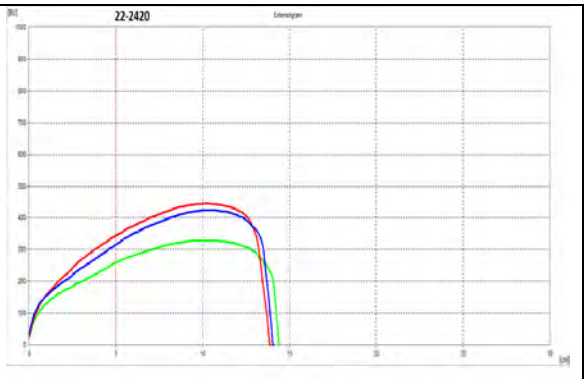

**22-2417, OK18510_OK**
R (BU) = 333, E (mm) = 146, W ($cm^2$) = 84
Rmax (BU) = 433, Ratio = 2.3 at 90 min




**22-2418, OK16107125C-17HR-2_OK**
R (BU) = 324, E (mm) = 153, W ($cm^2$) = 86
Rmax (BU) = 424, Ratio = 2.1 at 90 min



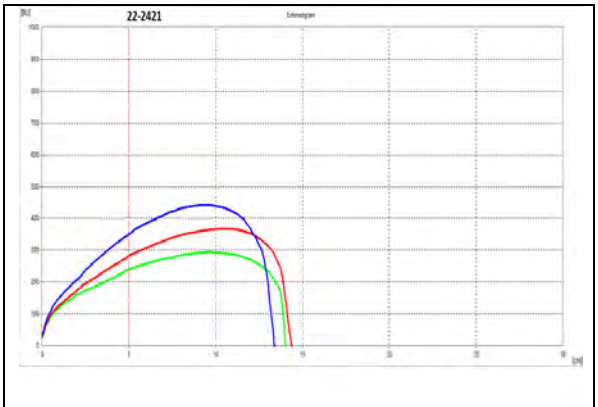

**22-2419, OKP17D101A666_OK**
R (BU) = 534, E (mm) = 137, W ($cm^2$) = 129
Rmax (BU) = 799, Ratio = 3.9 at 90 min



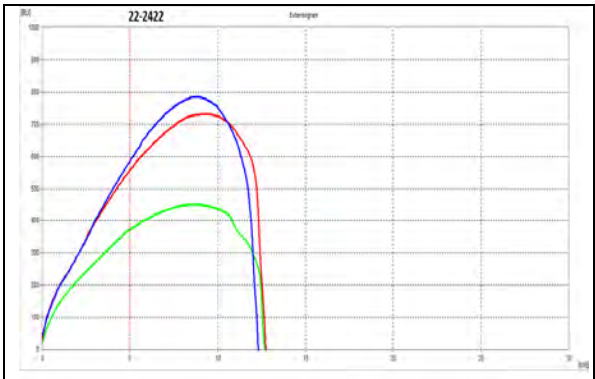

**22-2420, KS18H111-3_KH**
R (BU) = 345, E (mm) = 140, W ($cm^2$) = 83
Rmax (BU) = 445, Ratio = 2.5 at 90 min

# Physical Dough Tests - Extensigrams

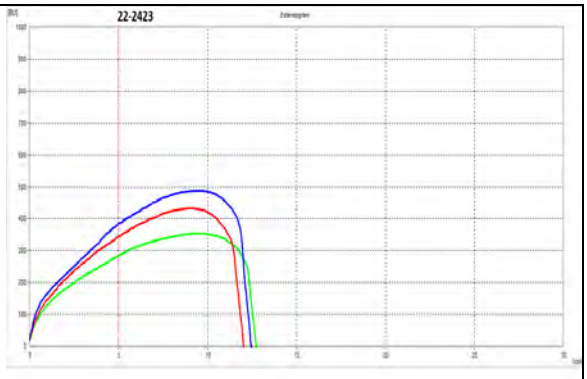
## 2022 (Small Scale) Samples – Southern Growout




**22-2421, CO16SF027_CO**
R (BU) = 283, E (mm) = 145, W ($cm^2$) = 70
Rmax (BU) = 367, Ratio = 2.0 at 90 min



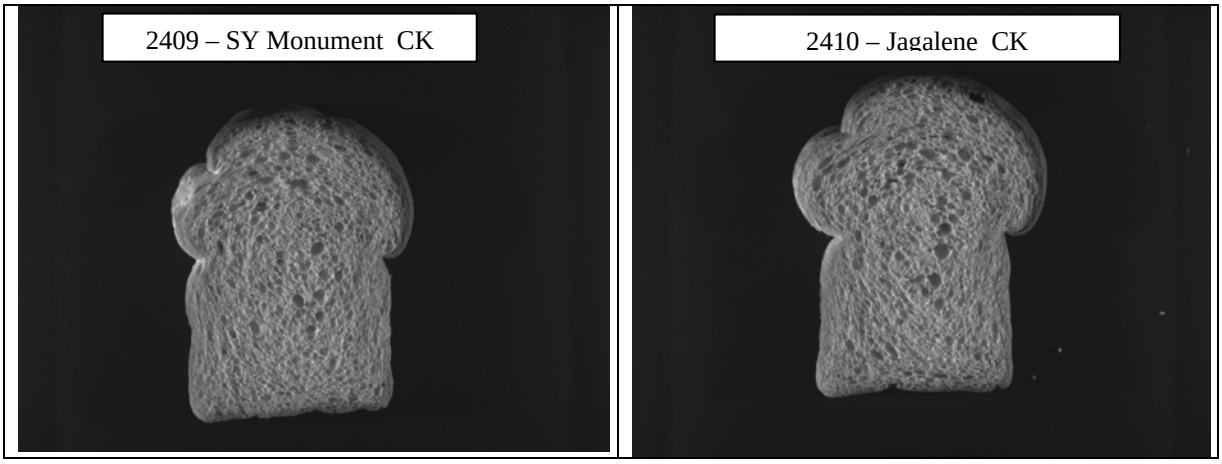

**22-2422, CO18D297R_CO**
R (BU) = 560, E (mm) = 129, W ($cm^2$) = 118
Rmax (BU) = 731, Ratio = 4.4 at 90 min



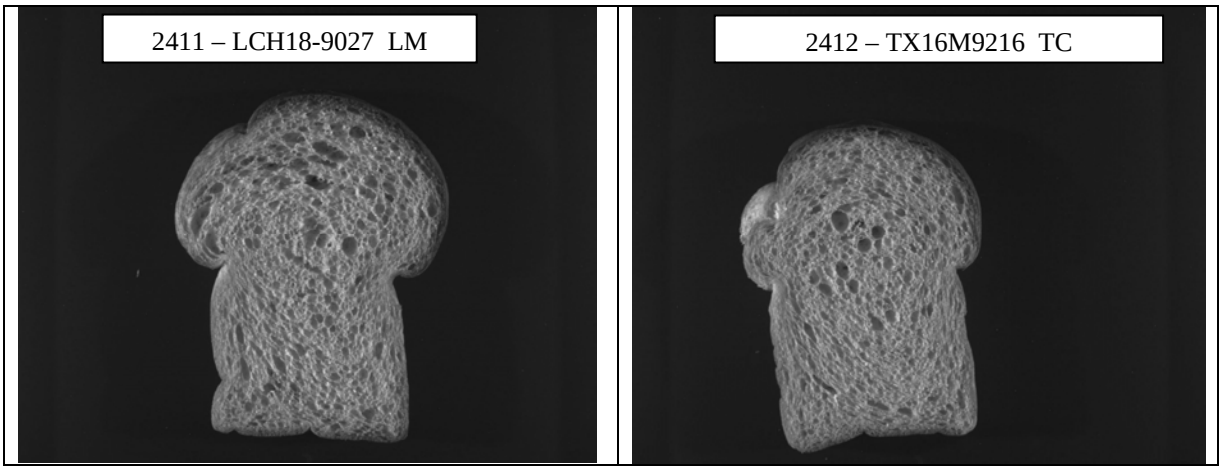

**22-2423, KS13DH0041-35_KM**
R (BU) = 346, E (mm) = 122, W ($cm^2$) = 67.5
Rmax (BU) = 432, Ratio = 2.9 at 90 min

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

# Southern Growout: C-Cell Bread Images and Analysis
# 2022 (Small-Scale) Samples

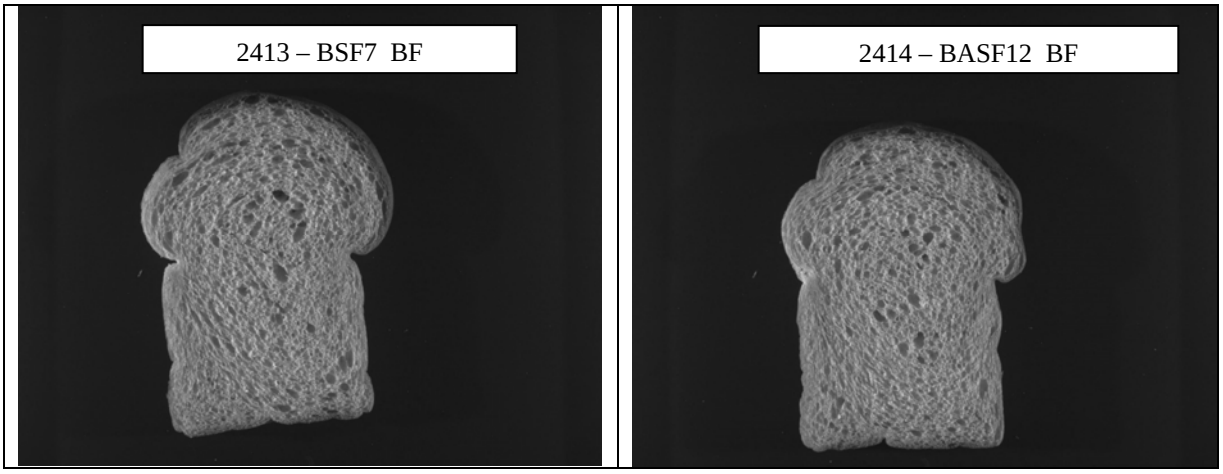



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2409** | 6248 | 108 | 3821 | 0.415 | 1.915 | 2.995 | 1.820 | -1.00 |
| **2410** | 6444 | 109 | 3705 | 0.425 | 2.073 | 4.120 | 1.840 | -4.45 |

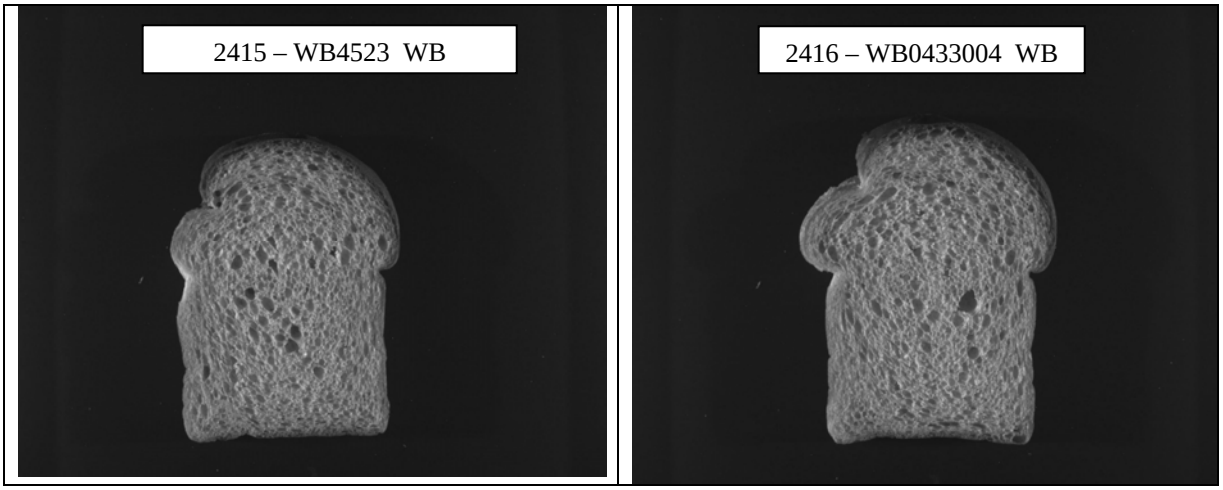



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2411** | 7213 | 106 | 3747 | 0.440 | 2.425 | 5.295 | 1.710 | -8.55 |
| **2412** | 6315 | 110 | 3715 | 0.430 | 2.040 | 5.170 | 1.775 | -4.75 |

# Southern Growout: C-Cell Bread Images and Analysis
# 2022 (Small-Scale) Samples

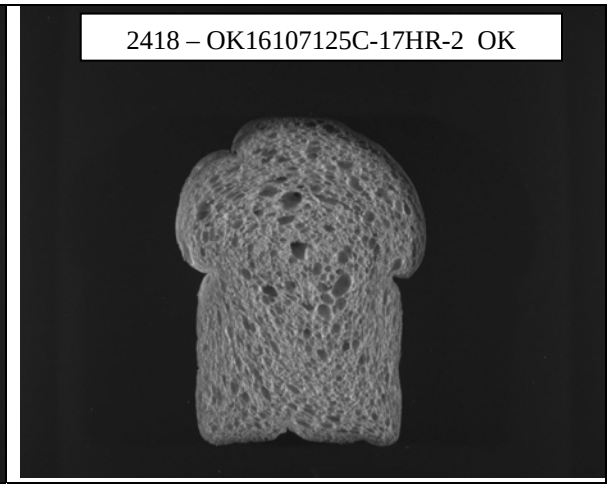



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2413** | 6647 | 114 | 4090 | 0.420 | 1.975 | 1.315 | 1.765 | -1.65 |
| **2414** | 6348 | 115 | 4029 | 0.420 | 1.880 | 1.125 | 1.790 | -5.60 |




| 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** | 5561 | 108 | 3227 | 0.428 | 2.050 | 4.993 | 1.798 | -6.10 |
| **2416** | 6078 | 109 | 3533 | 0.425 | 2.080 | 3.020 | 1.805 | -5.30 |

# Southern Growout: C-Cell Bread Images and Analysis
# 2022 (Small-Scale) Samples

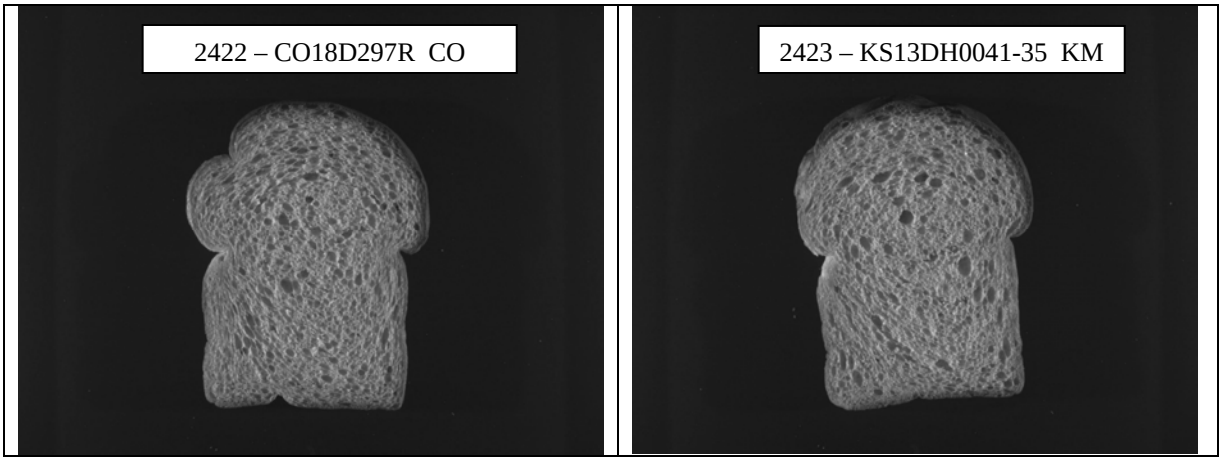

| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2417** | 6443 | 108 | 3812 | 0.420 | 2.165 | 4.690 | 1.795 | -5.60 |
| **2418** | 6345 | 107 | 3847 | 0.420 | 1.955 | 2.070 | 1.820 | -8.10 |



| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2419** | 6247 | 107 | 3648 | 0.430 | 2.060 | 3.005 | 1.750 | -7.65 |
| **2420** | 6264 | 110 | 3755 | 0.425 | 2.103 | 4.615 | 1.765 | -6.15 |

# Southern Growout: C-Cell Bread Images and Analysis
# 2022 (Small-Scale) Samples

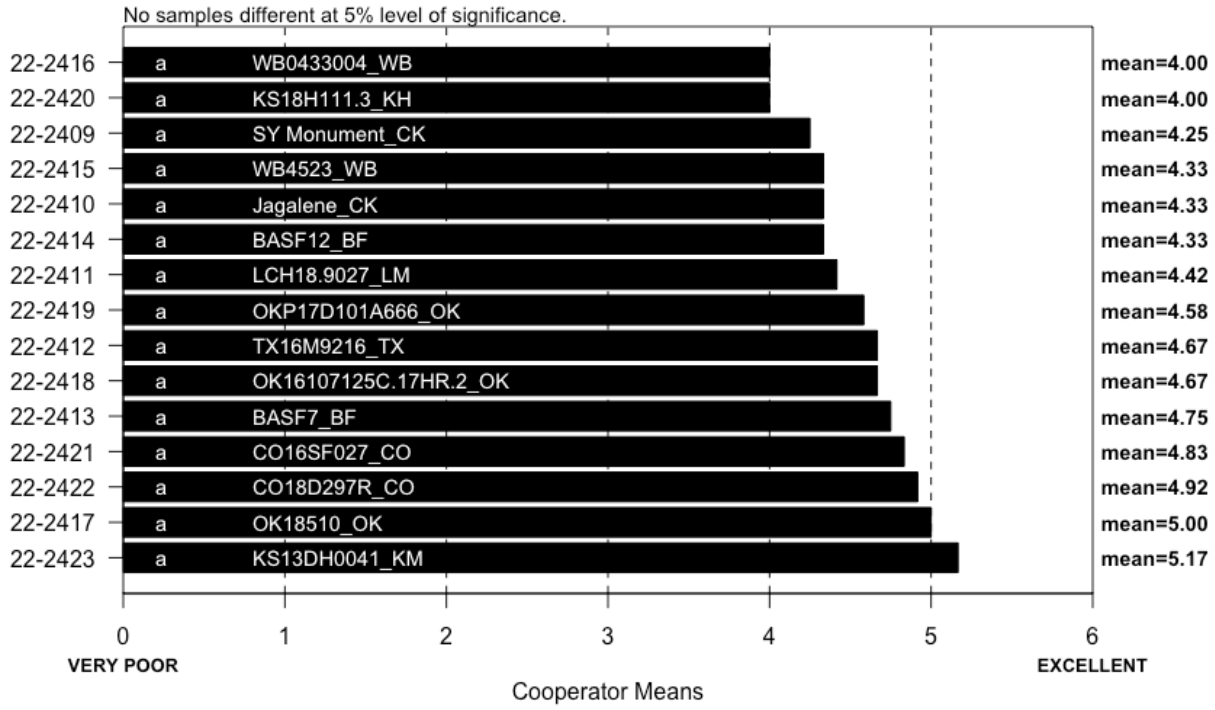

| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2421** | 6101 | 108 | 3354 | 0.435 | 2.273 | 2.495 | 1.780 | -6.98 |




| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2422** | 6121 | 106 | 3673 | 0.420 | 1.970 | 1.830 | 1.795 | -6.35 |
| **2423** | 6362 | 108 | 3792 | 0.420 | 2.050 | 2.025 | 1.710 | -3.50 |

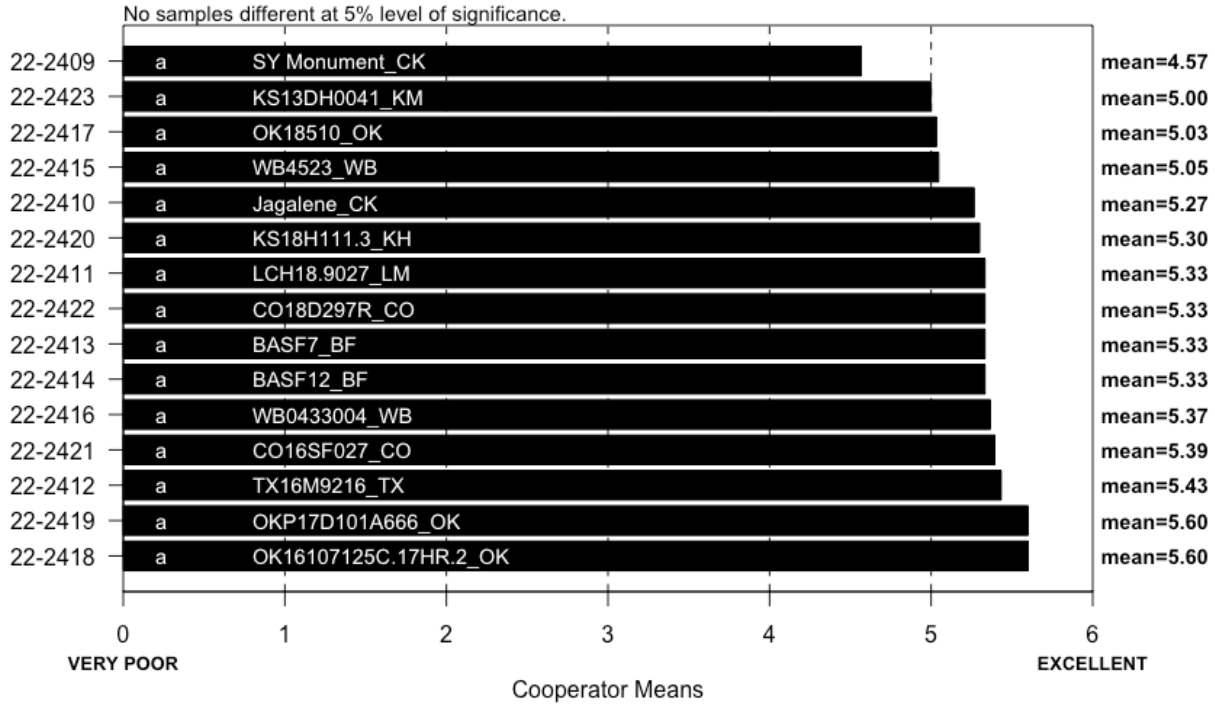
## SPONGE CHARACTERISTICS
## (Uniform Growout) Southern

Cooperators = 6
ChiSqCalc = 7
ChiSqTab = 23.7
P Value = 0.936




## BAKE ABSORPTION
## (Uniform Growout) Southern

Cooperators = 15
ChiSqCalc = 17.4
ChiSqTab = 23.7
P Value = 0.233

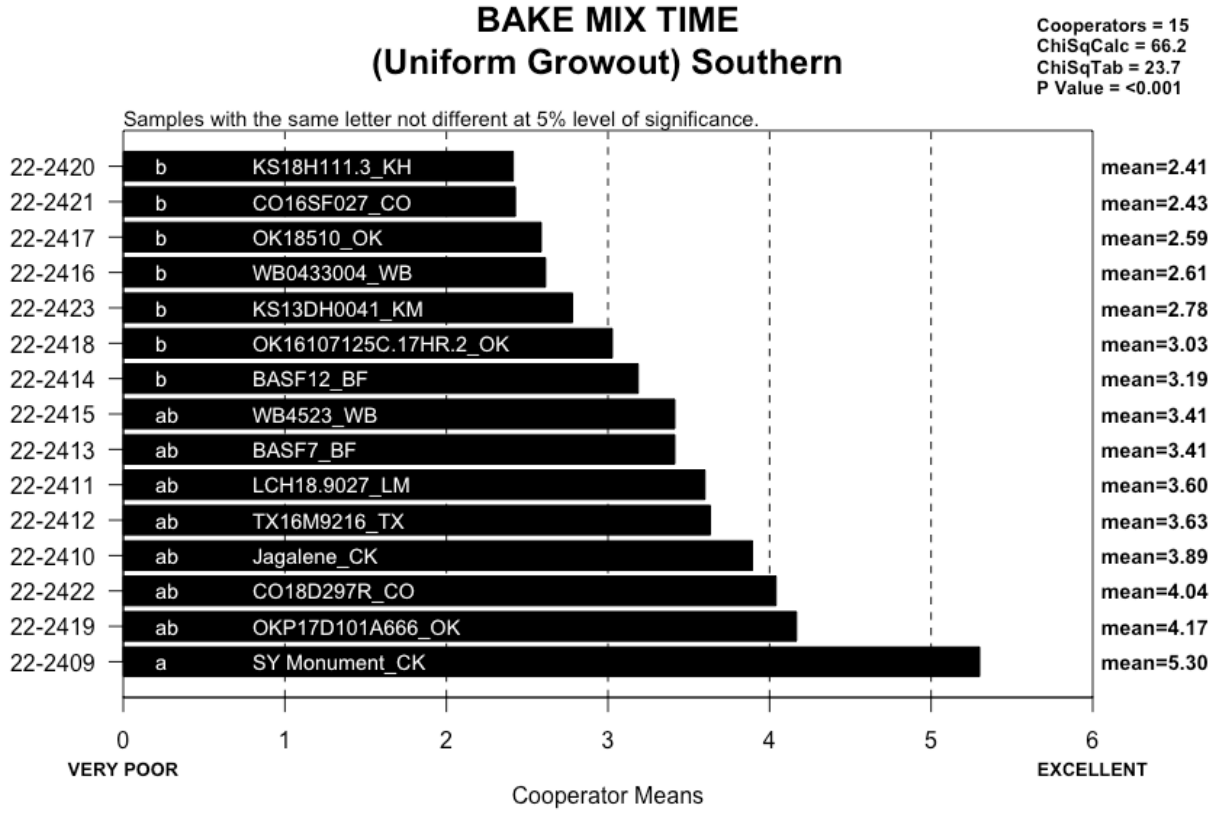


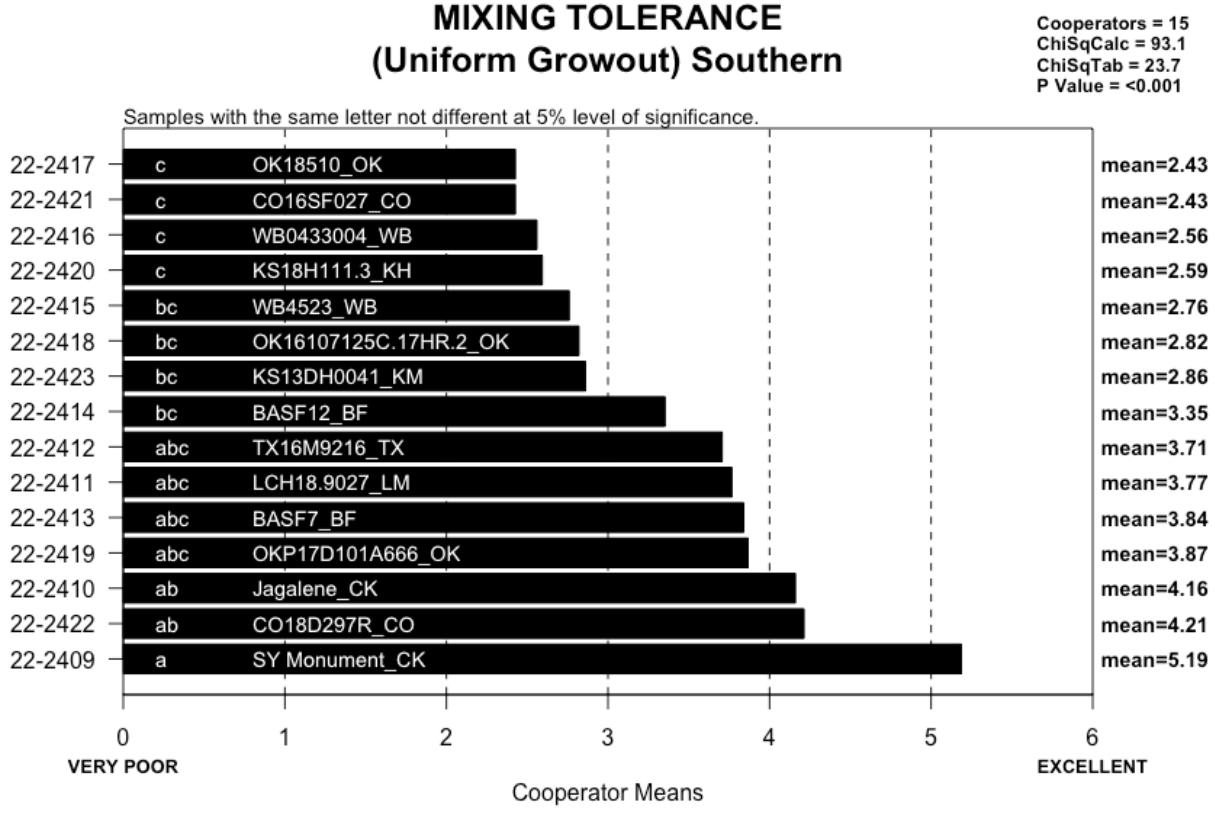
# BAKE ABSORPTION, ACTUAL (14% MB)
# (Uniform Growout) Southern
# Cooperators A – O

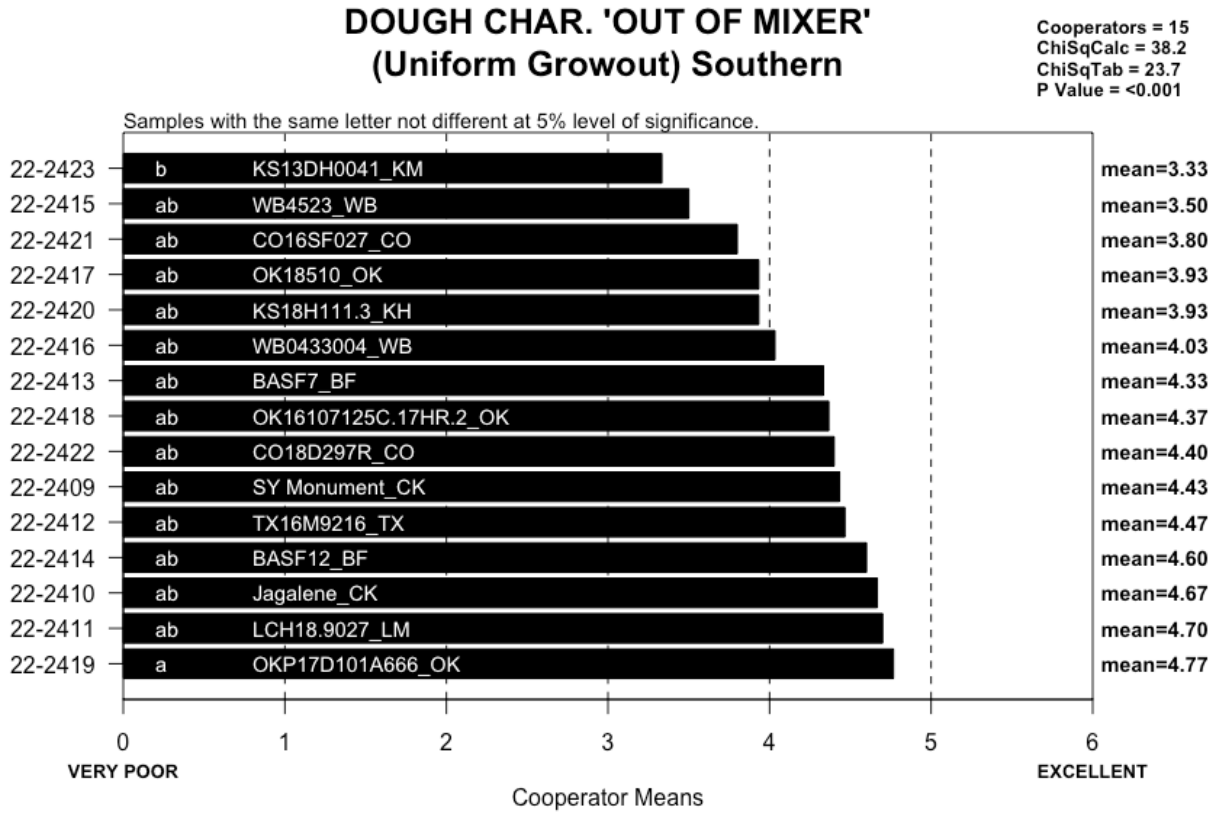
| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 58 | 66.7 | 65.1 | 69.0 | 68.3 | 64.9 | 64.1 | 60.9 | 66.6 | 68.0 | 64.1 | 71.1 | 68.4 | 66.9 | 64 |
| 22-2410 | Jagalene_CK | 59 | 66.2 | 65.9 | 72.2 | 68.9 | 67.8 | 67.0 | 62.6 | 69.3 | 69.6 | 67.0 | 74.5 | 69.4 | 68.5 | 67 |
| 22-2411 | LCH18.9027_LM | 59 | 67.3 | 66.9 | 71.9 | 68.3 | 67.9 | 66.9 | 62.4 | 68.1 | 69.6 | 66.9 | 74.7 | 70.1 | 65.9 | 67 |
| 22-2412 | TX16M9216_TX | 59 | 69.9 | 67.4 | 74.4 | 72.3 | 70.1 | 69.1 | 61.6 | 68.3 | 72.0 | 69.1 | 77.7 | 70.6 | 70.7 | 69 |
| 22-2413 | BASF7_BF | 59 | 69.5 | 66.1 | 70.4 | 68.7 | 66.2 | 65.5 | 60.8 | 69.5 | 68.0 | 65.5 | 73.4 | 71.3 | 68.6 | 66 |
| 22-2414 | BASF12_BF | 58 | 68.0 | 65.6 | 71.1 | 69.9 | 66.7 | 65.9 | 62.5 | 68.2 | 68.6 | 65.9 | 72.8 | 70.6 | 66.7 | 66 |
| 22-2415 | WB4523_WB | 57 | 67.3 | 64.7 | 73.1 | 71.7 | 70.3 | 68.4 | 61.5 | 67.7 | 71.7 | 68.4 | 77.5 | 69.7 | 70.2 | 68 |
| 22-2416 | WB0433004_WB | 58 | 67.6 | 66.1 | 74.7 | 70.4 | 71.0 | 69.5 | 62.0 | 68.7 | 72.8 | 69.5 | 78.2 | 70.8 | 72.4 | 70 |
| 22-2417 | OK18510_OK | 58 | 66.7 | 66.4 | 72.6 | 68.9 | 68.6 | 67.6 | 60.7 | 66.9 | 70.0 | 67.6 | 74.8 | 68.9 | 67.9 | 68 |
| 22-2418 | OK16107125C.17HR.2_OK | 59 | 72.0 | 68.1 | 75.9 | 72.6 | 72.4 | 70.8 | 62.1 | 69.8 | 73.8 | 70.8 | 78.9 | 71.9 | 72.9 | 71 |
| 22-2419 | OKP17D101A666_OK | 59 | 70.9 | 69.0 | 76.1 | 72.5 | 73.0 | 71.0 | 62.4 | 70.1 | 74.0 | 71.0 | 79.0 | 72.4 | 71.1 | 71 |
| 22-2420 | KS18H111.3_KH | 58 | 66.0 | 66.1 | 75.5 | 69.0 | 72.4 | 70.6 | 62.2 | 68.9 | 73.0 | 70.6 | 77.3 | 69.3 | 69.1 | 71 |
| 22-2421 | CO16SF027_CO | 58 | 66.4 | 64.9 | 75.7 | 66.4 | 72.3 | 70.9 | 62.0 | 69.2 | 73.2 | 70.9 | 75.0 | 69.2 | 67.9 | 71 |
| 22-2422 | CO18D297R_CO | 58 | 66.3 | 65.1 | 73.7 | 68.7 | 70.0 | 68.6 | 62.4 | 68.1 | 71.6 | 68.6 | 73.7 | 69.7 | 70.2 | 69 |
| 22-2423 | KS13DH0041_KM | 58 | 66.4 | 66.1 | 72.7 | 67.7 | 70.2 | 67.8 | 61.4 | 66.1 | 70.0 | 67.8 | 72.4 | 66.1 | 68.9 | 68 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 15 | 6.8 | 7.5 | 6.7 | 6.0 | 8.0 | 16.0 | 7 | 8.8 | 25 | 10.0 | 5.0 | 8.0 | 18 | 27 |
| 22-2410 | Jagalene_CK | 10 | 3.7 | 5.4 | 4.4 | 4.3 | 5.3 | 14.0 | 5 | 6.0 | 18 | 6.0 | 5.0 | 4.1 | 11 | 18 |
| 22-2411 | LCH18.9027_LM | 11 | 4.3 | 7.0 | 4.3 | 4.0 | 4.8 | 9.0 | 4 | 5.0 | 14 | 6.0 | 4.5 | 3.9 | 11 | 12 |
| 22-2412 | TX16M9216_TX | 10 | 4.2 | 4.5 | 4.1 | 4.0 | 5.3 | 15.5 | 4 | 5.0 | 12 | 6.0 | 5.0 | 4.5 | 10 | 12 |
| 22-2413 | BASF7_BF | 10 | 4.5 | 4.2 | 3.6 | 3.8 | 4.3 | 10.0 | 4 | 5.0 | 10 | 6.0 | 4.0 | 4.1 | 10 | 16 |
| 22-2414 | BASF12_BF | 8 | 3.7 | 4.8 | 4.5 | 4.0 | 4.3 | 13.0 | 4 | 4.3 | 8 | 4.5 | 4.5 | 3.9 | 10 | 14 |
| 22-2415 | WB4523_WB | 7 | 4.7 | 5.2 | 5.4 | 3.8 | 5.3 | 5.0 | 4 | 6.9 | 9 | 6.0 | 4.5 | 4.4 | 7 | 10 |
| 22-2416 | WB0433004_WB | 7 | 3.6 | 4.2 | 4.8 | 3.5 | 4.5 | 6.0 | 4 | 5.0 | 5 | 4.0 | 4.0 | 3.4 | 8 | 10 |
| 22-2417 | OK18510_OK | 6 | 3.4 | 5.8 | 3.6 | 3.5 | 3.5 | 6.0 | 4 | 4.0 | 8 | 6.0 | 4.0 | 3.0 | 7 | 8 |
| 22-2418 | OK16107125C.17HR.2_OK | 7 | 3.6 | 4.4 | 4.2 | 3.8 | 4.0 | 7.0 | 4 | 5.0 | 10 | 5.0 | 4.0 | 3.8 | 9 | 9 |
| 22-2419 | OKP17D101A666_OK | 9 | 4.8 | 7.0 | 4.9 | 4.8 | 5.5 | 9.0 | 6 | 5.8 | 20 | 7.0 | 5.3 | 5.1 | 14 | 15 |
| 22-2420 | KS18H111.3_KH | 6 | 3.6 | 4.2 | 4.4 | 3.5 | 3.8 | 7.0 | 4 | 4.0 | 6 | 6.0 | 4.5 | 3.4 | 6 | 7 |
| 22-2421 | CO16SF027_CO | 8 | 2.8 | 3.4 | 2.6 | 3.3 | 3.0 | 5.0 | 4 | 3.4 | 8 | 5.0 | 3.5 | 2.9 | 8 | 7 |
| 22-2422 | CO18D297R_CO | 9 | 4.0 | 5.6 | 5.6 | 4.5 | 5.3 | 8.0 | 5 | 6.5 | 12 | 8.0 | 5.0 | 4.9 | 10 | 16 |
| 22-2423 | KS13DH0041_KM | 6 | 3.8 | 4.2 | 3.8 | 3.5 | 4.0 | 11.0 | 4 | 4.5 | 8 | 6.0 | 5.0 | 2.9 | 6 | 10 |

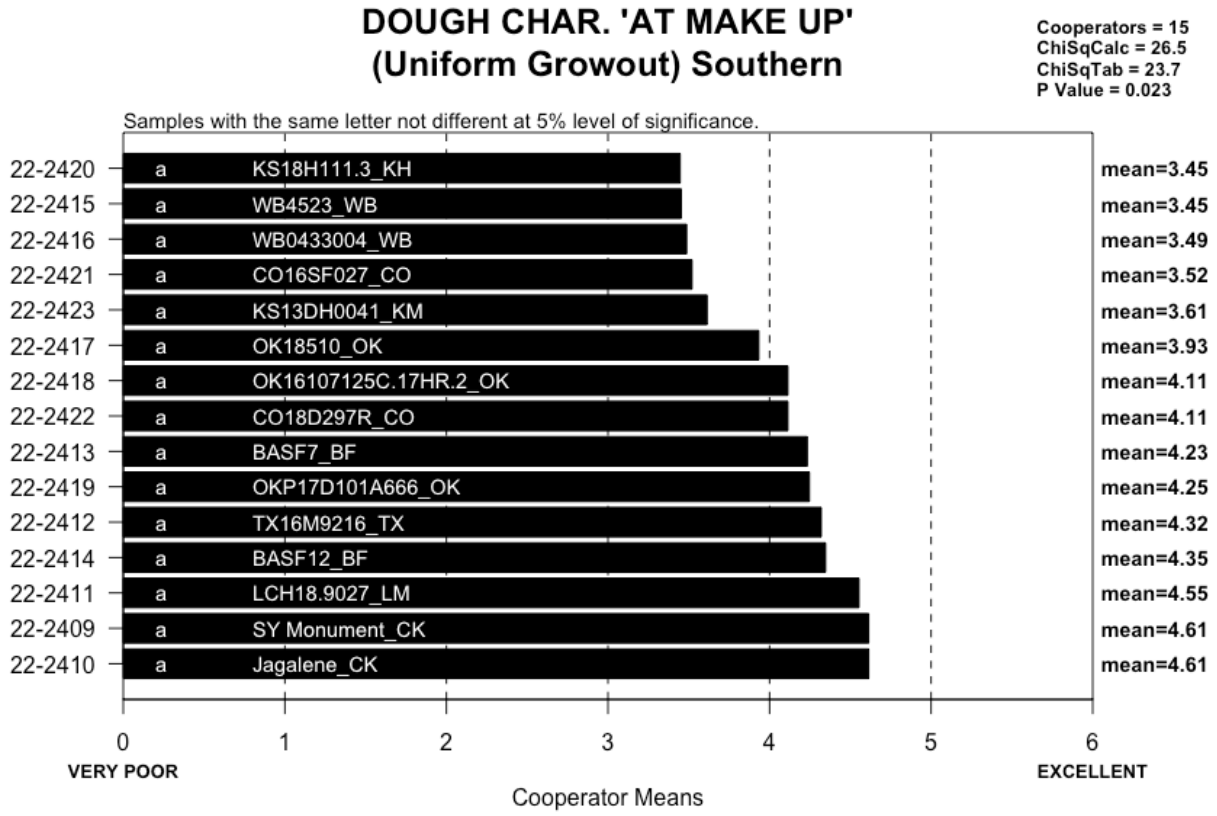

BAKE MIX TIME
(Uniform Growout) Southern
Cooperators = 15
ChiSqCalc = 66.2
ChiSqTab = 23.7
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
22-2420 b KS18H111.3_KH mean=2.41
22-2421 b CO16SF027_CO mean=2.43
22-2417 b OK18510_OK mean=2.59
22-2416 b WB0433004_WB mean=2.61
22-2423 b KS13DH0041_KM mean=2.78
22-2418 b OK16107125C.17HR.2_OK mean=3.03
22-2414 b BASF12_BF mean=3.19
22-2415 ab WB4523_WB mean=3.41
22-2413 ab BASF7_BF mean=3.41
22-2411 ab LCH18.9027_LM mean=3.60
22-2412 ab TX16M9216_TX mean=3.63
22-2410 ab Jagalene_CK mean=3.89
22-2422 ab CO18D297R_CO mean=4.04
22-2419 ab OKP17D101A666_OK mean=4.17
22-2409 a SY Monument_CK mean=5.30
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Uniform Growout) Southern
Cooperators = 15
ChiSqCalc = 93.1
ChiSqTab = 23.7
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
22-2417 c OK18510_OK mean=2.43
22-2421 c CO16SF027_CO mean=2.43
22-2416 c WB0433004_WB mean=2.56
22-2420 c KS18H111.3_KH mean=2.59
22-2415 bc WB4523_WB mean=2.76
22-2418 bc OK16107125C.17HR.2_OK mean=2.82
22-2423 bc KS13DH0041_KM mean=2.86
22-2414 bc BASF12_BF mean=3.35
22-2412 abc TX16M9216_TX mean=3.71
22-2411 abc LCH18.9027_LM mean=3.77
22-2413 abc BASF7_BF mean=3.84
22-2419 abc OKP17D101A666_OK mean=3.87
22-2410 ab Jagalene_CK mean=4.16
22-2422 ab CO18D297R_CO mean=4.21
22-2409 a SY Monument_CK mean=5.19
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means



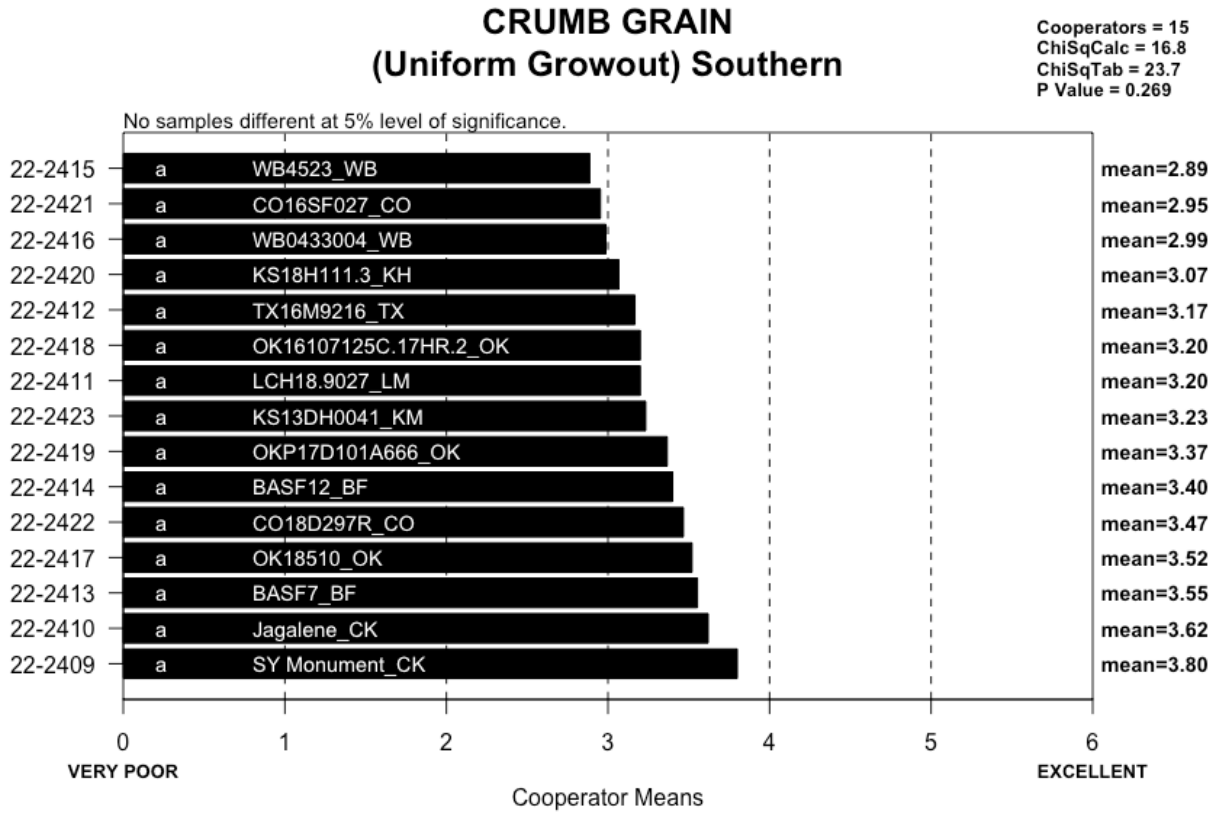

# DOUGH CHAR. 'OUT OF MIXER', DESCRIBED
## (Uniform Growout) Southern

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 3 | 0 | 5 | 6 | 1 |
| 22-2410 | Jagalene_CK | 1 | 0 | 3 | 10 | 1 |
| 22-2411 | LCH18.9027_LM | 3 | 0 | 1 | 8 | 3 |
| 22-2412 | TX16M9216_TX | 3 | 1 | 2 | 9 | 0 |
| 22-2413 | BASF7_BF | 3 | 1 | 1 | 9 | 1 |
| 22-2414 | BASF12_BF | 1 | 1 | 1 | 11 | 1 |
| 22-2415 | WB4523_WB | 4 | 3 | 1 | 6 | 1 |
| 22-2416 | WB0433004_WB | 4 | 3 | 1 | 6 | 1 |
| 22-2417 | OK18510_OK | 4 | 3 | 1 | 6 | 1 |
| 22-2418 | OK16107125C.17HR.2_OK | 3 | 0 | 3 | 9 | 0 |
| 22-2419 | OKP17D101A666_OK | 2 | 1 | 1 | 8 | 3 |
| 22-2420 | KS18H111.3_KH | 5 | 2 | 0 | 7 | 1 |
| 22-2421 | CO16SF027_CO | 6 | 3 | 1 | 4 | 1 |
| 22-2422 | CO18D297R_CO | 3 | 2 | 1 | 8 | 1 |
| 22-2423 | KS13DH0041_KM | 7 | 3 | 1 | 4 | 0 |




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

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 1 | 0 | 3 | 10 | 1 |
| 22-2410 | Jagalene_CK | 2 | 0 | 3 | 8 | 2 |
| 22-2411 | LCH18.9027_LM | 4 | 0 | 0 | 9 | 2 |
| 22-2412 | TX16M9216_TX | 6 | 0 | 0 | 8 | 1 |
| 22-2413 | BASF7_BF | 3 | 0 | 3 | 7 | 2 |
| 22-2414 | BASF12_BF | 3 | 2 | 1 | 8 | 1 |
| 22-2415 | WB4523_WB | 4 | 2 | 4 | 4 | 1 |
| 22-2416 | WB0433004_WB | 4 | 3 | 1 | 6 | 1 |
| 22-2417 | OK18510_OK | 6 | 0 | 1 | 6 | 2 |
| 22-2418 | OK16107125C.17HR.2_OK | 5 | 0 | 0 | 9 | 1 |
| 22-2419 | OKP17D101A666_OK | 4 | 0 | 2 | 7 | 2 |
| 22-2420 | KS18H111.3_KH | 5 | 2 | 1 | 7 | 0 |
| 22-2421 | CO16SF027_CO | 5 | 4 | 0 | 6 | 0 |
| 22-2422 | CO18D297R_CO | 5 | 1 | 0 | 8 | 1 |
| 22-2423 | KS13DH0041_KM | 7 | 2 | 0 | 6 | 0 |

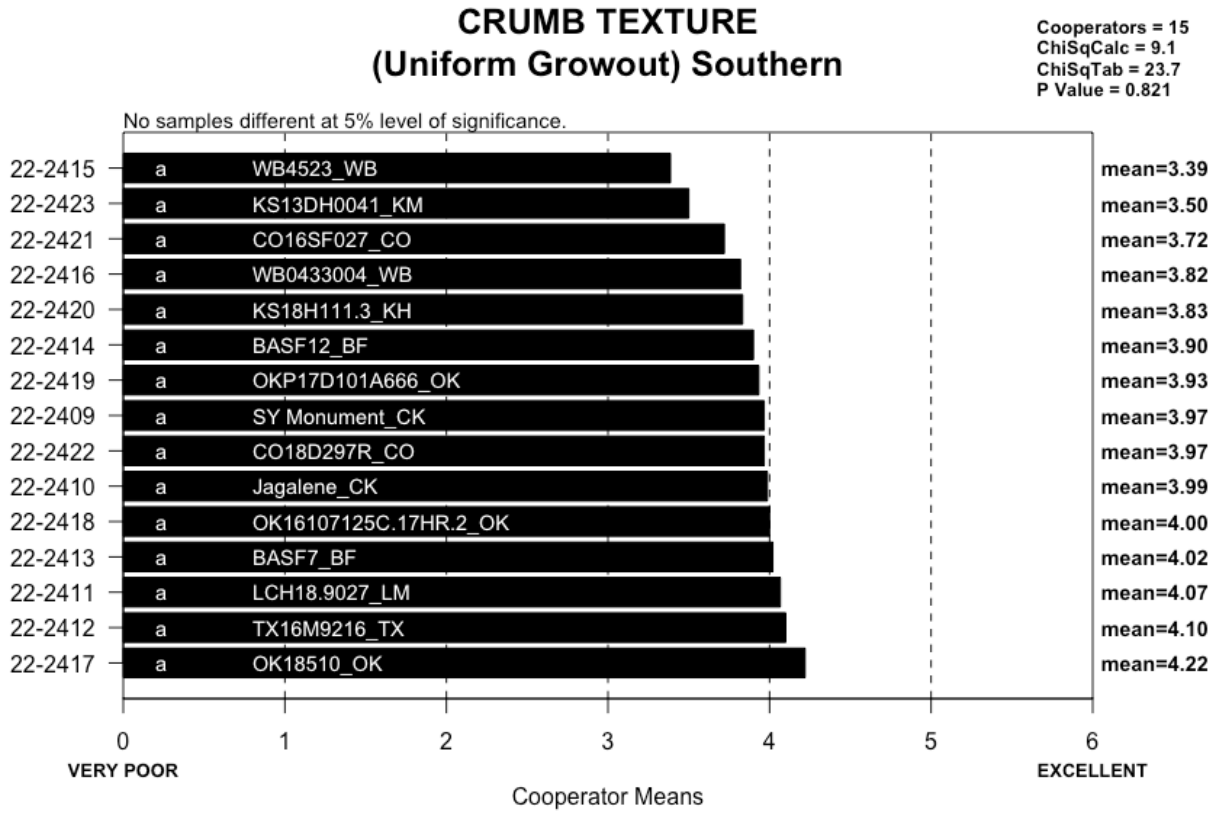



# CRUMB GRAIN, DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Open | Fine | Dense |
|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 7 | 6 | 2 |
| 22-2410 | Jagalene_CK | 10 | 5 | 0 |
| 22-2411 | LCH18.9027_LM | 10 | 4 | 1 |
| 22-2412 | TX16M9216_TX | 11 | 1 | 3 |
| 22-2413 | BASF7_BF | 8 | 7 | 0 |
| 22-2414 | BASF12_BF | 9 | 5 | 1 |
| 22-2415 | WB4523_WB | 8 | 3 | 4 |
| 22-2416 | WB0433004_WB | 11 | 2 | 2 |
| 22-2417 | OK18510_OK | 8 | 6 | 1 |
| 22-2418 | OK16107125C.17HR.2_OK | 10 | 3 | 2 |
| 22-2419 | OKP17D101A666_OK | 9 | 3 | 3 |
| 22-2420 | KS18H111.3_KH | 9 | 1 | 5 |
| 22-2421 | CO16SF027_CO | 10 | 2 | 3 |
| 22-2422 | CO18D297R_CO | 8 | 3 | 4 |
| 22-2423 | KS13DH0041_KM | 8 | 4 | 3 |

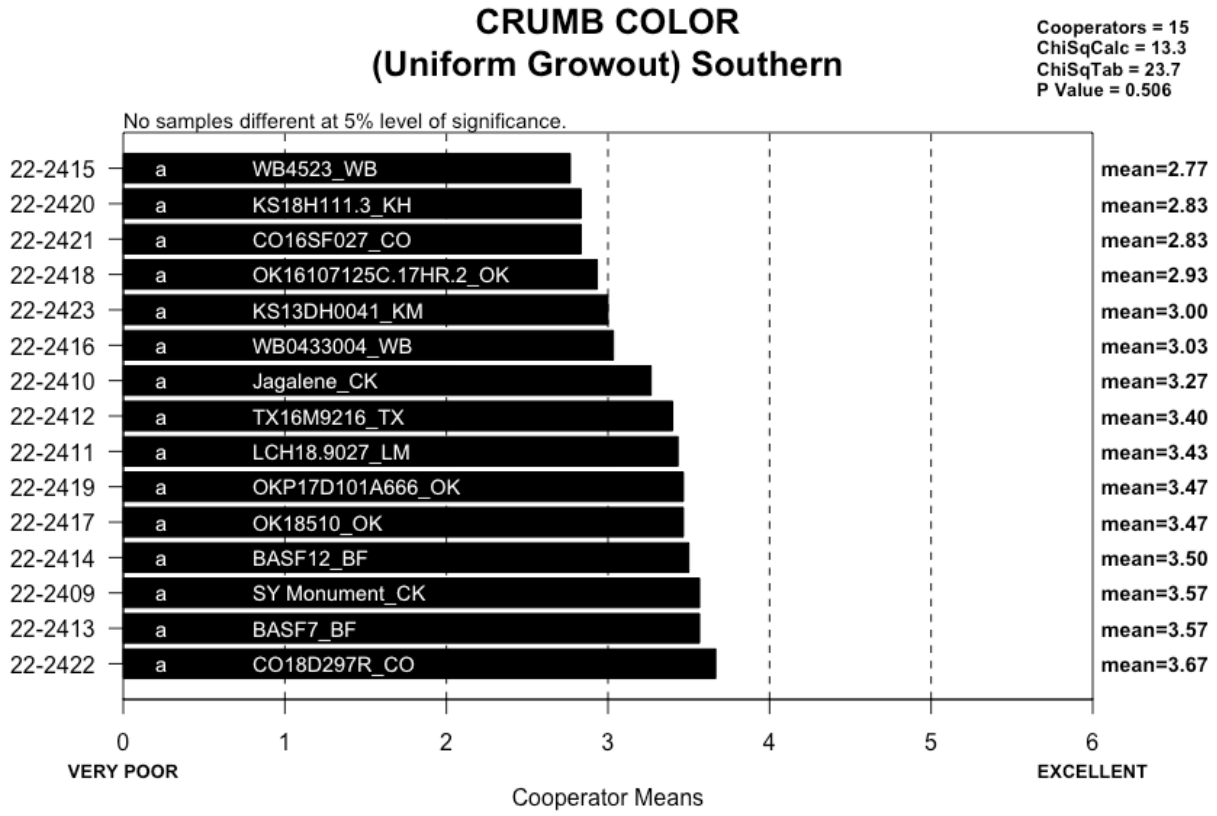
# CELL SHAPE, DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Round | Irregular | Elongated |
|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 4 | 6 | 5 |
| 22-2410 | Jagalene_CK | 4 | 7 | 4 |
| 22-2411 | LCH18.9027_LM | 8 | 5 | 2 |
| 22-2412 | TX16M9216_TX | 7 | 7 | 1 |
| 22-2413 | BASF7_BF | 7 | 5 | 3 |
| 22-2414 | BASF12_BF | 4 | 7 | 4 |
| 22-2415 | WB4523_WB | 6 | 7 | 2 |
| 22-2416 | WB0433004_WB | 7 | 7 | 1 |
| 22-2417 | OK18510_OK | 6 | 6 | 3 |
| 22-2418 | OK16107125C.17HR.2_OK | 8 | 5 | 2 |
| 22-2419 | OKP17D101A666_OK | 6 | 7 | 2 |
| 22-2420 | KS18H111.3_KH | 5 | 8 | 2 |
| 22-2421 | CO16SF027_CO | 7 | 7 | 1 |
| 22-2422 | CO18D297R_CO | 8 | 5 | 2 |
| 22-2423 | KS13DH0041_KM | 9 | 4 | 2 |




# CRUMB TEXTURE, DESCRIBED
# (Uniform Growout) Southern

| IDCODE | ID | Harsh | Smooth | Silky |
|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 5 | 6 | 4 |
| 22-2410 | Jagalene_CK | 3 | 8 | 4 |
| 22-2411 | LCH18.9027_LM | 2 | 10 | 3 |
| 22-2412 | TX16M9216_TX | 4 | 7 | 4 |
| 22-2413 | BASF7_BF | 3 | 7 | 5 |
| 22-2414 | BASF12_BF | 3 | 10 | 2 |
| 22-2415 | WB4523_WB | 6 | 7 | 2 |
| 22-2416 | WB0433004_WB | 5 | 8 | 2 |
| 22-2417 | OK18510_OK | 2 | 9 | 4 |
| 22-2418 | OK16107125C.17HR.2_OK | 4 | 8 | 3 |
| 22-2419 | OKP17D101A666_OK | 3 | 9 | 3 |
| 22-2420 | KS18H111.3_KH | 4 | 9 | 2 |
| 22-2421 | CO16SF027_CO | 5 | 9 | 1 |
| 22-2422 | CO18D297R_CO | 4 | 9 | 2 |
| 22-2423 | KS13DH0041_KM | 5 | 9 | 1 |




# CRUMB COLOR, DESCRIBED
# (Uniform Growout) Southern

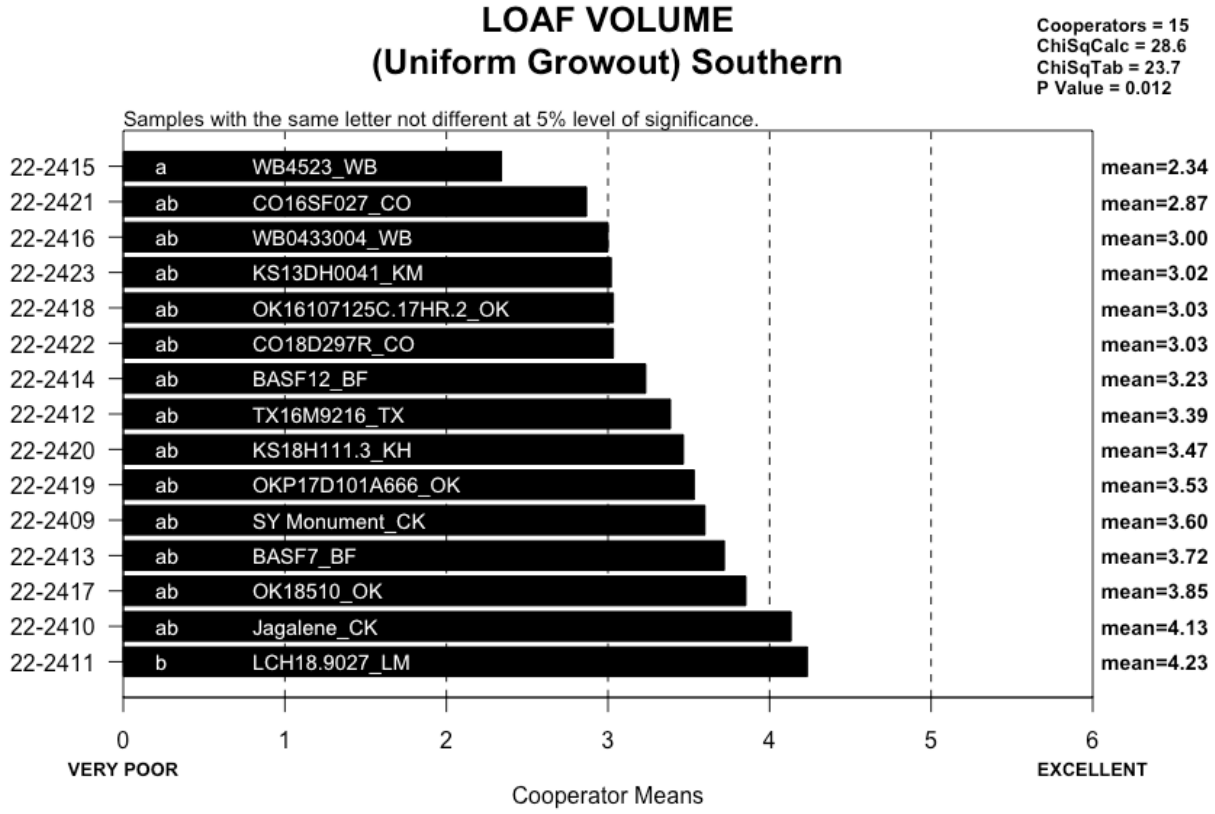
| IDCODE | ID | Gray | Dark_Yellow | Yellow | Dull | Creamy | White | Bright_White |
|---|---|---|---|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 0 | 0 | 4 | 1 | 8 | 2 | 0 |
| 22-2410 | Jagalene_CK | 0 | 0 | 4 | 4 | 6 | 1 | 0 |
| 22-2411 | LCH18.9027_LM | 0 | 1 | 4 | 2 | 6 | 2 | 0 |
| 22-2412 | TX16M9216_TX | 0 | 0 | 4 | 3 | 6 | 2 | 0 |
| 22-2413 | BASF7_BF | 0 | 0 | 4 | 2 | 6 | 3 | 0 |
| 22-2414 | BASF12_BF | 0 | 0 | 5 | 1 | 6 | 3 | 0 |
| 22-2415 | WB4523_WB | 0 | 3 | 5 | 1 | 4 | 2 | 0 |
| 22-2416 | WB0433004_WB | 0 | 3 | 2 | 3 | 6 | 1 | 0 |
| 22-2417 | OK18510_OK | 0 | 0 | 3 | 2 | 9 | 1 | 0 |
| 22-2418 | OK16107125C.17HR.2_OK | 0 | 1 | 4 | 3 | 6 | 1 | 0 |
| 22-2419 | OKP17D101A666_OK | 0 | 0 | 3 | 5 | 3 | 4 | 0 |
| 22-2420 | KS18H111.3_KH | 0 | 3 | 3 | 3 | 5 | 1 | 0 |
| 22-2421 | CO16SF027_CO | 0 | 3 | 2 | 3 | 6 | 1 | 0 |
| 22-2422 | CO18D297R_CO | 0 | 0 | 2 | 3 | 7 | 3 | 0 |
| 22-2423 | KS13DH0041_KM | 0 | 2 | 6 | 2 | 4 | 1 | 0 |

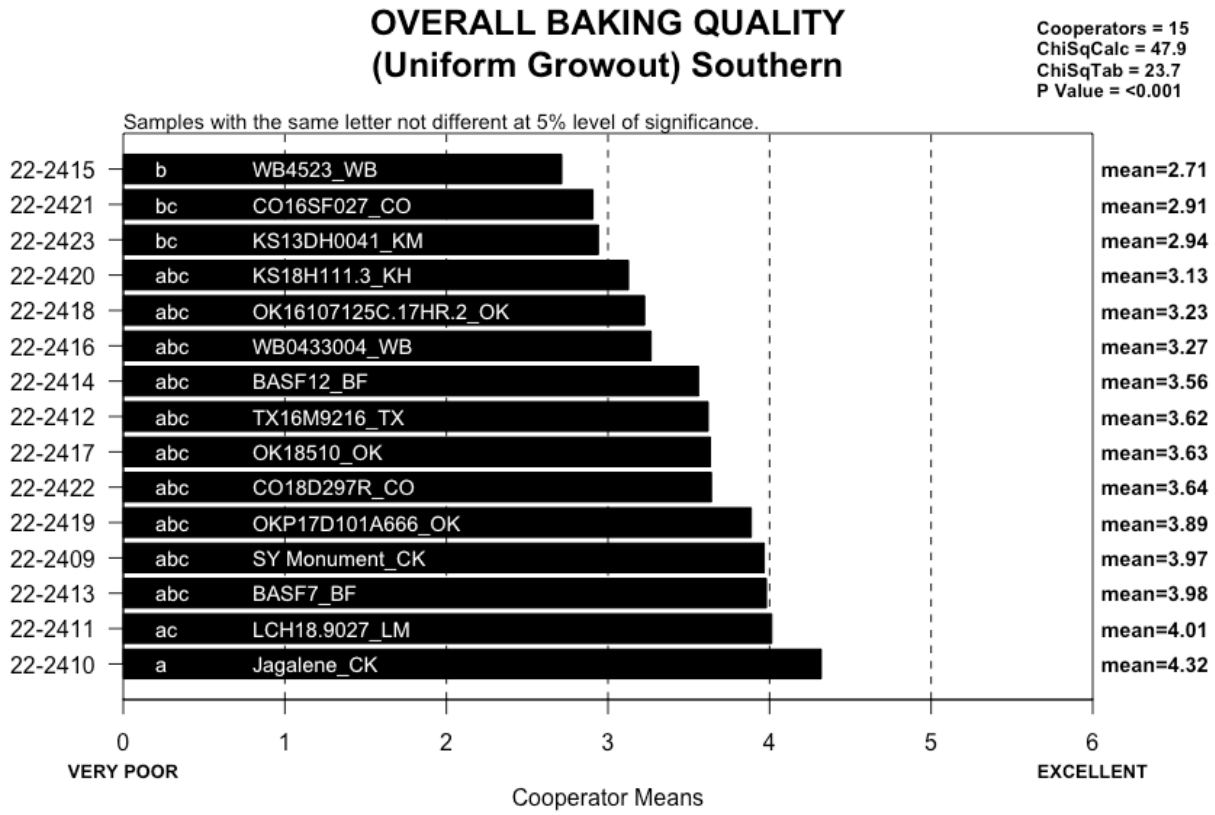
# LOAF WEIGHT, ACTUAL
# (Uniform Growout) Southern
# Cooperators A – O

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 419 | 150.5 | 144.9 | 137.0 | 146.3 | 146.3 | 452.0 | 481.7 | 153.2 | 445 | 459 | 131.5 | 144.7 | 430.7 | 478 |
| 22-2410 | Jagalene_CK | 419 | 155.8 | 145.6 | 136.2 | 146.7 | 148.1 | 446.5 | 472.9 | 155.9 | 438 | 454 | 133.5 | 145.6 | 426.2 | 473 |
| 22-2411 | LCH18.9027_LM | 418 | 155.4 | 140.8 | 135.2 | 147.8 | 146.8 | 451.5 | 480.0 | 152.4 | 433 | 460 | 136.6 | 146.3 | 423.9 | 471 |
| 22-2412 | TX16M9216_TX | 415 | 160.7 | 145.9 | 137.6 | 149.3 | 148.8 | 444.0 | 483.1 | 154.7 | 438 | 463 | 136.8 | 146.0 | 424.3 | 467 |
| 22-2413 | BASF7_BF | 415 | 160.2 | 145.3 | 137.1 | 145.2 | 148.8 | 447.5 | 485.6 | 158.1 | 441 | 456 | 142.9 | 146.9 | 420.5 | 474 |
| 22-2414 | BASF12_BF | 417 | 158.3 | 143.2 | 136.2 | 148.1 | 148.2 | 450.5 | 483.9 | 156.3 | 440 | 456 | 141.2 | 146.2 | 429.0 | 476 |
| 22-2415 | WB4523_WB | 416 | 162.9 | 144.8 | 139.2 | 147.9 | 150.3 | 442.5 | 481.2 | 154.8 | 439 | 458 | 135.0 | 144.8 | 426.9 | 472 |
| 22-2416 | WB0433004_WB | 419 | 156.5 | 147.1 | 136.6 | 148.6 | 150.6 | 442.5 | 479.0 | 155.7 | 438 | 454 | 141.1 | 146.6 | 423.6 | 467 |
| 22-2417 | OK18510_OK | 420 | 153.6 | 145.0 | 138.0 | 147.1 | 148.0 | 444.5 | 480.8 | 153.9 | 438 | 470 | 138.5 | 146.4 | 425.9 | 470 |
| 22-2418 | OK16107125C.17HR.2_OK | 421 | 156.6 | 147.7 | 137.9 | 149.2 | 151.6 | 444.0 | 483.4 | 155.5 | 442 | 462 | 138.5 | 146.2 | 430.8 | 468 |
| 22-2419 | OKP17D101A666_OK | 418 | 152.3 | 144.0 | 135.1 | 150.0 | 151.5 | 447.5 | 480.3 | 157.0 | 439 | 457 | 135.4 | 145.4 | 425.8 | 468 |
| 22-2420 | KS18H111.3_KH | 417 | 156.4 | 145.6 | 135.1 | 146.8 | 148.4 | 439.0 | 480.0 | 157.8 | 450 | 456 | 140.6 | 145.1 | 425.3 | 463 |
| 22-2421 | CO16SF027_CO | 419 | 155.3 | 142.9 | 137.5 | 143.0 | 148.5 | 442.0 | 481.4 | 155.7 | 433 | 457 | 136.8 | 146.5 | 434.2 | 462 |
| 22-2422 | CO18D297R_CO | 417 | 156.8 | 141.5 | 138.4 | 142.4 | 149.0 | 461.5 | 480.3 | 154.4 | 442 | 458 | 141.6 | 145.9 | 426.2 | 470 |
| 22-2423 | KS13DH0041_KM | 416 | 152.3 | 145.9 | 139.1 | 144.8 | 146.9 | 440.0 | 480.5 | 153.9 | 445 | 456 | 135.6 | 144.7 | 424.6 | 471 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2409 | SY Monument_CK | 2650 | 909 | 880 | 847 | 1065 | 744 | 1984 | 2313 | 905 | 2115 | 2480 | 790 | 740 | 2700 | 2706 |
| 22-2410 | Jagalene_CK | 2725 | 910 | 950 | 863 | 975 | 758 | 2085 | 2488 | 975 | 2332 | 2437 | 960 | 810 | 2725 | 2677 |
| 22-2411 | LCH18.9027_LM | 2725 | 1035 | 1050 | 938 | 1035 | 890 | 1679 | 2363 | 1090 | 2231 | 2269 | 1025 | 925 | 2725 | 2530 |
| 22-2412 | TX16M9216_TX | 2650 | 915 | 860 | 780 | 965 | 731 | 1780 | 2238 | 940 | 2256 | 2278 | 915 | 810 | 2525 | 2692 |
| 22-2413 | BASF7_BF | 2725 | 928 | 883 | 879 | 1000 | 765 | 1855 | 2275 | 990 | 2199 | 2494 | 900 | 855 | 2525 | 2648 |
| 22-2414 | BASF12_BF | 2650 | 913 | 885 | 816 | 935 | 721 | 1781 | 2413 | 915 | 2139 | 2300 | 890 | 785 | 2575 | 2633 |
| 22-2415 | WB4523_WB | 2550 | 729 | 760 | 693 | 830 | 572 | 2127 | 2325 | 780 | 2121 | 2247 | 890 | 705 | 2500 | 2604 |
| 22-2416 | WB0433004_WB | 2650 | 800 | 800 | 759 | 875 | 685 | 2130 | 2400 | 875 | 2196 | 2224 | 830 | 745 | 2550 | 2633 |
| 22-2417 | OK18510_OK | 2800 | 895 | 953 | 868 | 920 | 741 | 1966 | 2413 | 915 | 2262 | 2342 | 975 | 850 | 2650 | 2662 |
| 22-2418 | OK16107125C.17HR.2_OK | 2650 | 864 | 873 | 805 | 895 | 711 | 1897 | 2163 | 900 | 2153 | 2316 | 875 | 775 | 2525 | 2663 |
| 22-2419 | OKP17D101A666_OK | 2650 | 873 | 983 | 819 | 1040 | 736 | 1837 | 2213 | 925 | 2260 | 2311 | 940 | 765 | 2475 | 2648 |
| 22-2420 | KS18H111.3_KH | 2650 | 827 | 835 | 811 | 900 | 704 | 2031 | 2375 | 900 | 2273 | 2292 | 935 | 805 | 2450 | 2648 |
| 22-2421 | CO16SF027_CO | 2675 | 830 | 800 | 789 | 860 | 685 | 1741 | 2313 | 905 | 2190 | 2231 | 890 | 780 | 2400 | 2382 |
| 22-2422 | CO18D297R_CO | 2775 | 822 | 848 | 751 | 915 | 662 | 1689 | 2238 | 890 | 2150 | 2247 | 935 | 770 | 2475 | 2662 |
| 22-2423 | KS13DH0041_KM | 2750 | 825 | 835 | 753 | 865 | 670 | 1898 | 2275 | 890 | 2207 | 2387 | 850 | 710 | 2625 | 2618 |


LOAF VOLUME
(Uniform Growout) Southern
Cooperators = 15
ChiSqCalc = 28.6
ChiSqTab = 23.7
P Value = 0.012
Samples with the same letter not different at 5% level of significance.
22-2415 a WB4523_WB mean=2.34
22-2421 ab CO16SF027_CO mean=2.87
22-2416 ab WB0433004_WB mean=3.00
22-2423 ab KS13DH0041_KM mean=3.02
22-2418 ab OK16107125C.17HR.2_OK mean=3.03
22-2422 ab CO18D297R_CO mean=3.03
22-2414 ab BASF12_BF mean=3.23
22-2412 ab TX16M9216_TX mean=3.39
22-2420 ab KS18H111.3_KH mean=3.47
22-2419 ab OKP17D101A666_OK mean=3.53
22-2409 ab SY Monument_CK mean=3.60
22-2413 ab BASF7_BF mean=3.72
22-2417 ab OK18510_OK mean=3.85
22-2410 ab Jagalene_CK mean=4.13
22-2411 b LCH18.9027_LM mean=4.23
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Uniform Growout) Southern
Cooperators = 15
ChiSqCalc = 47.9
ChiSqTab = 23.7
P Value = <0.001
Samples with the same letter not different at 5% level of significance.
22-2415 b WB4523_WB mean=2.71
22-2421 bc CO16SF027_CO mean=2.91
22-2423 bc KS13DH0041_KM mean=2.94
22-2420 abc KS18H111.3_KH mean=3.13
22-2418 abc OK16107125C.17HR.2_OK mean=3.23
22-2416 abc WB0433004_WB mean=3.27
22-2414 abc BASF12_BF mean=3.56
22-2412 abc TX16M9216_TX mean=3.62
22-2417 abc OK18510_OK mean=3.63
22-2422 abc CO18D297R_CO mean=3.64
22-2419 abc OKP17D101A666_OK mean=3.89
22-2409 abc SY Monument_CK mean=3.97
22-2413 abc BASF7_BF mean=3.98
22-2411 ac LCH18.9027_LM mean=4.01
22-2410 a Jagalene_CK mean=4.32
0 1 2 3 4 5 6
VERY POOR
EXCELLENT
Cooperator Means

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP. 22-2409 SY Monument_CK**

A. Strong dough, long mix, low loaf volume, slightly open grain and creamy interior.
B. No comment.
C. High water absorption, long mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. Excellent loaf externals.
F. Average protein, long mix time.
G. No comment.
H. Average absorption, good mixing time and tolerance, good grain, low volume.
I. Long mix time, average absorption and grain, good mixing tolerance, good volume.
J. No comment.
K. No comment.
L. Small yellow colored loaf.
M. No comment.
N. Good protein and volume. High mix tolerance.
O. High absorption, excellent mix time and stability, dough handling, lacking in volume, improved volume to 2809 cc at 62% absorption, recommend lower absorption.

**COOP. 22-2410 Jagalene_CK**

A. Good dough out of mixer, average mix and volume, creamy interior, slightly open grain.
B. No comment.
C. Very high water absorption, medium mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, open elongate cells, good resilient and smooth texture.
D. No comment.
E. No comment.
F. No comment.
G. One side bulge.
H. High absorption, good grain, average volume.
I. Very high absorption, open grain, excellent volume.
J. No comment.
K. No comment.
L. No comment.
M. No comment.
N. Good protein and volume. High absorption. Fair mix tolerance and dough feels.
O. High absorption, good mix time and stability, dough handling, lacking in volume, improved volume to 2839 cc at 62% absorption, recommend lower absorption.

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP. 22-2411 LCH18-9027_LM**

A. Good dough out of mixer, average mix and volume, creamy interior, slightly open grain.
B. No comment.
C. Very high water abs, medium mix time, slight sticky and strong dough, super high loaf volume, yellow crumb grain, open elongate cells, soft resilient and smooth texture.
D. No comment.
E. Nice loaf externals.
F. Nice dough and crumb characteristics, soft crumb structure, good volume.
G. Very gummy, potentially over absorbed.
H. High absorption, low mixing time and tolerance, dense grain, dark yellow crumb, low volume.
I. High absorption, good dough character, excellent volume.
J. No comment.
K. No comment.
L. Crumb is average but yellow in color, largest volume.
M. No comment.
N. High protein, good volume. Fair mix tolerance.
O. High absorption, lower mix time and stability, slack and sticky dough handling, lacking in volume, improved volume to 2633 cc at 62% absorption, recommend lower absorption <62%, poor overall performance.

**COOP. 22-2412 TX16M9216_TX**

A. Good dough out of mixer, average mix and volume, creamy interior, pen grain.
B. No comment.
C. Very high water absorption, medium mix time, slight sticky and strong dough, mid high loaf volume, yellow crumb grain, open elongate cells, good resilient and slightly harsh texture.
D. No comment.
E. Nice loaf externals.
F. No comment.
G. No comment.
H. Average absorption, low mixing time and tolerance, very low volume.
I. High absorption, good volume.
J. No comment.
K. No comment.
L. No comment.
M. No comment.
N. High protein and absorption. Fair ix tolerance. Volume could be improved.
O. High absorption, lower mix time and stability, slack and sticky dough handling, lacking in volume, improved volume to 2780 cc at 62% absorption. Recommend lower absorption < 62%, poor overall performance.

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP. 22-2413 BASF7_BF**

A. Good dough out of mixer, average mix and volume, creamy interior, open grain.
B. No comment.
C. Very high water absorption, medium mix time, slight sticky and strong dough, high loaf volume, dull crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. Excellent loaf externals.
F. No comment.
G. Flat top.
H. Average absorption, open grain, very low volume.
I. Very high absorption, good grain, excellent volume.
J. No comment.
K. No comment.
L. Poor crumb and yellow color.
M. No comment.
N. High protein and absorption. Fair mix tolerance. Volume could be improved.
O. High absorption, good mix time and stability and dough handling, lacking in volume. No improvement at 62% absorption.

**COOP. 22-2414 BASF12_BF**

A. Shorter mix but good pliable dough low loaf volume, nice crumb grain. Creamy interior.
B. No comment.
C. High water absorption, medium mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. Nice loaf externals.
F. Good crumb resilience.
G. Some larger holes.
H. High absorption, low mixing time and tolerance, good grain.
I. High absorption, good grain and volume.
J. No comment.
K. No comment.
L. Open and irregular crumb.
M. No comment.
N. Good protein and absorption. Fair mix tolerance and volume.
O. High absorption, average mix time and stability, good dough handling, lacking in volume. No improvement at 62% absorption.

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP. 22-2415 WB4523_WB**

A. Shorter mix but good pliable dough, low loaf volume, nice crumb grain and creamy interior.
B. No comment.
C. Mid high-water absorption, medium mix time, slight sticky and strong dough, fair loaf volume, dark yellow crumb grain, open irregular cells, good resilient and harsh texture.
D. No comment.
E. Weak dough, left and right break.
F. Poor dough and loaf characteristics.
G. One of the shortest mix time.
H. Average absorption, low mixing time and tolerance, dark yellow crumb, low volume. Tough sponge character with no volume resulting dough was sticky and tough.
I. Tough lifeless dough with no gas retention, dense grain, dark yellow crumb, low volume. Low protein flour.
J. No comment.
K. No comment.
L. Poor crumb and very yellow color.
M. No comment.
N. Fair protein, high absorption. Low mix tolerance. Volume could be improved.
O. High absorption, low mix time and stability, slack and sticky dough handling, lacking in volume, slight improvement at 62% absorption to 2633. Recommend lower absorption <62% poor overall.

**COOP. 22-2416 WB0433004_WB**

A. Shorter mix but good pliable dough, low loaf volume. Nice crumb grain. Creamy interior.
B. No comment.
C. High water absorption, medium mix time, slight sticky and strong dough, fair loaf volume, dark yellow crumb grain, open irregular cells, good resilient and harsh texture.
D. No comment.
E. Cap
F. No comment.
G. No comment.
H. High absorption, low mixing time and tolerance, open grain, dark yellow crumb. Tough sponge character, sticky wet dough.
I. High absorption, low mixing tolerance, open grain, dark yellow crumb, average volume.
J. No comment.
K. No comment.
L. Small loaf with yellow color, not well suited for bread.
M. No comment.
N. Good protein, high absorption. Low mix tolerance. Volume could be improved.
O. High absorption, low mix time and stability, slack and sticky dough handling, lacking in volume, improved volume to 2751 cc at 62% absorption recommend lower absorption < 62% for optimization.

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP. 22-2417 OK18510_OK**

A. Short mix, slightly open grain, average loaf volume.
B. No comment.
C. High water absorption, medium mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. Left and right break.
F. No comment.
G. No comment.
H. Average absorption, low mixing time and tolerance, sticky dough character.
I. Average absorption, low mixing tolerance, open grain, good volume.
J. No comment.
K. No comment.
L. Very good crumb but not best color.
M. No comment.
N. Good protein, absorption, and volume. Low mix tolerance.
O. High absorption, low mix time and stability, slack and sticky dough handling, lacking in volume, no improvement at 62% absorption, poor overall performance.

**COOP. 22-2418 OK16107125C-17HR-2_OK**

A. Shorter mix but good pliable dough, low loaf volume, nice crumb grain, creamy interior.
B. No comment.
C. Very high water absorption, medium mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, open elongate cells, good resilient and smooth texture.
D. No comment.
E. No comment.
F. Higher than average protein, low tolerance.
G. No comment.
H. High absorption, low mixing time and tolerance, dense grain, dark yellow crumb, poor volume. Tough sponge character.
I. Very high absorption, good volume.
J. No comment.
K. No comment.
L. Poor color but average crumb.
M. No comment.
N. High protein and absorption. Low mix tolerance. Volume could be improved.
O. High absorption, low mix time and stability, slack and sticky dough handling, lacking in volume, no improvement at 62% absorption, poor overall performance.

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP. 22-2419 OKP17D101A666_OK**

A. Good dough out of mixer and make up average mix, lower protein, open grain, slightly dull interior.
B. No comment.
C. Very high water absorption, long mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. Nice loaf externals.
F. Higher than average protein, water absorption, and crumb resilience.
G. Large holes.
H. High absorption, good mixing time, dense grain, very low volume. Tough sponge character with no volume.
I. Very high absorption, good mixing tolerance, good volume.
J. No comment.
K. No comment.
L. Good loaf symmetry but average crumb.
M. No comment.
N. High protein and absorption. Fair mix tolerance, volume could be improved.
O. High absorption, average mix time and stability and dough handling, lacking in volume, improved volume to 2780 cc at 62% absorption. Recommend lower absorption < 62% for optimization.

**COOP. 22-2420 KS18H111-3_KH**

A. Good dough out of mixer and make up, average mix, lower protein, open grain, slightly dull interior.
B. No comment.
C. High water absorption, medium mix time, slight sticky and strong dough, fair loaf volume, dark yellow crumb grain, open round cells, good resilient and harsh texture.
D. No comment.
E. Nice loaf externals.
F. Good crumb springiness.
G. No comment.
H. High absorption, low mixing time and tolerance, sticky dough at makeup, open grain, dark yellow crumb, low volume.
I. High absorption, low mixing tolerance, dense grain, dark yellow crumb, good volume.
J. No comment.
K. No comment.
L. No comment.
M. No comment.
N. Fair protein. High absorption, low mix tolerance, volume could be improved.
O. High absorption, low mix time and stability, slack and sticky dough handling, lacking in volume, no improvement at 62$ absorption. Poor overall performance.

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP. 22-2421 CO16SF027_CO**

A. Good dough out of mixer and makeup. Average mix, lower protein, open grain. Slightly dull interior.
B. No comment.
C. High water absorption, short mix time, slight sticky and strong dough, fair loaf volume, dark yellow crumb grain, open round cells, good resilient and slightly harsh texture.
D. No comment.
E. Slight cap
F. Good crumb resilience.
G. One of the shortest mix time, flat top.
H. High absorption, low mixing time and tolerance, dense grain, dark yellow crumb, low volume.
I. Very high absorption, open grain, dark yellow crumb, good volume.
J. No comment.
K. No comment.
L. No comment.
M. No comment.
N. Good protein and absorption. Low mix tolerance. Unideal dough feels. Volume could be improved.
O. High absorption, low mix time and stability, slack and sticky dough handling, lacking in volume, no improvement at 62% absorption. Poor overall performance.

**COOP. 22-2422 CO18D297R_CO**

A. Good dough out of mixer and makeup, average mix, lower protein, open grain. Slightly dull interior.
B. No comment.
C. High water absorption, medium mix time, slight sticky and strong dough, medium loaf volume, creamy crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. No comment.
F. No comment.
G. No comment.
H. High absorption, very low volume.
I. High absorption, average volume.
J. No comment.
K. No comment.
L. Good loaf symmetry, dense harsh texture crumb.
M. No comment.
N. Good protein and dough feels. Fair mix tolerance. High absorption. Volume could be improved.
O. High absorption, average mix time and stability and dough handling, lacking in volume, similar volume at 62% absorption (improved dough handling).

# COOPERATOR'S COMMENTS
## (Small Scale) Southern

**COOP.** **22-2423** **KS13DH0041-35_KM**

A. Good dough out of mixer and makeup. Average mix, lower protein, open grain, slightly dull interior.
B. No comment.
C. High water absorption, medium mix time, slight sticky and strong dough, medium loaf volume, yellow crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. Slight cap.
F. No comment.
G. No comment.
H. Average absorption, low mix time and tolerance, sticky wet dough, dense grain, dark yellow crumb, very low volume.
I. Average absorption, low mixing tolerance, open grain, dark yellow crumb, average volume.
J. No comment.
K. No comment.
L. Poor crumb and yellow color.
M. No comment.
N. Good protein, volume, and dough feels. Low mix tolerance.
O. High absorption, low mix time and stability, slack and sticky dough handling, lacking in volume, no improvement at 62% absorption, poor overall performance.

Notes: **A, G, H, J, N, and O** conducted sponge and dough bake tests

# MICRO-QUALITY ANALYSIS

| Entry_Code | Entry_ID | Entry_No | Breeding Programs | Locations* |
|---|---|---|---|---|
| 22-AP2409 | SY Monument | 2409 | Check | AP |
| 22-AP2410 | Jagalene | 2410 | Check | AP |
| 22-AP2411 | LCH18-0027 | 2411 | Limagrain | AP |
| 22-AP2412 | TX16M9216 | 2412 | Texas A&M College Station | AP |
| 22-AP2413 | BASF7 | 2413 | BASF | AP |
| 22-AP2414 | BASF12 | 2414 | BASF | AP |
| 22-AP2415 | WB4523 | 2415 | Bayer/WestBred | AP |
| 22-AP2416 | WB0433004 | 2416 | Bayer/WestBred | AP |
| 22-AP2417 | OK18510 | 2417 | OSU | AP |
| 22-AP2418 | OK16107125C-17HR-2 | 2418 | OSU | AP |
| 22-AP2419 | OKP17D101A666 | 2419 | OSU | AP |
| 22-AP2420 | KS18H111-3 | 2420 | KSU-Hays | AP |
| 22-AP2421 | CO16SF027 | 2421 | CSU | AP |
| 22-AP2422 | CO18D297R | 2422 | CSU | AP |
| 22-AP2423 | KS13DH0041-35 | 2423 | KSU-Manhhatan | AP |
| 22-KH2409 | SY Monument | 2409 | Check | KH |
| 22-KH2410 | Jagalene | 2410 | Check | KH |
| 22-KH2411 | LCH18-0027 | 2411 | Limagrain | KH |
| 22-KH2412 | TX16M9216 | 2412 | Texas A&M College Station | KH |
| 22-KH2413 | BASF7 | 2413 | BASF | KH |
| 22-KH2414 | BASF12 | 2414 | BASF | KH |
| 22-KH2415 | WB4523 | 2415 | Bayer/WestBred | KH |
| 22-KH2416 | WB0433004 | 2416 | Bayer/WestBred | KH |
| 22-KH2417 | OK18510 | 2417 | OSU | KH |
| 22-KH2418 | OK16107125C-17HR-2 | 2418 | OSU | KH |
| 22-KH2419 | OKP17D101A666 | 2419 | OSU | KH |
| 22-KH2420 | KS18H111-3 | 2420 | KSU-Hays | KH |
| 22-KH2421 | CO16SF027 | 2421 | CSU | KH |
| 22-KH2422 | CO18D297R | 2422 | CSU | KH |
| 22-KH2423 | KS13DH0041-35 | 2423 | KSU-Manhhatan | KH |
| 22-LM2409 | SY Monument | 2409 | Check | LM |
| 22-LM2410 | Jagalene | 2410 | Check | LM |
| 22-LM2411 | LCH18-0027 | 2411 | Limagrain | LM |
| 22-LM2412 | TX16M9216 | 2412 | Texas A&M College Station | LM |
| 22-LM2413 | BASF7 | 2413 | BASF | LM |
| 22-LM2414 | BASF12 | 2414 | BASF | LM |
| 22-LM2415 | WB4523 | 2415 | Bayer/WestBred | LM |
| 22-LM2416 | WB0433004 | 2416 | Bayer/WestBred | LM |
| 22-LM2417 | OK18510 | 2417 | OSU | LM |
| 22-LM2418 | OK16107125C-17HR-2 | 2418 | OSU | LM |
| 22-LM2419 | OKP17D101A666 | 2419 | OSU | LM |
| 22-LM2420 | KS18H111-3 | 2420 | KSU-Hays | LM |
| 22-LM2421 | CO16SF027 | 2421 | CSU | LM |
| 22-LM2422 | CO18D297R | 2422 | CSU | LM |
| 22-LM2423 | KS13DH0041-35 | 2423 | KSU-Manhhatan | LM |

| Entry_Code | Entry_ID | Entry_No | Breeding Programs | Locations* |
|---|---|---|---|---|
| 22-OK2409 | SY Monument | 2409 | Check | OK |
| 22-OK2410 | Jagalene | 2410 | Check | OK |
| 22-OK2411 | LCH18-0027 | 2411 | Limagrain | OK |
| 22-OK2412 | TX16M9216 | 2412 | Texas A&M College Station | OK |
| 22-OK2413 | BASF7 | 2413 | BASF | OK |
| 22-OK2414 | BASF12 | 2414 | BASF | OK |
| 22-OK2415 | WB4523 | 2415 | Bayer/WestBred | OK |
| 22-OK2416 | WB0433004 | 2416 | Bayer/WestBred | OK |
| 22-OK2417 | OK18510 | 2417 | OSU | OK |
| 22-OK2418 | OK16107125C-17HR-2 | 2418 | OSU | OK |
| 22-OK2419 | OKP17D101A666 | 2419 | OSU | OK |
| 22-OK2420 | KS18H111-3 | 2420 | KSU-Hays | OK |
| 22-OK2421 | CO16SF027 | 2421 | CSU | OK |
| 22-OK2422 | CO18D297R | 2422 | CSU | OK |
| 22-OK2423 | KS13DH0041-35 | 2423 | KSU-Manhhatan | OK |
| 22-CO2409 | SY Monument | 2409 | Check | CO |
| 22-CO2410 | Jagalene | 2410 | Check | CO |
| 22-CO2411 | LCH18-0027 | 2411 | Limagrain | CO |
| 22-CO2412 | TX16M9216 | 2412 | Texas A&M College Station | CO |
| 22-CO2413 | BASF7 | 2413 | BASF | CO |
| 22-CO2414 | BASF12 | 2414 | BASF | CO |
| 22-CO2415 | WB4523 | 2415 | Bayer/WestBred | CO |
| 22-CO2416 | WB0433004 | 2416 | Bayer/WestBred | CO |
| 22-CO2417 | OK18510 | 2417 | OSU | CO |
| 22-CO2418 | OK16107125C-17HR-2 | 2418 | OSU | CO |
| 22-CO2419 | OKP17D101A666 | 2419 | OSU | CO |
| 22-CO2420 | KS18H111-3 | 2420 | KSU-Hays | CO |
| 22-CO2421 | CO16SF027 | 2421 | CSU | CO |
| 22-CO2422 | CO18D297R | 2422 | CSU | CO |
| 22-CO2423 | KS13DH0041-35 | 2423 | KSU-Manhhatan | CO |
| 22-BF2409 | SY Monument | 2409 | Check | BF |
| 22-BF2410 | Jagalene | 2410 | Check | BF |
| 22-BF2411 | LCH18-0027 | 2411 | Limagrain | BF |
| 22-BF2412 | TX16M9216 | 2412 | Texas A&M College Station | BF |
| 22-BF2413 | BASF7 | 2413 | BASF | BF |
| 22-BF2414 | BASF12 | 2414 | BASF | BF |
| 22-BF2415 | WB4523 | 2415 | Bayer/WestBred | BF |
| 22-BF2416 | WB0433004 | 2416 | Bayer/WestBred | BF |
| 22-BF2417 | OK18510 | 2417 | OSU | BF |
| 22-BF2418 | OK16107125C-17HR-2 | 2418 | OSU | BF |
| 22-BF2419 | OKP17D101A666 | 2419 | OSU | BF |
| 22-BF2420 | KS18H111-3 | 2420 | KSU-Hays | BF |
| 22-BF2421 | CO16SF027 | 2421 | CSU | BF |
| 22-BF2422 | CO18D297R | 2422 | CSU | BF |
| 22-BF2423 | KS13DH0041-35 | 2423 | KSU-Manhhatan | BF |

| Entry_Code | Entry_ID | Entry_No | Breeding Programs | Locations* |
|---|---|---|---|---|
| 22-TB2409 | SY Monument | 2409 | Check | TB |
| 22-TB2410 | Jagalene | 2410 | Check | TB |
| 22-TB2411 | LCH18-0027 | 2411 | Limagrain | TB |
| 22-TB2412 | TX16M9216 | 2412 | Texas A&M College Station | TB |
| 22-TB2413 | BASF7 | 2413 | BASF | TB |
| 22-TB2414 | BASF12 | 2414 | BASF | TB |
| 22-TB2415 | WB4523 | 2415 | Bayer/WestBred | TB |
| 22-TB2416 | WB0433004 | 2416 | Bayer/WestBred | TB |
| 22-TB2417 | OK18510 | 2417 | OSU | TB |
| 22-TB2418 | OK16107125C-17HR-2 | 2418 | OSU | TB |
| 22-TB2419 | OKP17D101A666 | 2419 | OSU | TB |
| 22-TB2420 | KS18H111-3 | 2420 | KSU-Hays | TB |
| 22-TB2421 | CO16SF027 | 2421 | CSU | TB |
| 22-TB2422 | CO18D297R | 2422 | CSU | TB |
| 22-TB2423 | KS13DH0041-35 | 2423 | KSU-Manhhatan | TB |
| | | | | |
| *AP=Agripro; KH=KSU-Hays; LM=Limagrain; OK=OSU; CO=CSU; BF=BASF | | | | |
| TB=Texas A&M Bushland. | | | | |

## 1. LOCATIONS AND ENTRIES

A. There are 7 locations:

Agripro = AP;

KSU-Hays = KH;

Limagrain = LM;

OSU = OK;

CSU = CO;

BASF = BF;

Texas A&M Bushland = TB.

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

SY Monument = 2409
Jagalene = 2410

LCH18-9027 = 2411

TX16M9216 = 2412

BASF7 = 2413
BASF12 = 2414

WB4523 = 2415
WB0433004 = 2416

OK18510 = 2417
OK16107125C-17HR-2 = 2418
OKP17D101A666 = 2419

KS18H111-3 = 2420

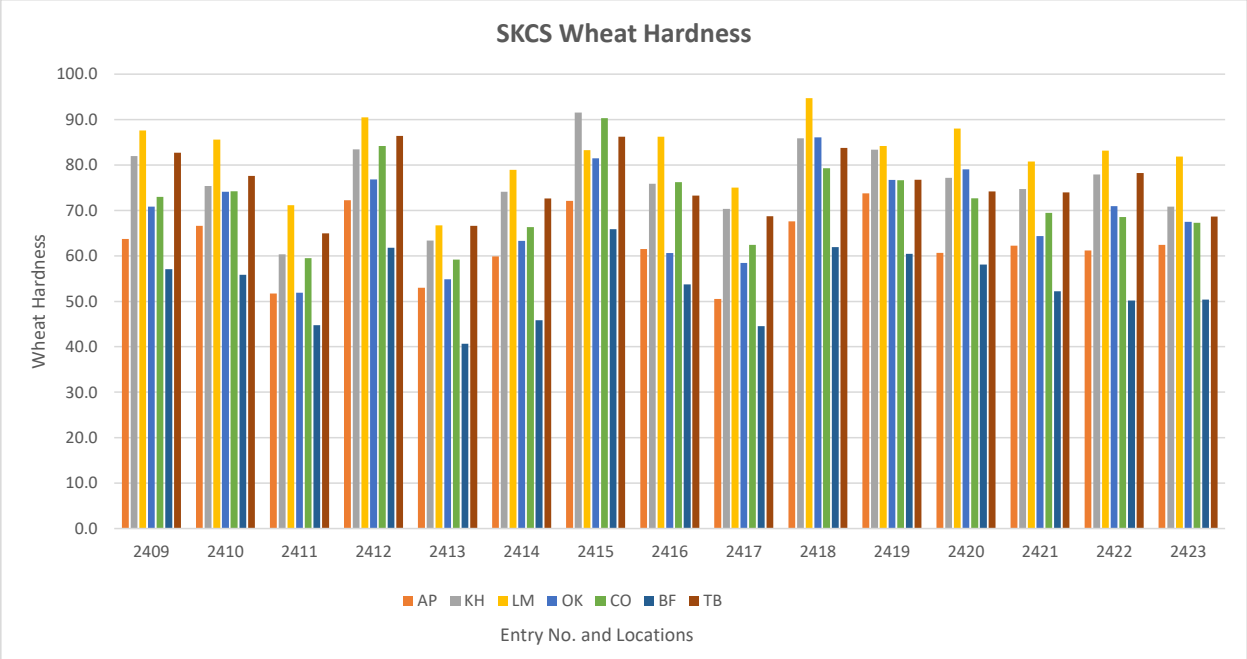
CO16SF027 = 2421
CO18D297R = 2422

KS13DH0041-35 = 2423

## 2. SKCS SINGLE KERNEL INFORMATION

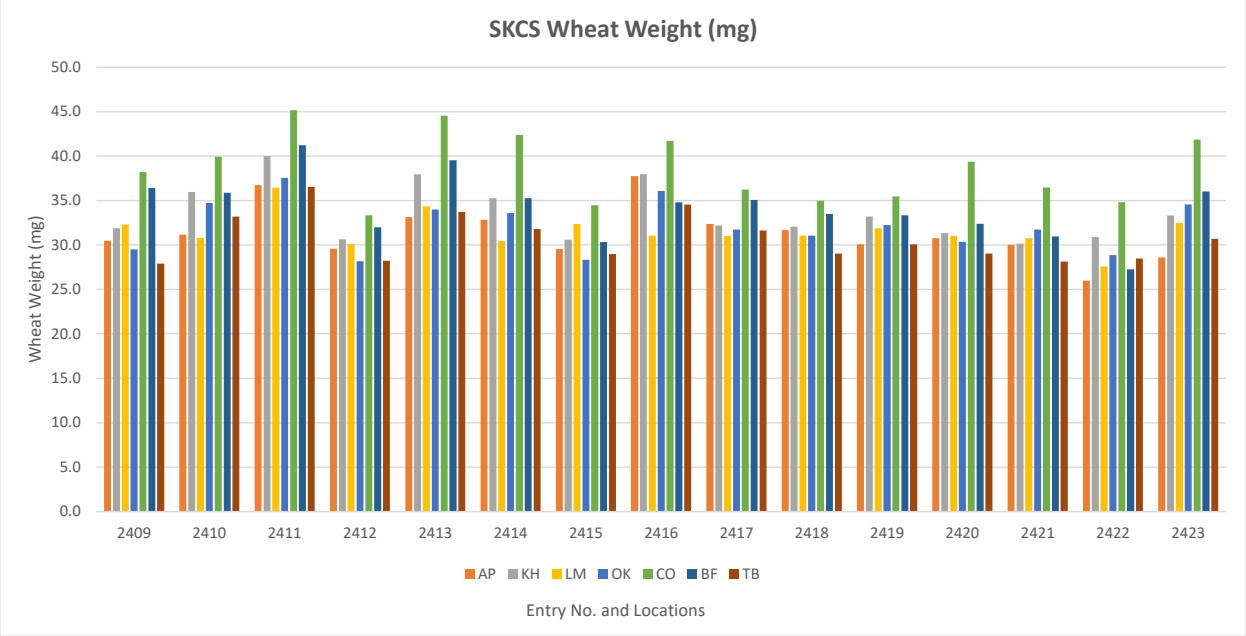
A. Kernel Hardness

| SKCS Wheat Kernel Hardness | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 63.7 | 82.0 | 87.6 | 70.8 | 73.0 | 57.1 | 82.7 | 73.8 | 11.00 |
| 2410 | 66.6 | 75.4 | 85.6 | 74.1 | 74.2 | 55.9 | 77.6 | 72.8 | 9.34 |
| 2411 | 51.7 | 60.3 | 71.2 | 51.9 | 59.5 | 44.7 | 64.9 | 57.8 | 8.96 |
| 2412 | 72.2 | 83.4 | 90.4 | 76.8 | 84.2 | 61.8 | 86.4 | 79.3 | 9.81 |
| 2413 | 53.0 | 63.4 | 66.7 | 54.9 | 59.2 | 40.7 | 66.6 | 57.8 | 9.26 |
| 2414 | 59.9 | 74.1 | 78.9 | 63.3 | 66.3 | 45.8 | 72.6 | 65.8 | 11.01 |
| 2415 | 72.1 | 91.5 | 83.3 | 81.4 | 90.3 | 65.8 | 86.2 | 81.5 | 9.46 |
| 2416 | 61.5 | 75.9 | 86.2 | 60.6 | 76.2 | 53.7 | 73.3 | 69.6 | 11.34 |
| 2417 | 50.5 | 70.3 | 75.0 | 58.5 | 62.4 | 44.5 | 68.7 | 61.4 | 11.05 |
| 2418 | 67.6 | 85.9 | 94.7 | 86.1 | 79.3 | 61.9 | 83.7 | 79.9 | 11.41 |
| 2419 | 73.7 | 83.4 | 84.2 | 76.7 | 76.7 | 60.4 | 76.8 | 76.0 | 7.86 |
| 2420 | 60.7 | 77.2 | 88.0 | 79.0 | 72.7 | 58.1 | 74.1 | 72.8 | 10.45 |
| 2421 | 62.3 | 74.7 | 80.8 | 64.3 | 69.4 | 52.2 | 73.9 | 68.2 | 9.49 |
| 2422 | 61.2 | 77.9 | 83.1 | 71.0 | 68.5 | 50.2 | 78.2 | 70.0 | 11.38 |
| 2423 | 62.4 | 70.8 | 81.8 | 67.5 | 67.3 | 50.4 | 68.6 | 67.0 | 9.43 |
| Avg. | 62.6 | 76.4 | 82.5 | 69.1 | 71.9 | 53.5 | 75.6 | | |
| Std | 7.18 | 8.26 | 7.30 | 10.11 | 8.73 | 7.48 | 6.90 | | |
| AP=Agripro; KH=KSU-Hays; LM=Limagrain; OK=OSU; CO=CSU; BF=BASF; TB=Texas A&M Bushland. | | | | | | | | | |



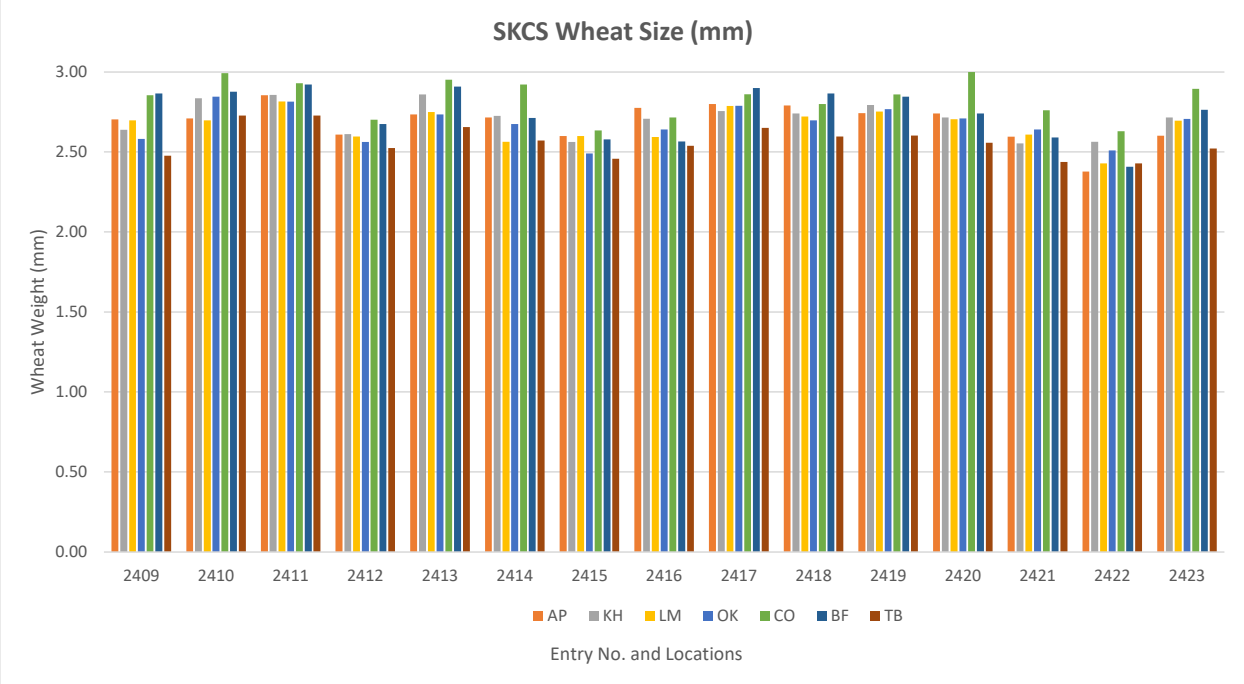
B. Kernel Weight (mg)

| SKCS Wheat Kernel Weight (mg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 30.5 | 31.9 | 32.3 | 29.5 | 38.2 | 36.4 | 27.9 | 32.4 | 3.71 |
| 2410 | 31.2 | 36.0 | 30.8 | 34.7 | 39.9 | 35.9 | 33.2 | 34.5 | 3.17 |
| 2411 | 36.7 | 40.0 | 36.4 | 37.6 | 45.2 | 41.2 | 36.5 | 39.1 | 3.26 |
| 2412 | 29.6 | 30.6 | 30.1 | 28.2 | 33.3 | 32.0 | 28.2 | 30.3 | 1.89 |
| 2413 | 33.1 | 37.9 | 34.4 | 34.0 | 44.6 | 39.5 | 33.7 | 36.7 | 4.20 |
| 2414 | 32.9 | 35.3 | 30.5 | 33.6 | 42.4 | 35.3 | 31.8 | 34.5 | 3.89 |
| 2415 | 29.5 | 30.6 | 32.4 | 28.3 | 34.5 | 30.3 | 29.0 | 30.7 | 2.12 |
| 2416 | 37.8 | 38.0 | 31.1 | 36.1 | 41.7 | 34.8 | 34.6 | 36.3 | 3.34 |
| 2417 | 32.4 | 32.2 | 31.0 | 31.7 | 36.3 | 35.1 | 31.6 | 32.9 | 1.97 |
| 2418 | 31.7 | 32.1 | 31.1 | 31.1 | 35.0 | 33.5 | 29.0 | 31.9 | 1.90 |
| 2419 | 30.1 | 33.2 | 31.9 | 32.2 | 35.5 | 33.3 | 30.1 | 32.3 | 1.92 |
| 2420 | 30.8 | 31.3 | 31.0 | 30.4 | 39.4 | 32.4 | 29.0 | 32.0 | 3.39 |
| 2421 | 30.0 | 30.2 | 30.7 | 31.7 | 36.5 | 31.0 | 28.1 | 31.2 | 2.59 |
| 2422 | 26.0 | 30.9 | 27.6 | 28.9 | 34.8 | 27.3 | 28.5 | 29.1 | 2.93 |
| 2423 | 28.6 | 33.3 | 32.5 | 34.6 | 41.9 | 36.0 | 30.7 | 33.9 | 4.26 |
| Avg. | 31.4 | 33.6 | 31.6 | 32.2 | 38.6 | 34.3 | 30.8 | | |
| Std | 2.98 | 3.13 | 1.99 | 2.87 | 3.85 | 3.53 | 2.68 | | |



C. Kernel Size

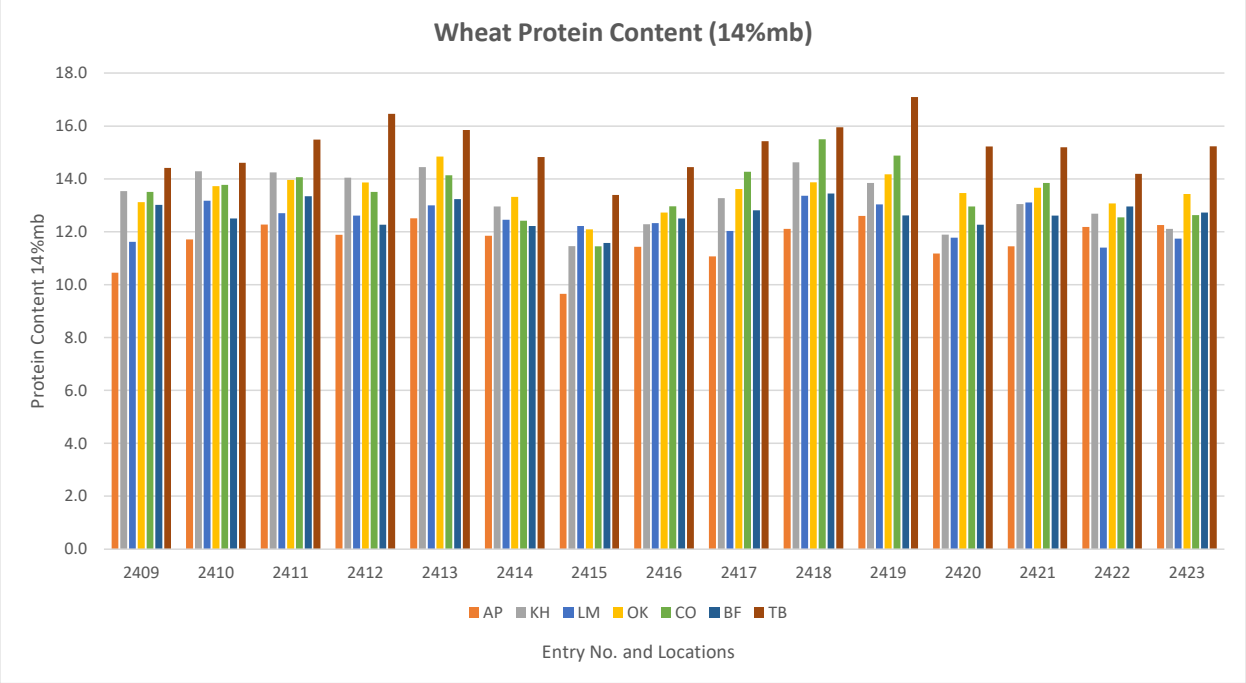
| SKCS Wheat Kernel Size (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 2.70 | 2.64 | 2.70 | 2.58 | 2.85 | 2.86 | 2.48 | 2.69 | 0.14 |
| 2410 | 2.71 | 2.83 | 2.70 | 2.85 | 2.99 | 2.88 | 2.73 | 2.81 | 0.11 |
| 2411 | 2.85 | 2.86 | 2.82 | 2.81 | 2.93 | 2.92 | 2.73 | 2.85 | 0.07 |
| 2412 | 2.61 | 2.61 | 2.60 | 2.56 | 2.70 | 2.67 | 2.53 | 2.61 | 0.06 |
| 2413 | 2.73 | 2.86 | 2.75 | 2.73 | 2.95 | 2.91 | 2.65 | 2.80 | 0.11 |
| 2414 | 2.71 | 2.72 | 2.56 | 2.68 | 2.92 | 2.71 | 2.57 | 2.70 | 0.12 |
| 2415 | 2.60 | 2.56 | 2.60 | 2.49 | 2.63 | 2.58 | 2.46 | 2.56 | 0.06 |
| 2416 | 2.78 | 2.71 | 2.59 | 2.64 | 2.71 | 2.57 | 2.54 | 2.65 | 0.09 |
| 2417 | 2.80 | 2.76 | 2.79 | 2.79 | 2.86 | 2.90 | 2.65 | 2.79 | 0.08 |
| 2418 | 2.79 | 2.74 | 2.72 | 2.70 | 2.80 | 2.86 | 2.60 | 2.74 | 0.09 |
| 2419 | 2.74 | 2.79 | 2.75 | 2.77 | 2.86 | 2.85 | 2.60 | 2.77 | 0.08 |
| 2420 | 2.74 | 2.71 | 2.70 | 2.71 | 3.00 | 2.74 | 2.56 | 2.74 | 0.13 |
| 2421 | 2.60 | 2.55 | 2.61 | 2.64 | 2.76 | 2.59 | 2.44 | 2.60 | 0.10 |
| 2422 | 2.38 | 2.56 | 2.43 | 2.51 | 2.63 | 2.41 | 2.43 | 2.48 | 0.09 |
| 2423 | 2.60 | 2.71 | 2.70 | 2.71 | 2.89 | 2.76 | 2.52 | 2.70 | 0.12 |
| Avg. | 2.69 | 2.71 | 2.67 | 2.68 | 2.83 | 2.75 | 2.56 | | |
| Std | 0.12 | 0.10 | 0.10 | 0.11 | 0.12 | 0.16 | 0.10 | | |



## 3. PROTEN CONTENT

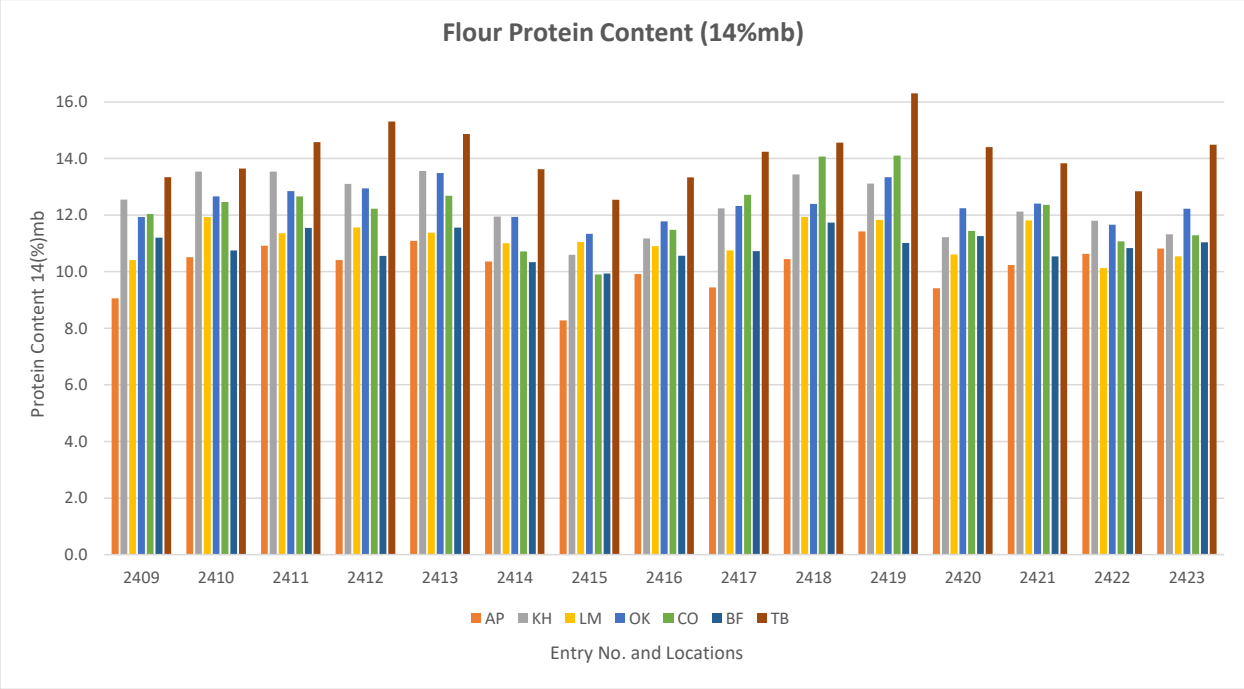
A. Wheat Protein

| Wheat Protein Content (14%mb) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 10.4 | 13.5 | 11.6 | 13.1 | 13.5 | 13.0 | 14.4 | 12.8 | 1.34 |
| 2410 | 11.7 | 14.3 | 13.2 | 13.7 | 13.8 | 12.5 | 14.6 | 13.4 | 1.02 |
| 2411 | 12.3 | 14.2 | 12.7 | 14.0 | 14.1 | 13.3 | 15.5 | 13.7 | 1.07 |
| 2412 | 11.9 | 14.0 | 12.6 | 13.9 | 13.5 | 12.3 | 16.5 | 13.5 | 1.53 |
| 2413 | 12.5 | 14.4 | 13.0 | 14.8 | 14.1 | 13.2 | 15.8 | 14.0 | 1.16 |
| 2414 | 11.9 | 13.0 | 12.5 | 13.3 | 12.4 | 12.2 | 14.8 | 12.9 | 0.99 |
| 2415 | 9.7 | 11.5 | 12.2 | 12.1 | 11.4 | 11.6 | 13.4 | 11.7 | 1.13 |
| 2416 | 11.4 | 12.3 | 12.3 | 12.7 | 13.0 | 12.5 | 14.4 | 12.7 | 0.92 |
| 2417 | 11.1 | 13.3 | 12.0 | 13.6 | 14.3 | 12.8 | 15.4 | 13.2 | 1.43 |
| 2418 | 12.1 | 14.6 | 13.4 | 13.9 | 15.5 | 13.4 | 16.0 | 14.1 | 1.33 |
| 2419 | 12.6 | 13.8 | 13.0 | 14.2 | 14.9 | 12.6 | 17.1 | 14.0 | 1.59 |
| 2420 | 11.2 | 11.9 | 11.8 | 13.5 | 13.0 | 12.3 | 15.2 | 12.7 | 1.36 |
| 2421 | 11.5 | 13.0 | 13.1 | 13.7 | 13.8 | 12.6 | 15.2 | 13.3 | 1.15 |
| 2422 | 12.2 | 12.7 | 11.4 | 13.1 | 12.6 | 13.0 | 14.2 | 12.7 | 0.86 |
| 2423 | 12.3 | 12.1 | 11.7 | 13.4 | 12.6 | 12.7 | 15.2 | 12.9 | 1.17 |
| Avg. | 11.6 | 13.2 | 12.4 | 13.5 | 13.5 | 12.7 | 15.2 | | |
| Std | 0.81 | 0.99 | 0.63 | 0.64 | 1.04 | 0.49 | 0.94 | | |



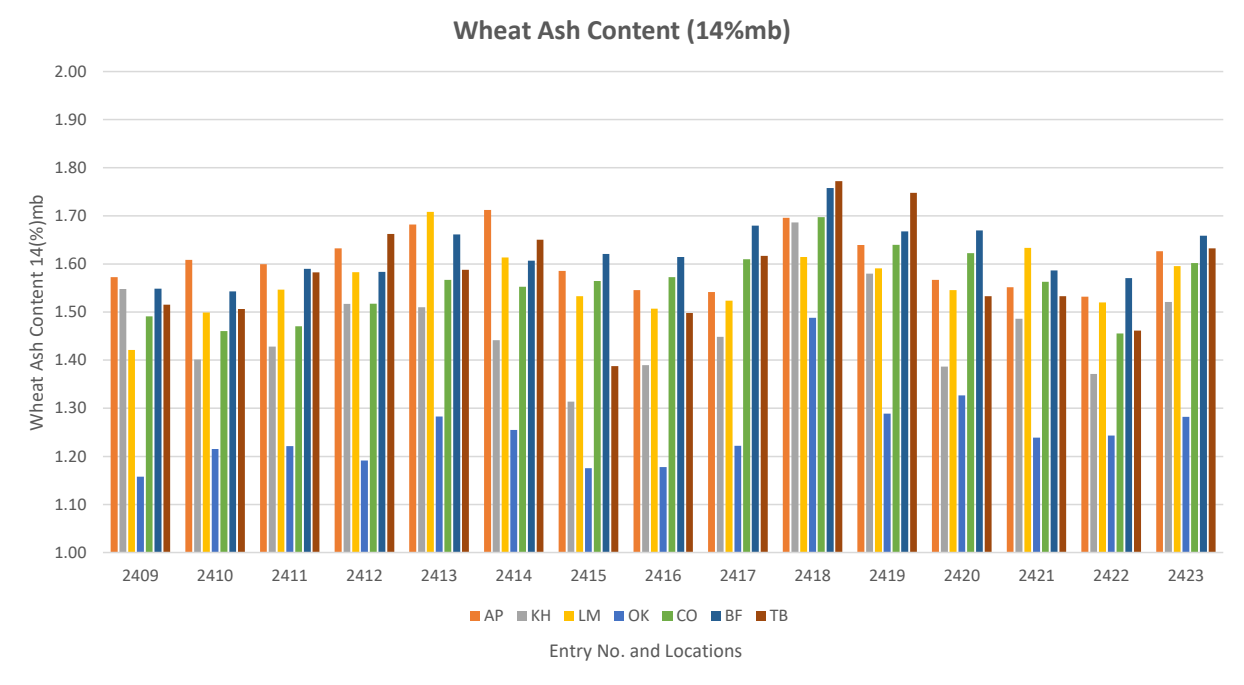
B. Flour Protein

| Flour Protein Content (14%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 9.1 | 12.6 | 10.4 | 11.9 | 12.0 | 11.2 | 13.3 | 11.5 | 1.43 |
| 2410 | 10.5 | 13.5 | 11.9 | 12.7 | 12.5 | 10.8 | 13.6 | 12.2 | 1.24 |
| 2411 | 10.9 | 13.5 | 11.4 | 12.8 | 12.7 | 11.5 | 14.6 | 12.5 | 1.31 |
| 2412 | 10.4 | 13.1 | 11.6 | 12.9 | 12.2 | 10.6 | 15.3 | 12.3 | 1.70 |
| 2413 | 11.1 | 13.6 | 11.4 | 13.5 | 12.7 | 11.6 | 14.9 | 12.7 | 1.40 |
| 2414 | 10.4 | 11.9 | 11.0 | 11.9 | 10.7 | 10.3 | 13.6 | 11.4 | 1.18 |
| 2415 | 8.3 | 10.6 | 11.0 | 11.3 | 9.9 | 9.9 | 12.5 | 10.5 | 1.34 |
| 2416 | 9.9 | 11.2 | 10.9 | 11.8 | 11.5 | 10.6 | 13.3 | 11.3 | 1.08 |
| 2417 | 9.4 | 12.2 | 10.8 | 12.3 | 12.7 | 10.7 | 14.2 | 11.8 | 1.58 |
| 2418 | 10.4 | 13.4 | 11.9 | 12.4 | 14.1 | 11.7 | 14.6 | 12.7 | 1.45 |
| 2419 | 11.4 | 13.1 | 11.8 | 13.3 | 14.1 | 11.0 | 16.3 | 13.0 | 1.83 |
| 2420 | 9.4 | 11.2 | 10.6 | 12.2 | 11.4 | 11.3 | 14.4 | 11.5 | 1.54 |
| 2421 | 10.2 | 12.1 | 11.8 | 12.4 | 12.4 | 10.5 | 13.8 | 11.9 | 1.22 |
| 2422 | 10.6 | 11.8 | 10.1 | 11.7 | 11.1 | 10.8 | 12.8 | 11.3 | 0.90 |
| 2423 | 10.8 | 11.3 | 10.5 | 12.2 | 11.3 | 11.0 | 14.5 | 11.7 | 1.35 |
| Avg. | 10.2 | 12.4 | 11.1 | 12.4 | 12.1 | 10.9 | 14.1 | | |
| Std | 0.84 | 1.00 | 0.59 | 0.61 | 1.15 | 0.50 | 0.98 | | |



## 4. Wheat Ash

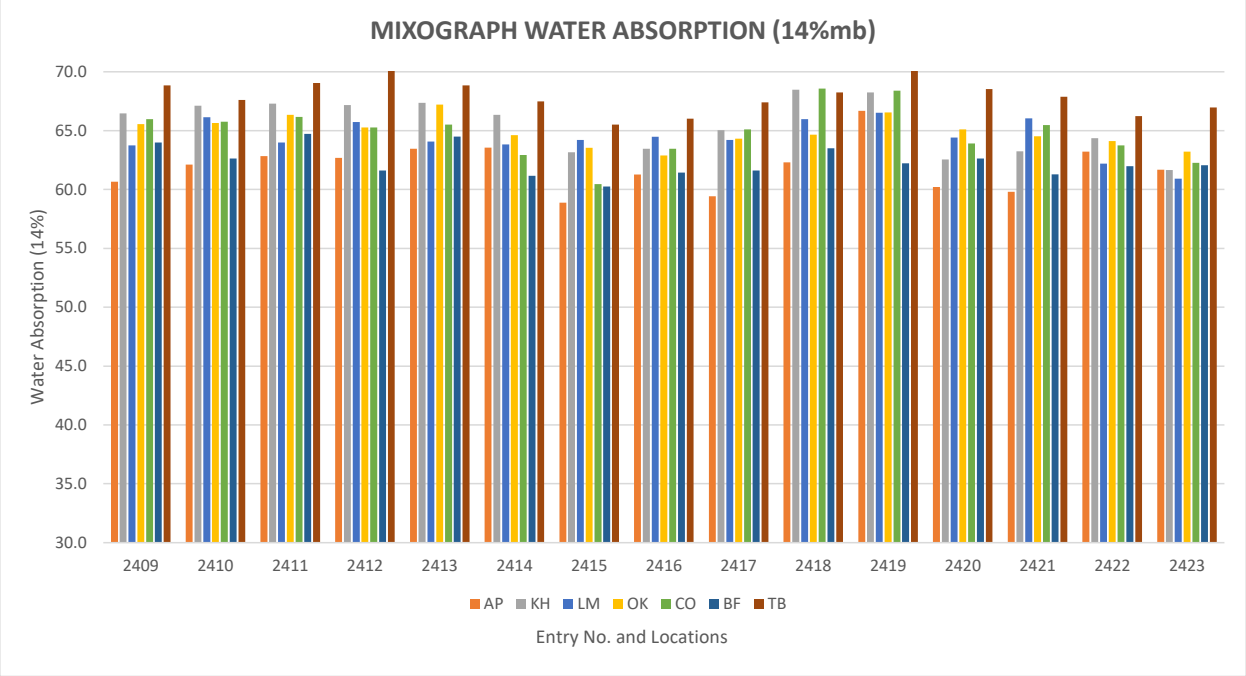
| Wheat Ash Content (14%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 1.57 | 1.55 | 1.42 | 1.16 | 1.49 | 1.55 | 1.52 | 1.46 | 0.14 |
| 2410 | 1.61 | 1.40 | 1.50 | 1.22 | 1.46 | 1.54 | 1.51 | 1.46 | 0.13 |
| 2411 | 1.60 | 1.43 | 1.55 | 1.22 | 1.47 | 1.59 | 1.58 | 1.49 | 0.14 |
| 2412 | 1.63 | 1.52 | 1.58 | 1.19 | 1.52 | 1.58 | 1.66 | 1.53 | 0.16 |
| 2413 | 1.68 | 1.51 | 1.71 | 1.28 | 1.57 | 1.66 | 1.59 | 1.57 | 0.15 |
| 2414 | 1.71 | 1.44 | 1.61 | 1.25 | 1.55 | 1.61 | 1.65 | 1.55 | 0.15 |
| 2415 | 1.59 | 1.31 | 1.53 | 1.18 | 1.56 | 1.62 | 1.39 | 1.45 | 0.17 |
| 2416 | 1.55 | 1.39 | 1.51 | 1.18 | 1.57 | 1.61 | 1.50 | 1.47 | 0.15 |
| 2417 | 1.54 | 1.45 | 1.52 | 1.22 | 1.61 | 1.68 | 1.62 | 1.52 | 0.15 |
| 2418 | 1.70 | 1.69 | 1.61 | 1.49 | 1.70 | 1.76 | 1.77 | 1.67 | 0.10 |
| 2419 | 1.64 | 1.58 | 1.59 | 1.29 | 1.64 | 1.67 | 1.75 | 1.59 | 0.15 |
| 2420 | 1.57 | 1.39 | 1.55 | 1.33 | 1.62 | 1.67 | 1.53 | 1.52 | 0.12 |
| 2421 | 1.55 | 1.49 | 1.63 | 1.24 | 1.56 | 1.59 | 1.53 | 1.51 | 0.13 |
| 2422 | 1.53 | 1.37 | 1.52 | 1.24 | 1.46 | 1.57 | 1.46 | 1.45 | 0.11 |
| 2423 | 1.63 | 1.52 | 1.60 | 1.28 | 1.60 | 1.66 | 1.63 | 1.56 | 0.13 |
| Avg. | 1.61 | 1.47 | 1.56 | 1.25 | 1.56 | 1.62 | 1.58 | | |
| Std | 0.06 | 0.10 | 0.07 | 0.08 | 0.07 | 0.06 | 0.10 | | |



## 5. MIXOGRAPH TEST RESULTS

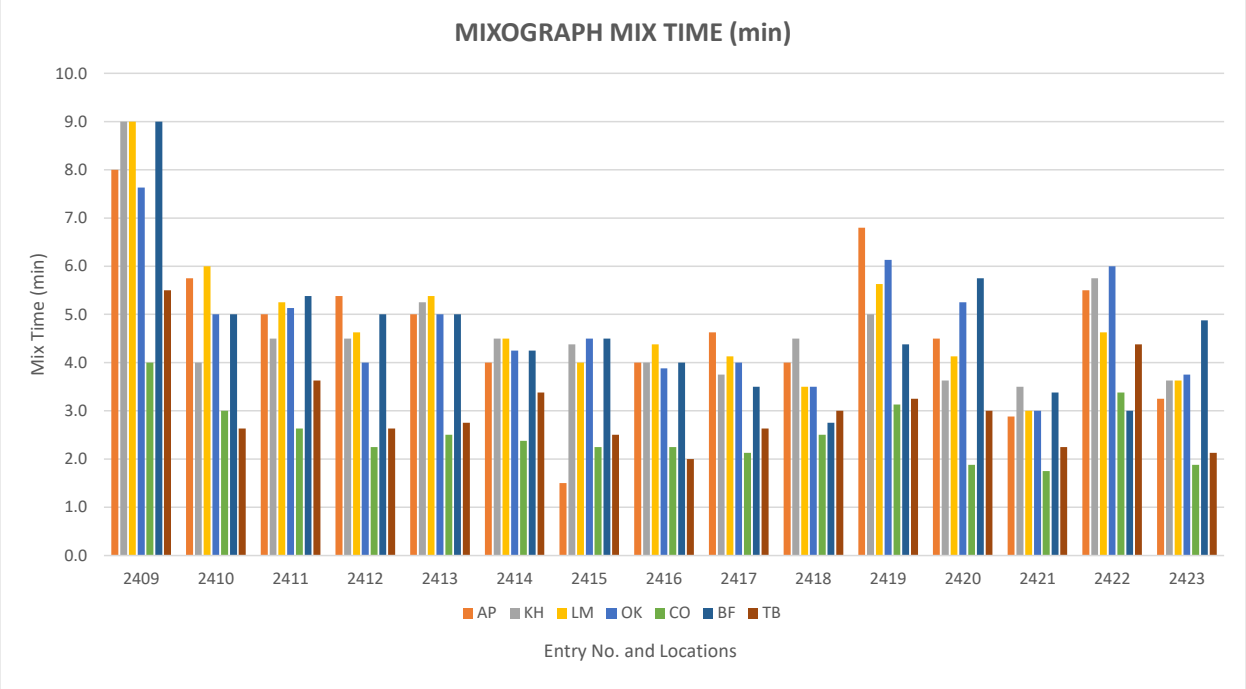
A. Mixograph Water Absorption

| Mixograph Water Absorption (14%mb) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 60.7 | 66.5 | 63.8 | 65.5 | 66.0 | 64.0 | 68.8 | 65.0 | 2.57 |
| 2410 | 62.1 | 67.1 | 66.1 | 65.7 | 65.8 | 62.6 | 67.6 | 65.3 | 2.12 |
| 2411 | 62.8 | 67.3 | 64.0 | 66.3 | 66.2 | 64.7 | 69.0 | 65.8 | 2.10 |
| 2412 | 62.7 | 67.2 | 65.7 | 65.3 | 65.3 | 61.6 | 70.1 | 65.4 | 2.81 |
| 2413 | 63.5 | 67.3 | 64.1 | 67.2 | 65.5 | 64.5 | 68.8 | 65.8 | 2.00 |
| 2414 | 63.6 | 66.4 | 63.8 | 64.6 | 62.9 | 61.2 | 67.5 | 64.3 | 2.12 |
| 2415 | 58.9 | 63.2 | 64.2 | 63.5 | 60.5 | 60.3 | 65.5 | 62.3 | 2.43 |
| 2416 | 61.3 | 63.4 | 64.5 | 62.9 | 63.5 | 61.4 | 66.0 | 63.3 | 1.66 |
| 2417 | 59.4 | 65.0 | 64.2 | 64.3 | 65.1 | 61.6 | 67.4 | 63.9 | 2.60 |
| 2418 | 62.3 | 68.5 | 66.0 | 64.7 | 68.6 | 63.5 | 68.2 | 66.0 | 2.57 |
| 2419 | 66.7 | 68.3 | 66.5 | 66.5 | 68.4 | 62.2 | 73.0 | 67.4 | 3.22 |
| 2420 | 60.2 | 62.6 | 64.4 | 65.1 | 63.9 | 62.6 | 68.5 | 63.9 | 2.59 |
| 2421 | 59.8 | 63.2 | 66.0 | 64.5 | 65.5 | 61.3 | 67.9 | 64.0 | 2.80 |
| 2422 | 63.2 | 64.4 | 62.2 | 64.1 | 63.7 | 62.0 | 66.2 | 63.7 | 1.44 |
| 2423 | 61.7 | 61.7 | 60.9 | 63.2 | 62.3 | 62.1 | 67.0 | 62.7 | 2.02 |
| Avg. | 61.9 | 65.5 | 64.4 | 64.9 | 64.9 | 62.4 | 68.1 | | |
| Std | 2.00 | 2.23 | 1.52 | 1.23 | 2.15 | 1.30 | 1.84 | | |



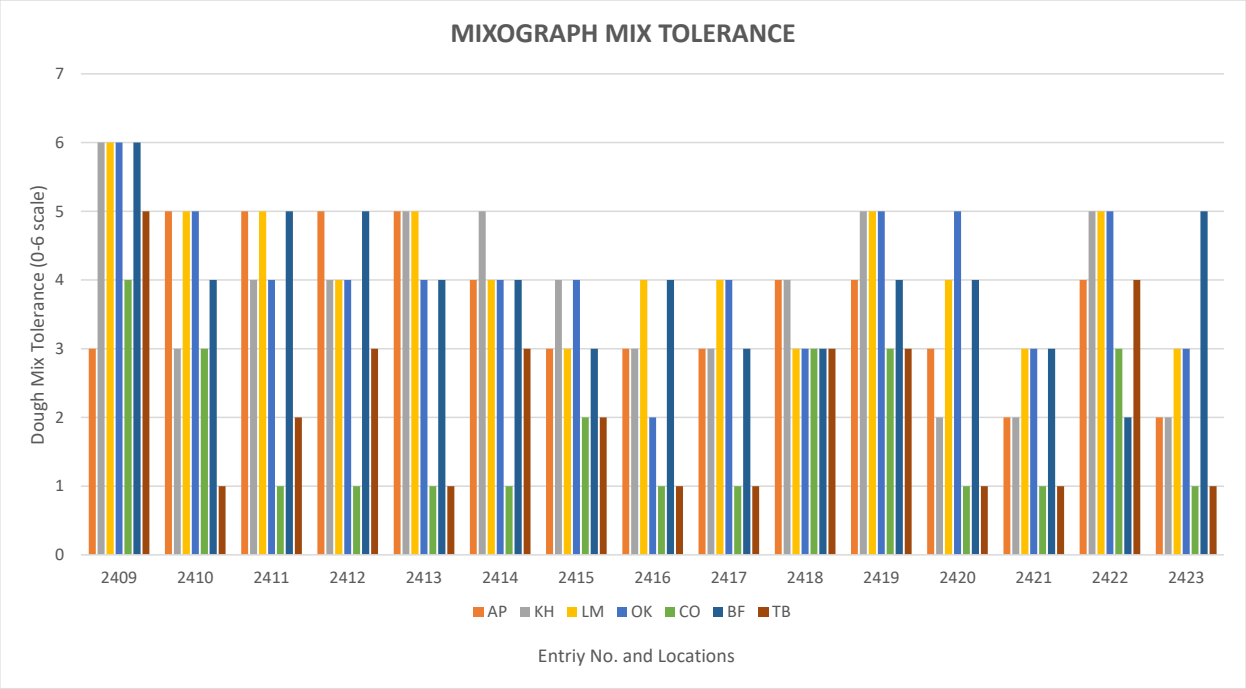
B. Mixograph Mix Time

| Mixograph Mix Time (min) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 8.0 | 9.0 | 9.0 | 7.6 | 4.0 | 9.0 | 5.5 | 7.4 | 1.97 |
| 2410 | 5.8 | 4.0 | 6.0 | 5.0 | 3.0 | 5.0 | 2.6 | 4.5 | 1.31 |
| 2411 | 5.0 | 4.5 | 5.3 | 5.1 | 2.6 | 5.4 | 3.6 | 4.5 | 1.02 |
| 2412 | 5.4 | 4.5 | 4.6 | 4.0 | 2.3 | 5.0 | 2.6 | 4.1 | 1.19 |
| 2413 | 5.0 | 5.3 | 5.4 | 5.0 | 2.5 | 5.0 | 2.8 | 4.4 | 1.23 |
| 2414 | 4.0 | 4.5 | 4.5 | 4.3 | 2.4 | 4.3 | 3.4 | 3.9 | 0.77 |
| 2415 | 1.5 | 4.4 | 4.0 | 4.5 | 2.3 | 4.5 | 2.5 | 3.4 | 1.26 |
| 2416 | 4.0 | 4.0 | 4.4 | 3.9 | 2.3 | 4.0 | 2.0 | 3.5 | 0.96 |
| 2417 | 4.6 | 3.8 | 4.1 | 4.0 | 2.1 | 3.5 | 2.6 | 3.5 | 0.88 |
| 2418 | 4.0 | 4.5 | 3.5 | 3.5 | 2.5 | 2.8 | 3.0 | 3.4 | 0.70 |
| 2419 | 6.8 | 5.0 | 5.6 | 6.1 | 3.1 | 4.4 | 3.3 | 4.9 | 1.40 |
| 2420 | 4.5 | 3.6 | 4.1 | 5.3 | 1.9 | 5.8 | 3.0 | 4.0 | 1.32 |
| 2421 | 2.9 | 3.5 | 3.0 | 3.0 | 1.8 | 3.4 | 2.3 | 2.8 | 0.62 |
| 2422 | 5.5 | 5.8 | 4.6 | 6.0 | 3.4 | 3.0 | 4.4 | 4.7 | 1.17 |
| 2423 | 3.3 | 3.6 | 3.6 | 3.8 | 1.9 | 4.9 | 2.1 | 3.3 | 1.03 |
| Avg. | 4.7 | 4.7 | 4.8 | 4.7 | 2.5 | 4.7 | 3.0 | | |
| Std | 1.58 | 1.36 | 1.43 | 1.20 | 0.62 | 1.49 | 0.92 | | |



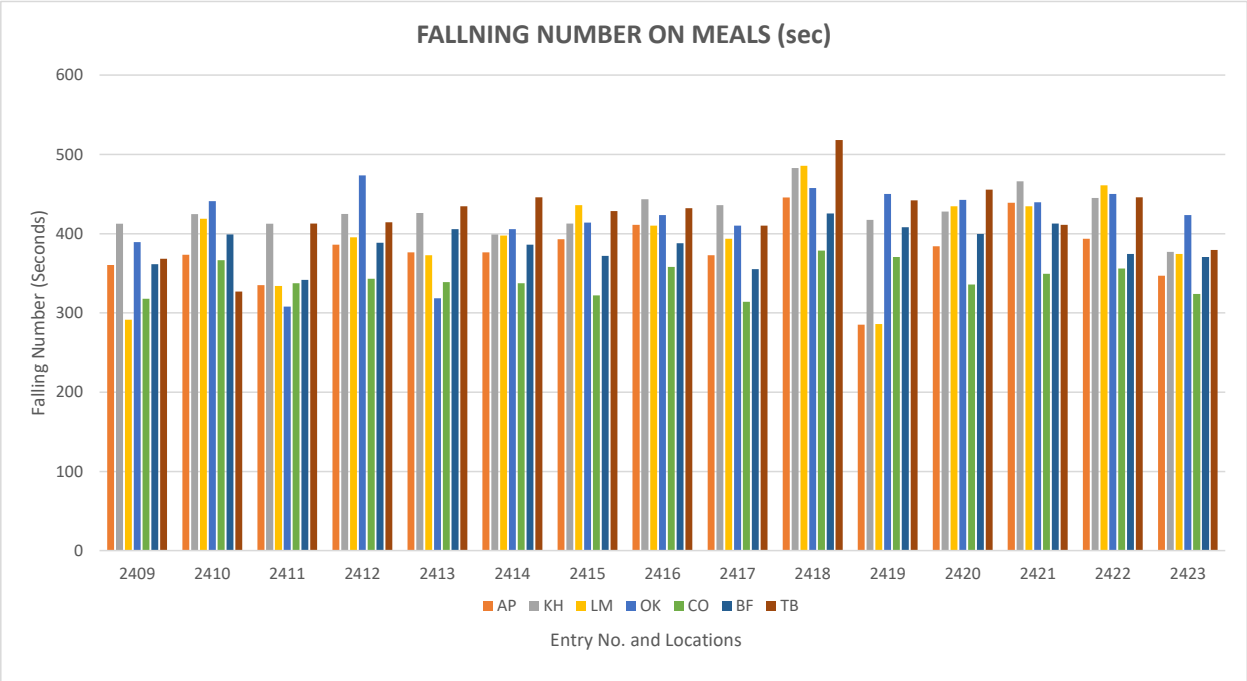
C. Mixograph Mix Tolerance

| Mixograph Mix Tolerance | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 3 | 6 | 6 | 6 | 4 | 6 | 5 | 5.1 | 1.2 |
| 2410 | 5 | 3 | 5 | 5 | 3 | 4 | 1 | 3.7 | 1.5 |
| 2411 | 5 | 4 | 5 | 4 | 1 | 5 | 2 | 3.7 | 1.6 |
| 2412 | 5 | 4 | 4 | 4 | 1 | 5 | 3 | 3.7 | 1.4 |
| 2413 | 5 | 5 | 5 | 4 | 1 | 4 | 1 | 3.6 | 1.8 |
| 2414 | 4 | 5 | 4 | 4 | 1 | 4 | 3 | 3.6 | 1.3 |
| 2415 | 3 | 4 | 3 | 4 | 2 | 3 | 2 | 3.0 | 0.8 |
| 2416 | 3 | 3 | 4 | 2 | 1 | 4 | 1 | 2.6 | 1.3 |
| 2417 | 3 | 3 | 4 | 4 | 1 | 3 | 1 | 2.7 | 1.3 |
| 2418 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3.3 | 0.5 |
| 2419 | 4 | 5 | 5 | 5 | 3 | 4 | 3 | 4.1 | 0.9 |
| 2420 | 3 | 2 | 4 | 5 | 1 | 4 | 1 | 2.9 | 1.6 |
| 2421 | 2 | 2 | 3 | 3 | 1 | 3 | 1 | 2.1 | 0.9 |
| 2422 | 4 | 5 | 5 | 5 | 3 | 2 | 4 | 4.0 | 1.2 |
| 2423 | 2 | 2 | 3 | 3 | 1 | 5 | 1 | 2.4 | 1.4 |
| Avg. | 3.7 | 3.8 | 4.2 | 4.1 | 1.8 | 3.9 | 2.1 | | |
| Std | 1.05 | 1.26 | 0.94 | 1.03 | 1.08 | 1.03 | 1.30 | | |



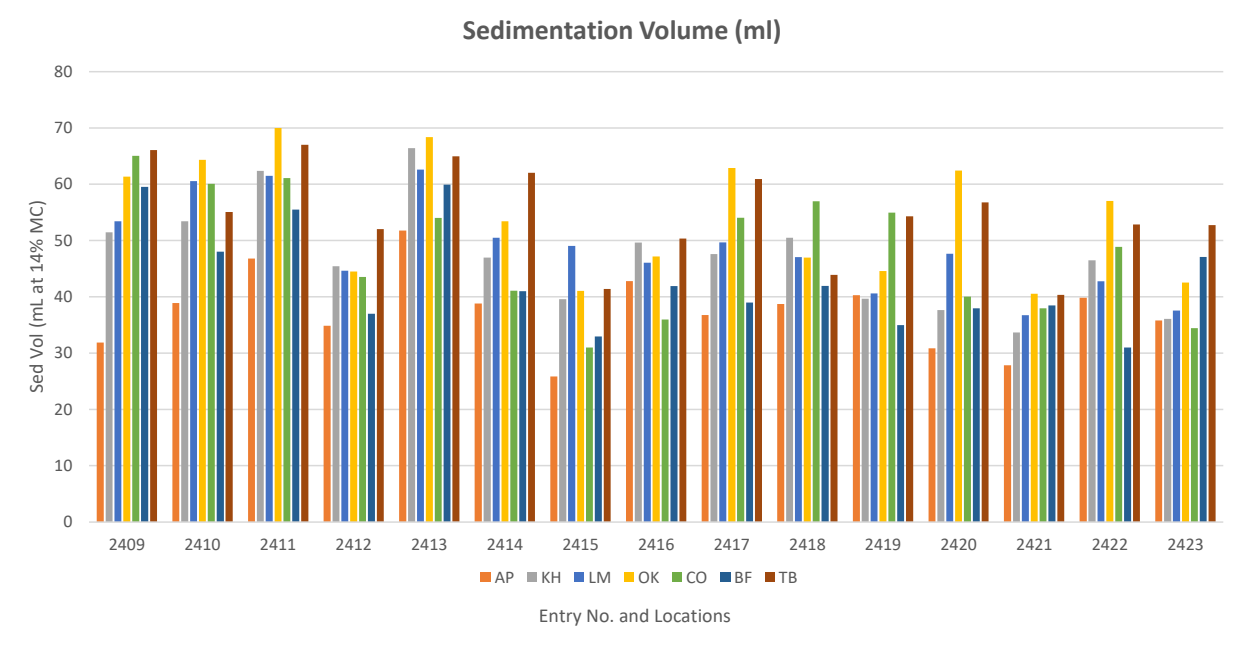
## 6. FALLING NUMBER TEST

| Falling Number on Meals (sec) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 361 | 413 | 292 | 390 | 318 | 362 | 369 | 357 | 41 |
| 2410 | 374 | 425 | 419 | 441 | 367 | 399 | 327 | 393 | 40 |
| 2411 | 335 | 413 | 334 | 308 | 338 | 342 | 413 | 355 | 41 |
| 2412 | 386 | 425 | 396 | 474 | 343 | 389 | 415 | 404 | 40 |
| 2413 | 377 | 426 | 373 | 319 | 339 | 406 | 435 | 382 | 43 |
| 2414 | 377 | 399 | 398 | 406 | 338 | 386 | 446 | 393 | 33 |
| 2415 | 393 | 413 | 436 | 414 | 322 | 372 | 429 | 397 | 39 |
| 2416 | 411 | 444 | 410 | 424 | 358 | 388 | 432 | 409 | 29 |
| 2417 | 373 | 436 | 394 | 410 | 314 | 355 | 410 | 385 | 41 |
| 2418 | 446 | 483 | 486 | 458 | 379 | 426 | 518 | 456 | 46 |
| 2419 | 285 | 418 | 286 | 450 | 371 | 408 | 442 | 380 | 69 |
| 2420 | 384 | 428 | 435 | 443 | 336 | 400 | 456 | 411 | 41 |
| 2421 | 439 | 466 | 435 | 440 | 350 | 413 | 411 | 422 | 37 |
| 2422 | 394 | 445 | 461 | 450 | 356 | 375 | 446 | 418 | 42 |
| 2423 | 347 | 377 | 375 | 424 | 324 | 371 | 380 | 371 | 31 |
| Avg. | 379 | 427 | 395 | 416 | 343 | 386 | 422 | | |
| Std | 39 | 26 | 57 | 47 | 20 | 23 | 43 | | |



## 7. SEDIMENTATION TEST

| Sedimentation Volume (ml) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOCATIONS | | | | | | | | |
| Entry No. | AP | KH | LM | OK | CO | BF | TB | Avg | Std |
| 2409 | 31.9 | 51.5 | 53.4 | 61.3 | 65.1 | 59.5 | 66.1 | 55.5 | 11.78 |
| 2410 | 38.9 | 53.4 | 60.5 | 64.3 | 60.1 | 48.0 | 55.1 | 54.3 | 8.67 |
| 2411 | 46.8 | 62.4 | 61.5 | 70.0 | 61.1 | 55.5 | 67.0 | 60.6 | 7.64 |
| 2412 | 34.9 | 45.4 | 44.6 | 44.5 | 43.5 | 37.0 | 52.0 | 43.1 | 5.70 |
| 2413 | 51.8 | 66.4 | 62.6 | 68.4 | 54.0 | 59.9 | 65.0 | 61.2 | 6.29 |
| 2414 | 38.8 | 47.0 | 50.5 | 53.4 | 41.1 | 41.0 | 62.1 | 47.7 | 8.31 |
| 2415 | 25.8 | 39.6 | 49.1 | 41.1 | 31.0 | 33.0 | 41.4 | 37.3 | 7.80 |
| 2416 | 42.8 | 49.6 | 46.1 | 47.2 | 35.9 | 41.9 | 50.4 | 44.8 | 5.03 |
| 2417 | 36.8 | 47.6 | 49.7 | 62.9 | 54.1 | 39.0 | 60.9 | 50.1 | 10.03 |
| 2418 | 38.7 | 50.5 | 47.1 | 47.0 | 57.0 | 42.0 | 43.9 | 46.6 | 5.97 |
| 2419 | 40.3 | 39.7 | 40.6 | 44.6 | 54.9 | 35.0 | 54.3 | 44.2 | 7.65 |
| 2420 | 30.8 | 37.6 | 47.6 | 62.4 | 40.0 | 38.0 | 56.8 | 44.8 | 11.39 |
| 2421 | 27.8 | 33.7 | 36.7 | 40.6 | 37.9 | 38.5 | 40.3 | 36.5 | 4.48 |
| 2422 | 39.8 | 46.5 | 42.7 | 57.0 | 48.9 | 31.0 | 52.9 | 45.6 | 8.66 |
| 2423 | 35.8 | 36.1 | 37.6 | 42.5 | 34.5 | 47.1 | 52.7 | 40.9 | 6.86 |
| Avg. | 37.4 | 47.1 | 48.7 | 53.8 | 47.9 | 43.1 | 54.7 | | |
| Std | 6.82 | 9.22 | 8.11 | 10.48 | 10.89 | 9.15 | 8.53 | | |



# MONTANA

| | |
|---|---|
| 22-2424 | SY Monument_CK |
| 22-2425 | Yellowstone_CK |
| 22-2426 | MTFH19132_MT |
| 22-2427 | MTS1908_MT |
| 22-2428 | MTCL19151_MT |

# Description of Test Plots and Breeder Entries

## Montana – Suchismita (Sue) Mondal

### Growing conditions

For the 2022 Northern Wheat Quality Council (WQC), we planted 5 entries with two checks (Yellowstone and SY Monument) at Post Research Farm, Bozeman, MT. The trial was sown on 29th September, 2021 with pre-sowing application fertilizer. Fall of 2021 was characterized by severe drought conditions, due to which there was no emergence in Fall prior to snow cover. In spring 2022, emergence was normal. With rains coming in late spring and cool temperatures across the growing season, growth and development were normal. No diseases were observed through the season, though in some varieties physiological leaf spot was observed. Due to rains and high wind, lodging was observed in test plots. Plots were harvested later than normal due to longer growing season.

### MSU Variety Description

MTFH19132 is a hard red winter wheat developed from a three-way cross MT1078//Colter/Emerson for the purpose of FHB resistance. MTFH19132 is a tall early maturing line which shows moderate resistance to FHB. It has good adaptation in terms of yield and agronomic performance in eastern and high rainfall area of north western Montana. It is a hollow line and therefore is not suitable for sawfly affected regions in Montana. MTFH19132 has an average test weight, protein and baking quality.

MTS1908 is a hard red winter wheat derived from the three-way cross MTS0819//08X350-A6/Warhorse. It is a solid-stem variety with high solid stem scores and very low sawfly cutting in multiple years of testing under sawfly pressure. It is a medium to late maturing tall line that has shown good adaptation and yield potential in Golden Triangle region of Montana where sawfly pressure is high. It has good resistance to stripe and stem rust. MTS1908 is a low PPO line, with average test weight, protein and baking quality.

MTCL19151 is a hard red winter wheat line derived from a cross of MT0871/06X445B1-2. The line 06X445B1-2 is a sister line of SY Clearstone (segregated for two *als* genes conveying tolerance to imidazolinone herbicide). It has good winter hardiness. Agronomically, it has medium height, early heading line with medium maturity. MTCL19151 shows good yield potential across locations and years of testing in Montana. However, it is a hollow line and therefore primarily targeted for areas with low or no sawfly pressure. It has good resistance to stripe rust, though moderately susceptible to stem rust. MTCL19151 is a low PPO line with average mill and bake quality.

# Montana: 2022 (Small-Scale) Samples

| Test entry number | 22-2424 | 22-2425 | 22-2426 |
|---|---|---|---|
| **Sample identification** | **SY Monument** | **Yellowstone** | **MTFH19132** |
| **Wheat Data** | | | |
| **GIPSA classification** | 1 HRW | 1 HRW | 1 HRW |
| **Test weight (lb/bu)** | 63.2 | 62.8 | 62.`1 |
| **Hectoliter weight (kg/hl)** | 83.1 | 82.6 | 81.7 |
| **1000 kernel weight (gm)** | 32.7 | 33.7 | 30.6 |
| **Wheat kernel size (Rotap)** | | | |
| Over 7 wire (%) | 77.9 | 72.6 | 60.3 |
| Over 9 wire (%) | 21.8 | 27.1 | 39.1 |
| Through 9 wire (%) | 0.3 | 0.3 | 0.6 |
| **Single kernel (skcs)[a]** | | | |
| Hardness (avg /s.d) | 68.2/16.9 | 68.6/15.0 | 65.7/17.4 |
| Weight (mg) (avg/s.d) | 32.7/10.5 | 33.7/10.0 | 30.6/9.5 |
| Diameter (mm)(avg/s.d) | 2.67/0.39 | 2.66/0.34 | 2.53/0.37 |
| Moisture (%) (avg/s.d) | 9.2/0.9 | 9.6/0.7 | 9.3/0.8 |
| SKCS distribution | 02-08-20-70-01 | 02-05-18-75-01 | 03-09-23-65-01 |
| Classification | Hard | Hard | Hard |
| **Wheat protein (12% mb)** | 12.6 | 12.9 | 13.2 |
| **Wheat ash (12% mb)** | 1.37 | 1.48 | 1.42 |
| **Milling and Flour Quality Data** | | | |
| **Flour yield (%, str. grade)** | | | |
| Miag Multomat Mill | 75.4 | 75.6 | 76.5 |
| Quadrumat Sr. Mill | 68.2 | 67.6 | 68.9 |
| **Flour moisture (%)** | 12.0 | 12.7 | 12.5 |
| **Flour protein (14% mb)** | 11.4 | 11.8 | 12.0 |
| **Flour ash (14% mb)** | 0.42 | 0.46 | 0.41 |
| **Rapid Visco-Analyser** | | | |
| Peak Time (min) | 6.2 | 6.4 | 6.4 |
| Peak Viscosity (RVU) | 177.8 | 199.0 | 209.6 |
| Breakdown (RVU) | 50.8 | 55.7 | 60.5 |
| Final Viscosity at 13 min (RVU) | 229.8 | 247.9 | 255.0 |
| **Minolta color meter** | | | |
| L* | 91.62 | 91.09 | 91.46 |
| a* | -1.54 | -1.33 | -1.13 |
| b* | 8.84 | 8.77 | 7.93 |
| **PPO** | 0.265 | 0.407 | 0.631 |
| **Falling number (sec)** | 403 | 407 | 393 |
| **Damaged Starch** | | | |
| (AI%) | 99.3 | 98.5 | 98.9 |
| (AACC76-31) | 9.1 | 8.4 | 8.7 |

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

# Montana: 2022 (Small-Scale) Samples (Continued)

| Test entry number | 22-2427 | 22-2428 |
|---|---|---|
| **Sample identification** | **MTS1908** | **MTCL19151** |
| **Wheat Data** | | |
| **GIPSA classification** | 1 HRW | 1 HRW |
| **Test weight (lb/bu)** | 64.4 | 64.0 |
| **Hectoliter weight (kg/hl)** | 84.6 | 84.1 |
| **1000 kernel weight (gm)** | 31.3 | 30.7 |
| **Wheat kernel size (Rotap)** | | |
| Over 7 wire (%) | 67.3 | 70.0 |
| Over 9 wire (%) | 32.3 | 29.8 |
| Through 9 wire (%) | 0.4 | 0.2 |
| **Single kernel (skcs)[a]** | | |
| Hardness (avg /s.d) | 69.2/15.4 | 69.1/17.1 |
| Weight (mg) (avg/s.d) | 31.3/8.7 | 30.7/10.1 |
| Diameter (mm)(avg/s.d) | 2.62/0.34 | 2.69/0.35 |
| Moisture (%) (avg/s.d) | 9.0/0.9 | 9.2/0.8 |
| SKCS distribution | 01-05-19-75-01 | 02-08-19-71-01 |
| Classification | Hard | Hard |
| **Wheat protein (12% mb)** | 13.4 | 12.6 |
| **Wheat ash (12% mb)** | 1.37 | 1.43 |
| **Milling and Flour Quality Data** | | |
| **Flour yield (%, str. grade)** | | |
| Miag Multomat Mill | 76.8 | 76.2 |
| Quadrumat Sr. Mill | 69.9 | 68.2 |
| **Flour moisture (%)** | 12.4 | 12.1 |
| **Flour protein (14% mb)** | 12.4 | 11.7 |
| **Flour ash (14% mb)** | 0.39 | 0.44 |
| **Rapid Visco-Analyser** | | |
| Peak Time (min) | 6.3 | 6.3 |
| Peak Viscosity (RVU) | 198.7 | 202.3 |
| Breakdown (RVU) | 54.3 | 62.1 |
| Final Viscosity at 13 min (RVU) | 257.3 | 246.3 |
| **Minolta color meter** | | |
| L* | 91.45 | 91.51 |
| a* | -1.66 | -1.52 |
| b* | 9.70 | 8.98 |
| **PPO** | 0.215 | 0.158 |
| **Falling number (sec)** | 386 | 425 |
| **Damaged Starch** | | |
| (AI%) | 98.9 | 99.2 |
| (AACC76-31) | 8.7 | 9.0 |

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

# Montana: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples

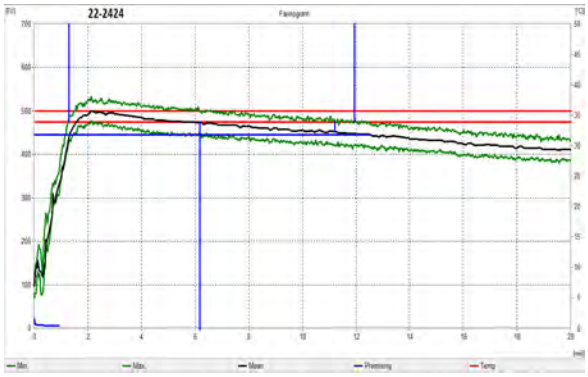
| Test Entry Number | 22-2424 | 22-2425 | 22-2426 |
|---|---|---|---|
| Sample Identification | SY Monument | Yellowstone | MTFH19132 |
| **MIXOGRAPH** | | | |
| Flour Abs (% as-is) | 71.3 | 71.7 | 71.9 |
| Flour Abs (14% mb) | 69.0 | 70.3 | 70.3 |
| Mix Time (min) | 7.5 | 6.1 | 6.5 |
| Mix tolerance (0-6) | 5 | 5 | 5 |
| **FARINOGRAPH** | | | |
| Flour Abs (% as-is) | 71.0 | 69.7 | 70.9 |
| Flour Abs (14% mb) | 68.7 | 68.3 | 69.3 |
| Peak time (min) | 6.2 | 5.7 | 7.2 |
| Mix stability (min) | 10.6 | 8.7 | 11.8 |
| Mix Tolerance Index (FU) | 23 | 33 | 24 |
| Breakdown time (min) | 12.5 | 10.1 | 14.6 |
| **ALVEOGRAPH** | | | |
| P(mm): Tenacity | 182 | 164 | 192 |
| L(mm): Extensibility | 36 | 35 | 46 |
| G(mm): Swelling index | 13.3 | 13.1 | 15.1 |
| W($10^{-4}$ J): strength (curve area) | 294 | 245 | 388 |
| P/L: curve configuration ratio | 5.06 | 4.69 | 4.17 |
| Ie($P_{200}$/P): elasticity index | 0.0 | 0.0 | 61.8 |
| **EXTENSIGRAPH** | | | |
| Resist (BU at 45/90/135 min) | 528/711/804 | 500/697/672 | 509/1021/875 |
| Extensibility (mm at 45/90/135 min) | 122/119/117 | 142/121/113 | 131/101/103 |
| Energy ($cm^2$ at 45/90/135 min) | 102/129/128 | 131/139/112 | 109/149/123 |
| Resist $_{max}$ (BU at 45/90/135 min) | 671/937/939 | 742/947/853 | 658/1323/1067 |
| Ratio (at 45/90/135 min) | 4.3/6.0/6.0 | 3.5/5.8/5.9 | 3.9/10.1/8.5 |
| **PROTEIN ANALYSIS** | | | |
| HMW-GS Composition | 2*, 7+9, 5+10 | 1, 7+8, 5+10 | 1, 7+8, 5+10 |
| TPP/TMP | 0.96 | 0.94 | 1.00 |
| **SEDIMENTATION TEST** | | | |
| Volume (ml) | 65.5 | 67.6 | 68.4 |

# Montana: Physical Dough Tests and Protein Analysis 2022 (Small-Scale) Samples (Continued)

| Test Entry Number | 22-2427 | 22-2428 |
|---|---|---|
| Sample Identification | MTS1908 | MTCL19151 |
| **MIXOGRAPH** | | |
| Flour Abs (% as-is) | 73.2 | 72.6 |
| Flour Abs (14% mb) | 71.7 | 70.4 |
| Mix Time (min) | 9.5 | 6.0 |
| Mix tolerance (0-6) | 6 | 5 |
| **FARINOGRAPH** | | |
| Flour Abs (% as-is) | 70.1 | 72.6 |
| Flour Abs (14% mb) | 68.5 | 70.4 |
| Peak time (min) | 6.3 | 6.0 |
| Mix stability (min) | 16.8 | 10.4 |
| Mix Tolerance Index (FU) | 16 | 24 |
| Breakdown time (min) | 15.2 | 11.4 |
| **ALVEOGRAPH** | | |
| P(mm): Tenacity | 188 | 184 |
| L(mm): Extensibility | 33 | 42 |
| G(mm): Swelling index | 12.8 | 14.4 |
| W($10^{-4}$ J): strength (curve area) | 275 | 334 |
| P/L: curve configuration ratio | 5.70 | 4.38 |
| Ie($P_{200}$/P): elasticity index | 0.0 | 56.8 |
| **EXTENSIGRAPH** | | |
| Resist (BU at 45/90/135 min) | 635/1283/1334 | 448/635/725 |
| Extensibility (mm at 45/90/135 min) | 114/92/78 | 141/133/121 |
| Energy ($cm^2$ at 45/90/135 min) | 108/141/104 | 111/148/132 |
| Resist $_{max}$ (BU at 45/90/135 min) | 784/1351/1346 | 635/947/910 |
| Ratio (at 45/90/135 min) | 5.6/13.9/17.2 | 3.2/4.8/6.0 |
| **PROTEIN ANALYSIS** | | |
| HMW-GS Composition | 1, 7+8, 5+10 | 2*, 7+9, 5+10 |
| TPP/TMP | 0.88 | 0.98 |
| **SEDIMENTATION TEST** | | |
| Volume (ml) | 70.8 | 69.4 |

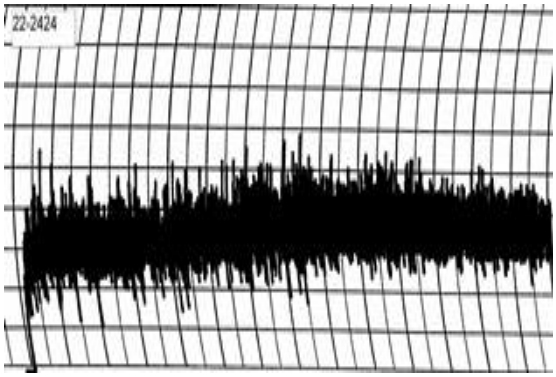
# Physical Dough Tests
## 2022 (Small Scale) Samples – Montana

### Farinograms



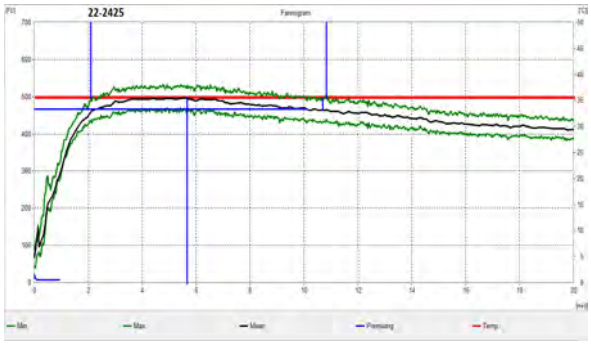

Water abs = 68.7%, Peak time = 6.2 min
Mix stab = 10.6 min, MTI = 23 FU

### Mixograms

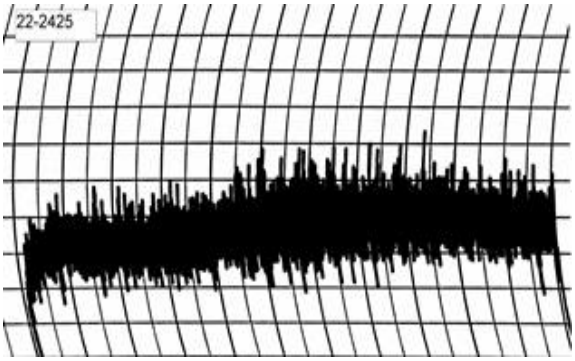



Water abs = 69.0%
Mix time = 7.5 min

**22-2424, SY Monument**




Water abs = 68.3%, Peak time = 5.7 min,
Mix stab = 8.7 min, MTI = 33 FU



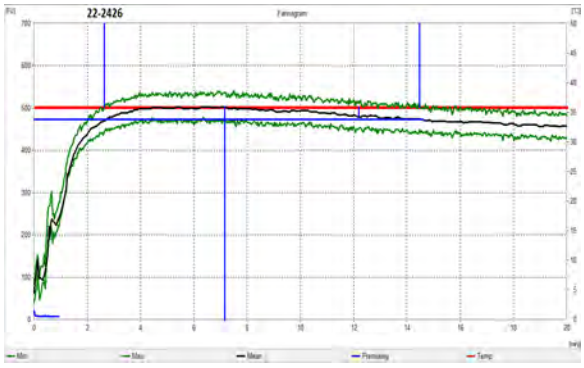

Water abs = 70.3%
Mix time = 6.1 min

**22-2425, Yellowstone**

# Physical Dough Tests

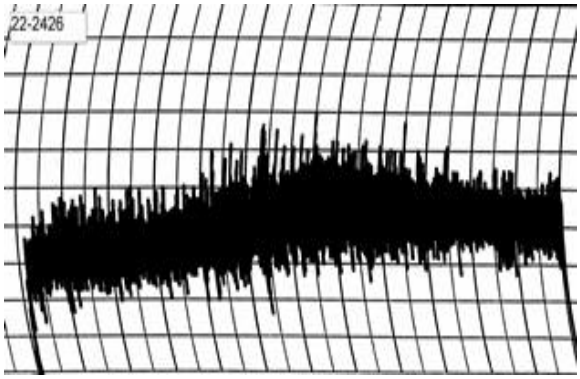
## 2022 (Small Scale) Samples – Montana (continued)

### Farinograms



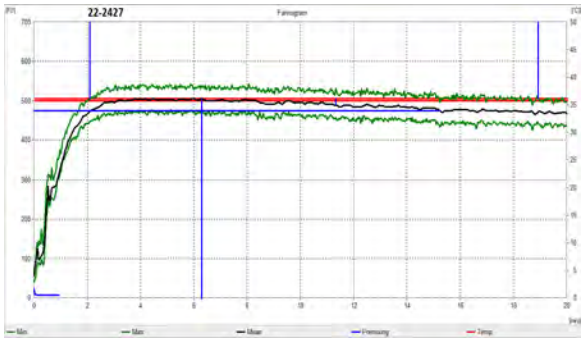

Water abs. = 69.3%, Peak time = 7.2 min,
Mix stab = 11.8 min, MTI = 24 FU

### Mixograms

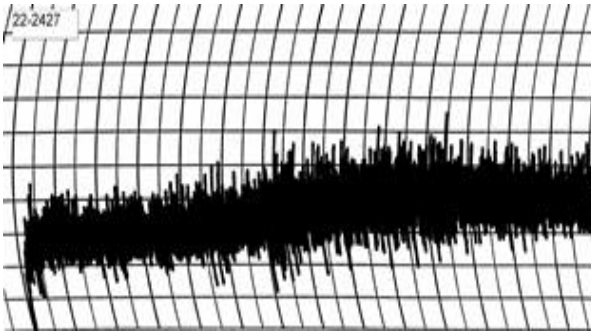



Water abs = 70.3%
Mix time = 6.5 min

**22-2426, MTFH19132**




Water abs. = 68.5%, Peak time = 6.3 min,
Mix stab = 16.8 min, MTI = 16 FU



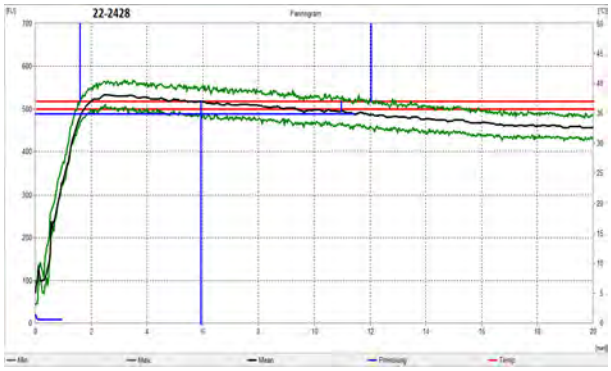

Water abs = 71.7%
Mix time = 9.5 min

**22-2427, MTS1908**

# Physical Dough Tests

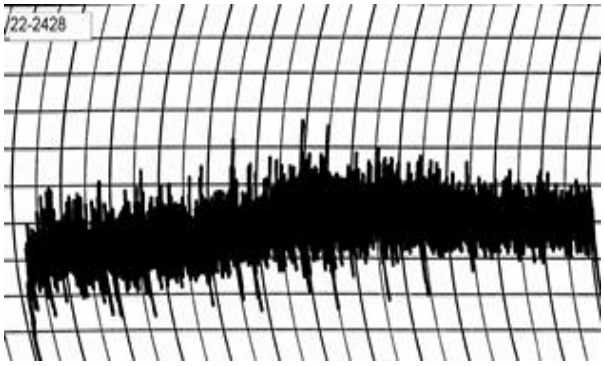
## 2022 (Small Scale) Samples – Montana (continued)

### Farinograms




Water abs. = 70.4%, Peak time = 6.0 min,
Mix stab = 10.4 min, MTI = 24 FU

### Mixograms

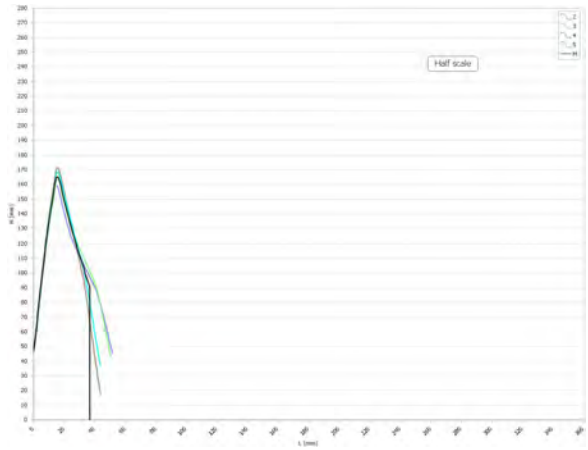



Water abs = 70.4%
Mix time = 6.0 min

**22-2428, MTCL19151**

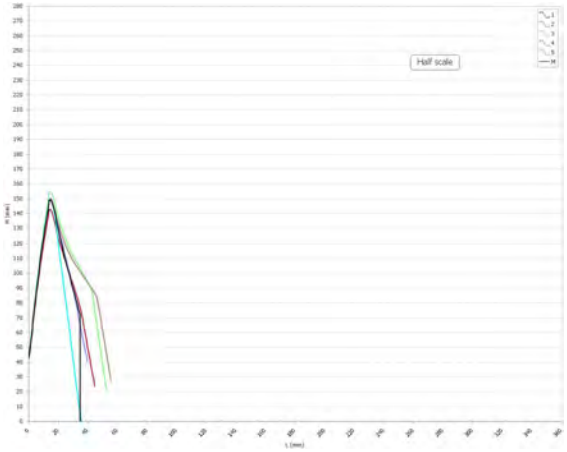
# Physical Dough Tests - Alveograph

## 2022 (Small Scale) Samples – Montana



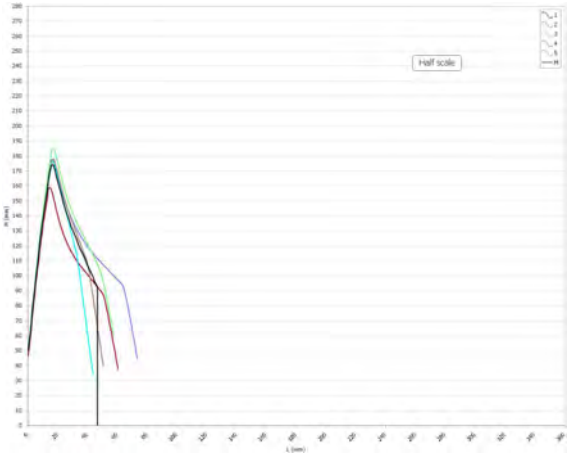

**22-2424, SY Monument**

P (mm $H_20$) = 182, L (mm) = 36, W ($10E^{-4}J$) = 294



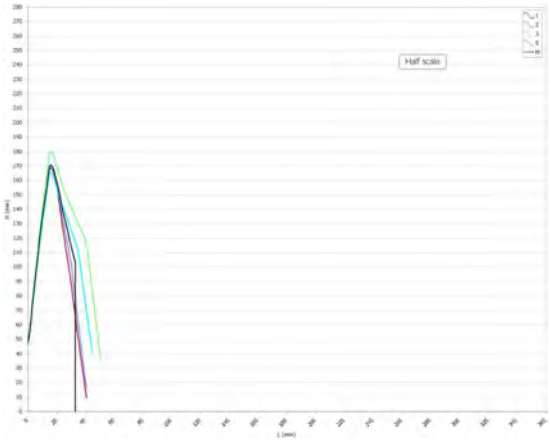

**22-2425, Yellowstone**

P (mm $H_20$) = 164, L (mm) = 35, W ($10E^{-4}J$) = 245




**22-2426, MTFH19132**

P (mm $H_20$) = 192, L (mm) = 46, W ($10E^{-4}J$) = 388

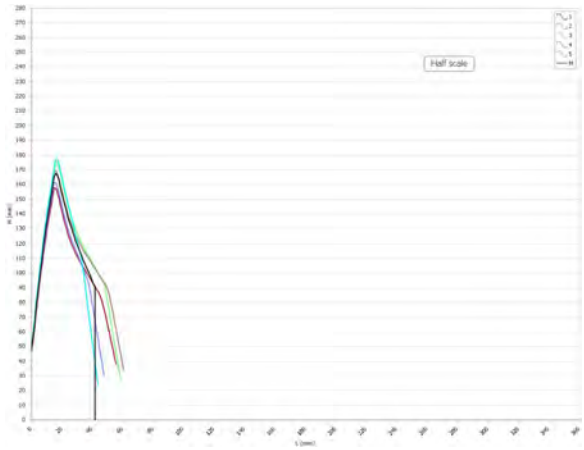



**22-2427, MTS1908**

P (mm $H_20$) = 188, L (mm) = 33, W ($10E^{-4}J$) = 275

# Physical Dough Tests - Alveograph

## 2022 (Small Scale) Samples – Montana

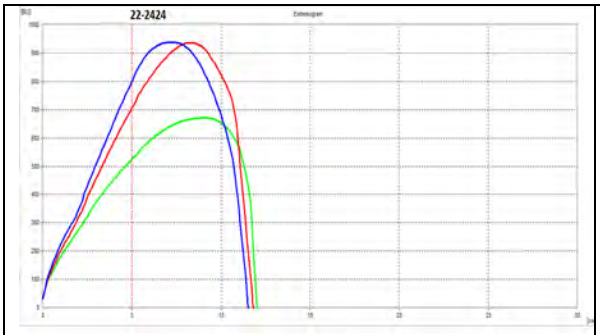



**22-2428, MTCL19151**

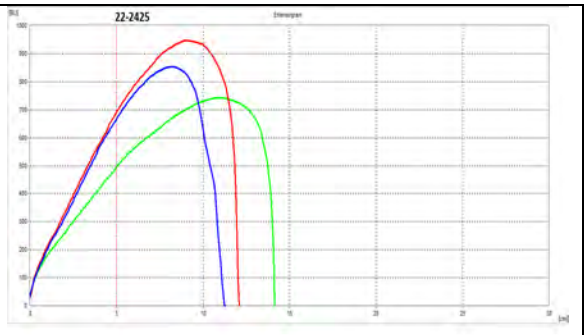
P (mm $H_20$) = 184, L (mm) = 42, W ($10E^{-4}J$) = 334

# Physical Dough Tests - Extensigraph

## 2022 (Small Scale) Samples – Montana

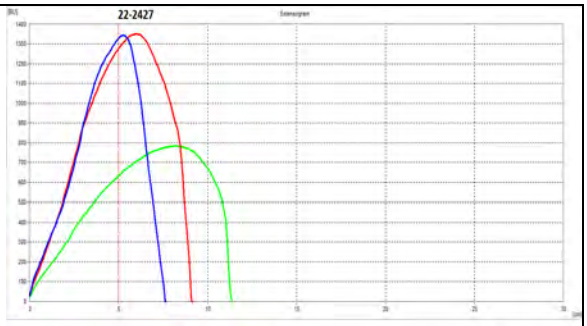



**22-2424, SY Monument**
R (BU) = 711, E (mm) = 119, W ($cm^2$) = 129
Rmax (BU) = 937, Ratio = 6.0 at 90 min




**22-2425, Yellowstone**
R (BU) = 697, E (mm) = 121, W ($cm^2$) = 139
Rmax (BU) = 947, Ratio = 5.8 at 90 min


**22-2426, MTFH19132**
R (BU) = 1021, E (mm) = 101, W ($cm^2$) = 149
Rmax (BU) = 1323, Ratio = 10.1 at 90 min

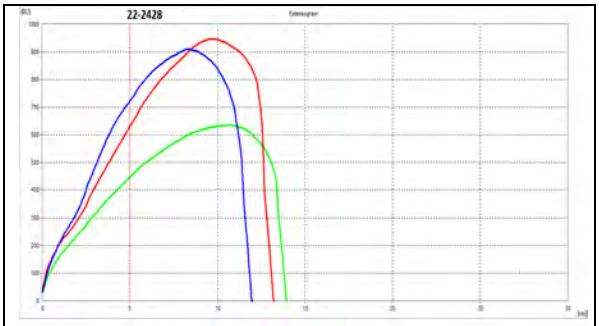



**22-2427, MTS1908**
R (BU) = 1283, E (mm) = 92.4, W ($cm^2$) = 141
Rmax (BU) = 1351, Ratio = 13.9 at 90 min

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

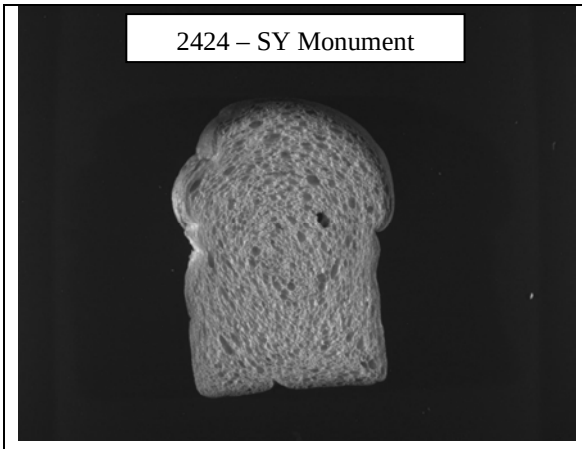
# Physical Dough Tests - Extensigraph

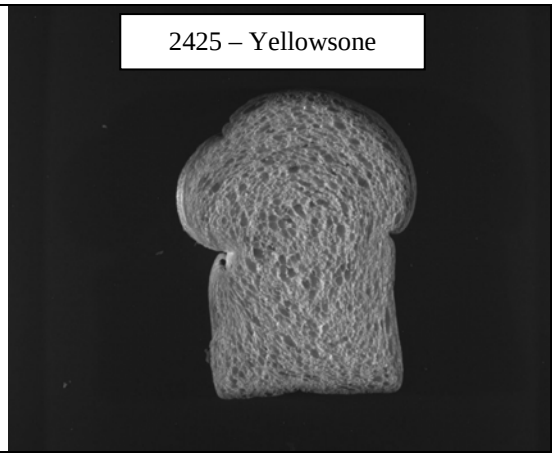
## 2022 (Small Scale) Samples – Montana



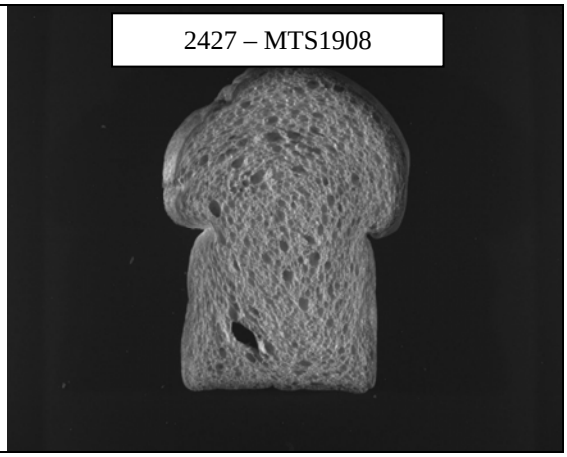

**22-2428, MTCL19151**
R (BU) = 635, E (mm) = 133, W ($cm^2$) = 148
Rmax (BU) = 947, Ratio = 4.8 at 90 min

# Montana: C-Cell Bread Images and Analysis
# 2022 (Small-Scale) Samples



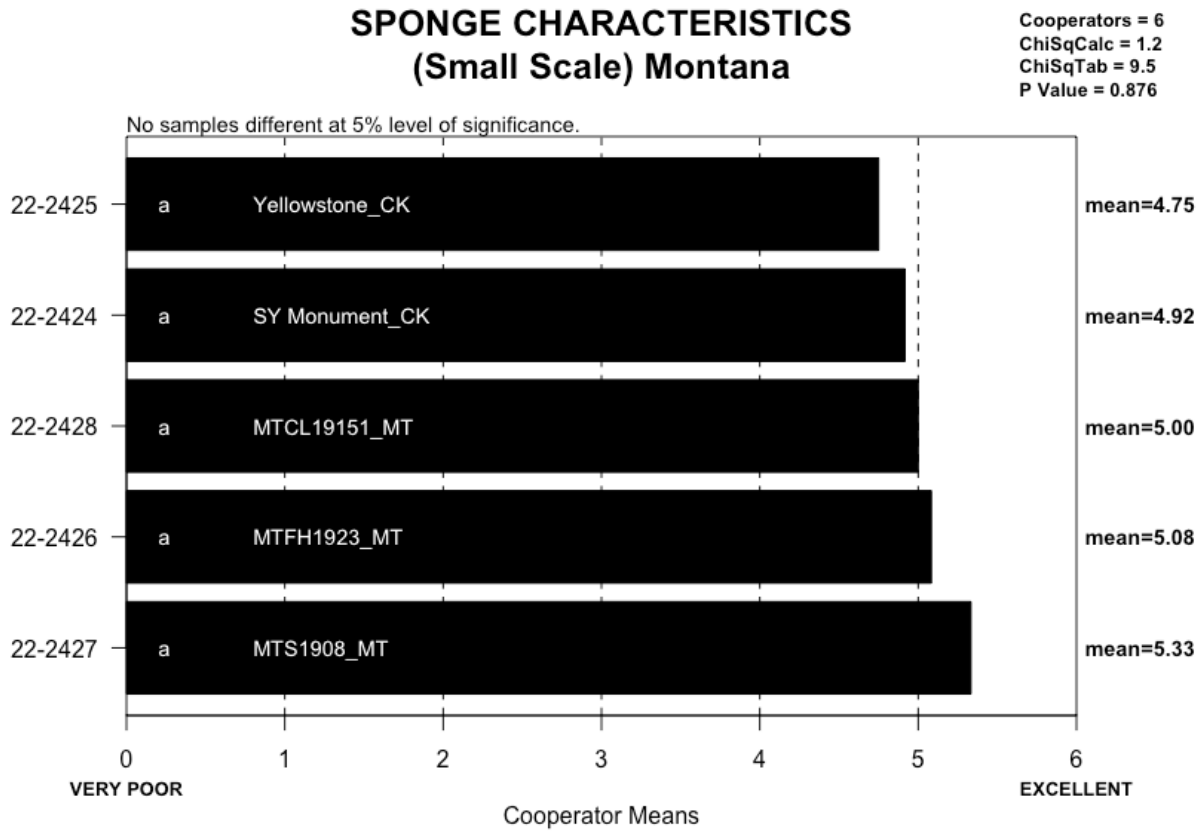

| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2424** | 5891 | 116 | 3667 | 0.413 | 1.903 | 5.568 | 1.815 | -4.65 |
| **2425** | 6333 | 114 | 3614 | 0.430 | 2.100 | 1.190 | 1.785 | -6.98 |

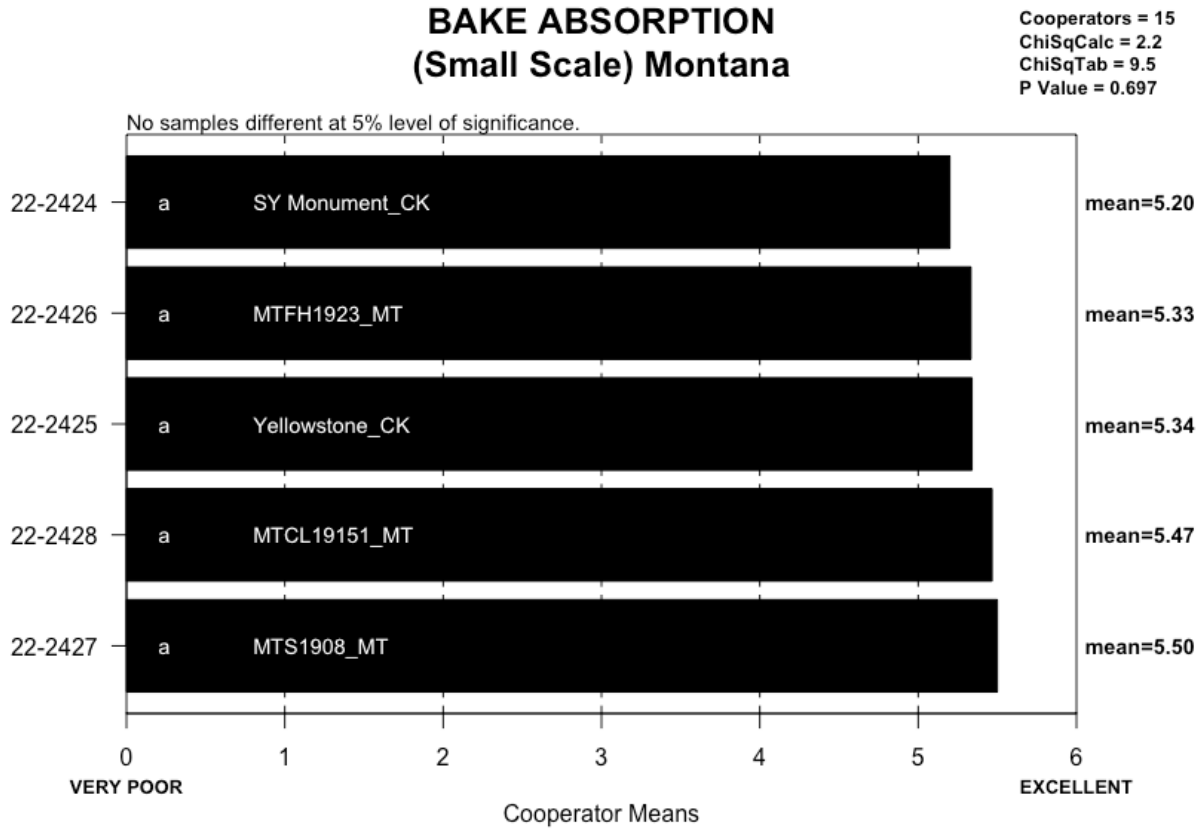




| Entry # | Slice Area ($mm^2$) | Slice Brightness | Number Cells | Wall Thick (mm) | Cell Diameter (mm) | Non-uniformity | Avg. Cell Elongation | Cell Angle to Vertical ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2426** | 6507 | 110 | 3717 | 0.430 | 2.180 | 10.060 | 1.825 | -3.75 |
| **2427** | 6875 | 110 | 3822 | 0.420 | 2.150 | 12.745 | 1.835 | -4.30 |

# Montana: C-Cell Bread Images and Analysis
# 2022 (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 ($^0$) |
|---|---|---|---|---|---|---|---|---|
| **2428** | 6824 | 106 | 3475 | 0.445 | 2.575 | 8.635 | 1.805 | -11.80 |


SPONGE CHARACTERISTICS
(Small Scale) Montana
Cooperators = 6
ChiSqCalc = 1.2
ChiSqTab = 9.5
P Value = 0.876
No samples different at 5% level of significance.
22-2425
a
Yellowstone_CK
mean=4.75
22-2424
a
SY Monument_CK
mean=4.92
22-2428
a
MTCL19151_MT
mean=5.00
22-2426
a
MTFH1923_MT
mean=5.08
22-2427
a
MTS1908_MT
mean=5.33
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

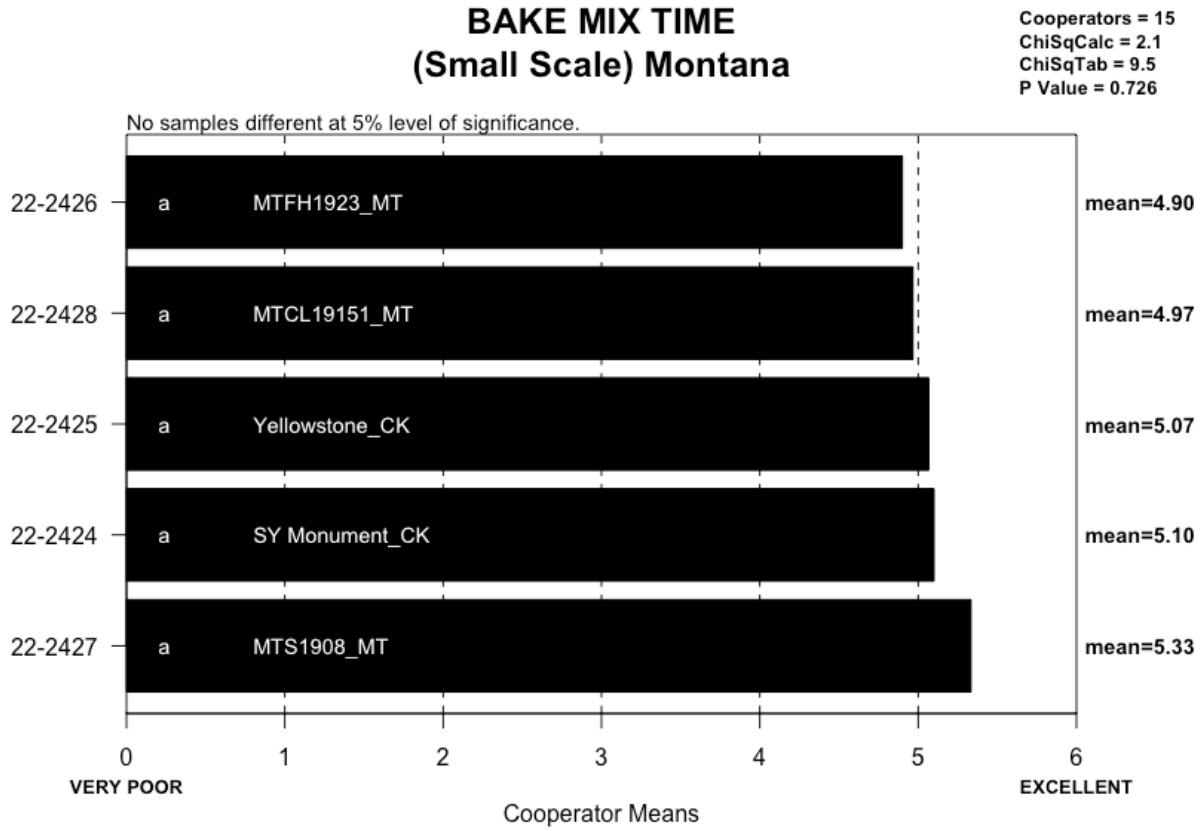

BAKE ABSORPTION
(Small Scale) Montana
Cooperators = 15
ChiSqCalc = 2.2
ChiSqTab = 9.5
P Value = 0.697
No samples different at 5% level of significance.
22-2424
a
SY Monument_CK
mean=5.20
22-2426
a
MTFH1923_MT
mean=5.33
22-2425
a
Yellowstone_CK
mean=5.34
22-2428
a
MTCL19151_MT
mean=5.47
22-2427
a
MTS1908_MT
mean=5.50
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

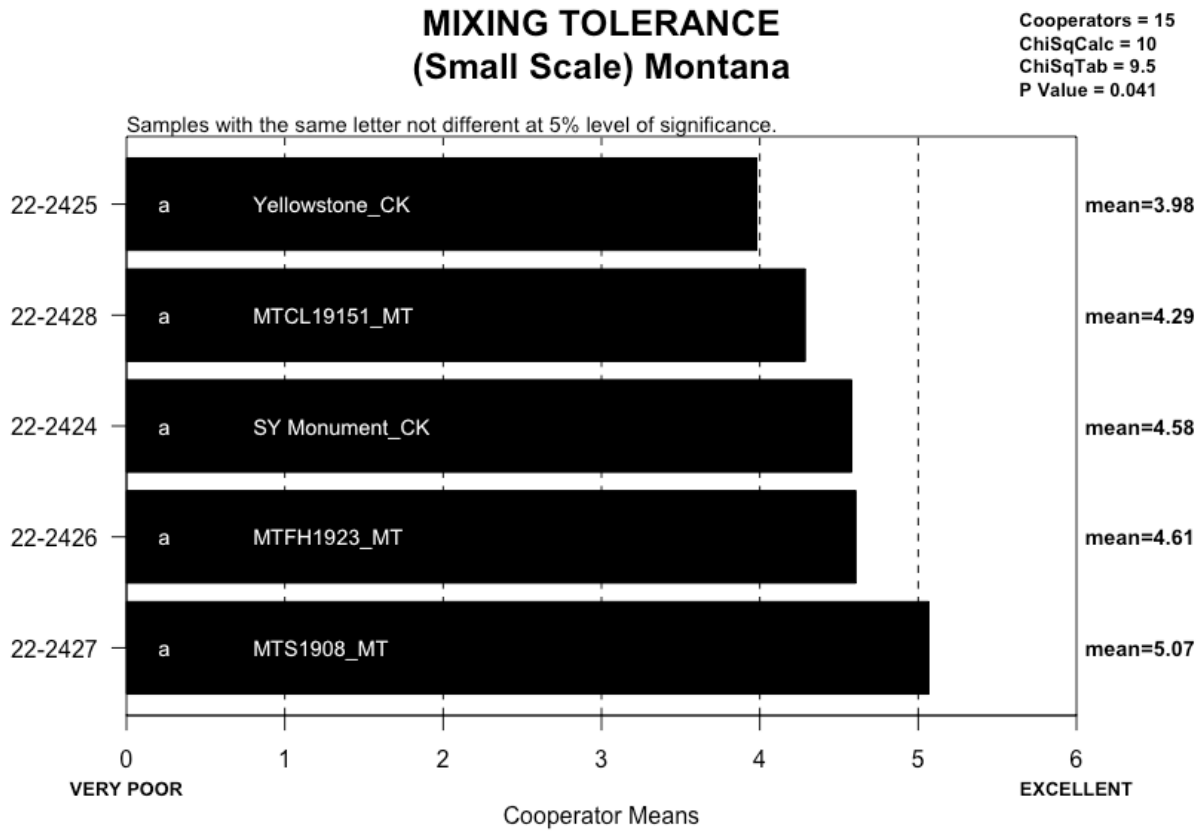
# BAKE ABSORPTION, ACTUAL (14% MB)
# (Small Scale) Montana
# Cooperators A – O

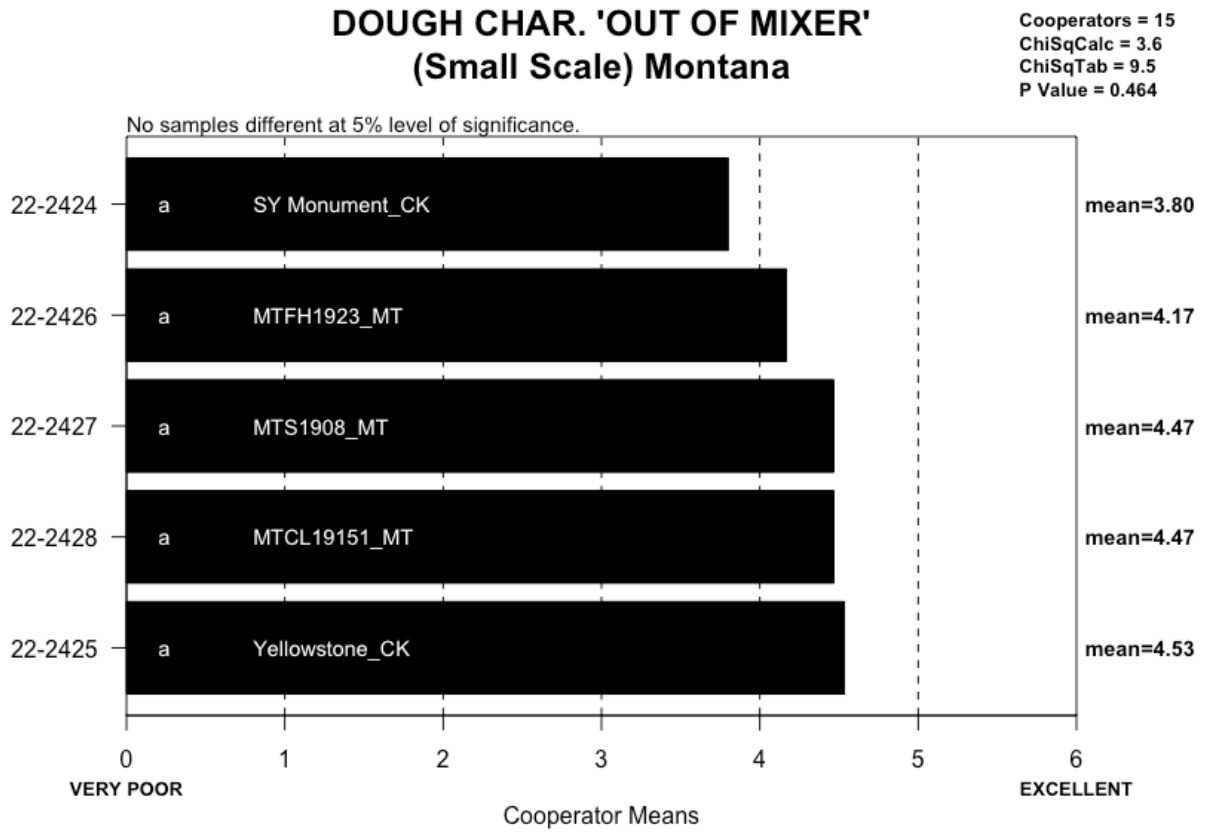
| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 58 | 66.4 | 65.6 | 73.7 | 68.9 | 70.7 | 68.7 | 62.7 | 68.4 | 71.2 | 68.7 | 73.0 | 69.0 | 68.6 | 68 |
| 22-2425 | Yellowstone_CK | 59 | 67.8 | 64.6 | 73.1 | 69.0 | 70.8 | 68.3 | 61.6 | 69.3 | 71.3 | 68.3 | 71.1 | 70.3 | 66.6 | 68 |
| 22-2426 | MTFH1923_MT | 59 | 67.2 | 65.1 | 74.3 | 68.4 | 70.8 | 69.3 | 60.4 | 69.1 | 72.0 | 69.3 | 72.4 | 70.3 | 66.8 | 69 |
| 22-2427 | MTS1908_MT | 59 | 71.2 | 65.1 | 73.3 | 69.4 | 71.5 | 68.5 | 63.4 | 70.1 | 71.0 | 68.5 | 71.7 | 71.7 | 66.8 | 68 |
| 22-2428 | MTCL19151_MT | 59 | 70.4 | 66.1 | 70.5 | 67.9 | 71.9 | 70.4 | 62.8 | 69.5 | 73.0 | 70.4 | 74.5 | 70.4 | 67.8 | 70 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 15 | 6.3 | 11.1 | 8.1 | 6.0 | 7.5 | 10 | 8 | 10.0 | 25 | 6 | 4.5 | 7.5 | 18 | 18 |
| 22-2425 | Yellowstone_CK | 15 | 6.3 | 9.7 | 7.2 | 5.5 | 7.5 | 10 | 9 | 9.3 | 25 | 6 | 5.5 | 6.1 | 17 | 20 |
| 22-2426 | MTFH1923_MT | 15 | 5.5 | 9.3 | 7.8 | 5.5 | 7.0 | 9 | 8 | 9.0 | 13 | 7 | 5.5 | 6.5 | 20 | 20 |
| 22-2427 | MTS1908_MT | 15 | 9.4 | 10.4 | 9.1 | 7.0 | 8.5 | 12 | 10 | 13.0 | 13 | 7 | 5.0 | 9.5 | 20 | 25 |
| 22-2428 | MTCL19151_MT | 15 | 6.7 | 8.4 | 7.0 | 5.0 | 7.0 | 12 | 7 | 8.5 | 25 | 6 | 5.0 | 6.0 | 12 | 25 |

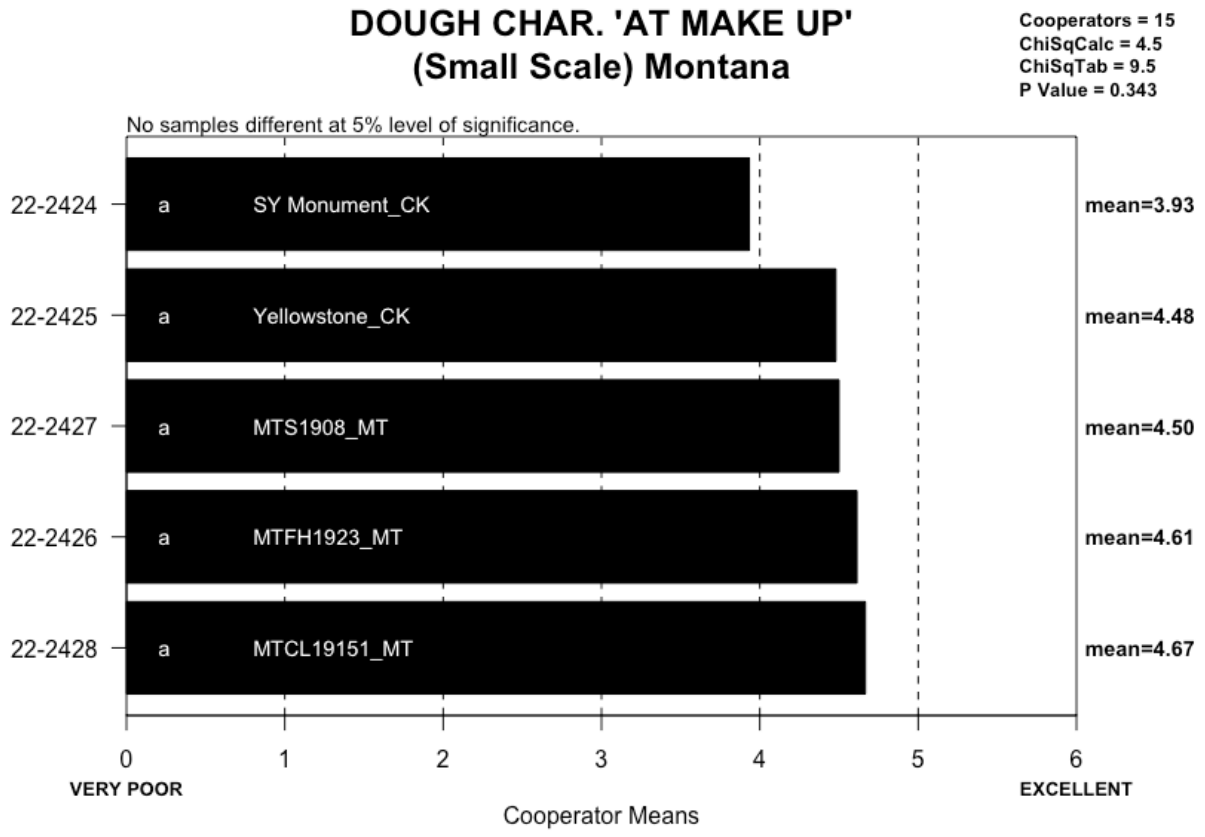

BAKE MIX TIME
(Small Scale) Montana
Cooperators = 15
ChiSqCalc = 2.1
ChiSqTab = 9.5
P Value = 0.726
No samples different at 5% level of significance.
22-2426
a
MTFH1923_MT
mean=4.90
22-2428
a
MTCL19151_MT
mean=4.97
22-2425
a
Yellowstone_CK
mean=5.07
22-2424
a
SY Monument_CK
mean=5.10
22-2427
a
MTS1908_MT
mean=5.33
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


MIXING TOLERANCE
(Small Scale) Montana
Cooperators = 15
ChiSqCalc = 10
ChiSqTab = 9.5
P Value = 0.041
Samples with the same letter not different at 5% level of significance.
22-2425
a
Yellowstone_CK
mean=3.98
22-2428
a
MTCL19151_MT
mean=4.29
22-2424
a
SY Monument_CK
mean=4.58
22-2426
a
MTFH1923_MT
mean=4.61
22-2427
a
MTS1908_MT
mean=5.07
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means



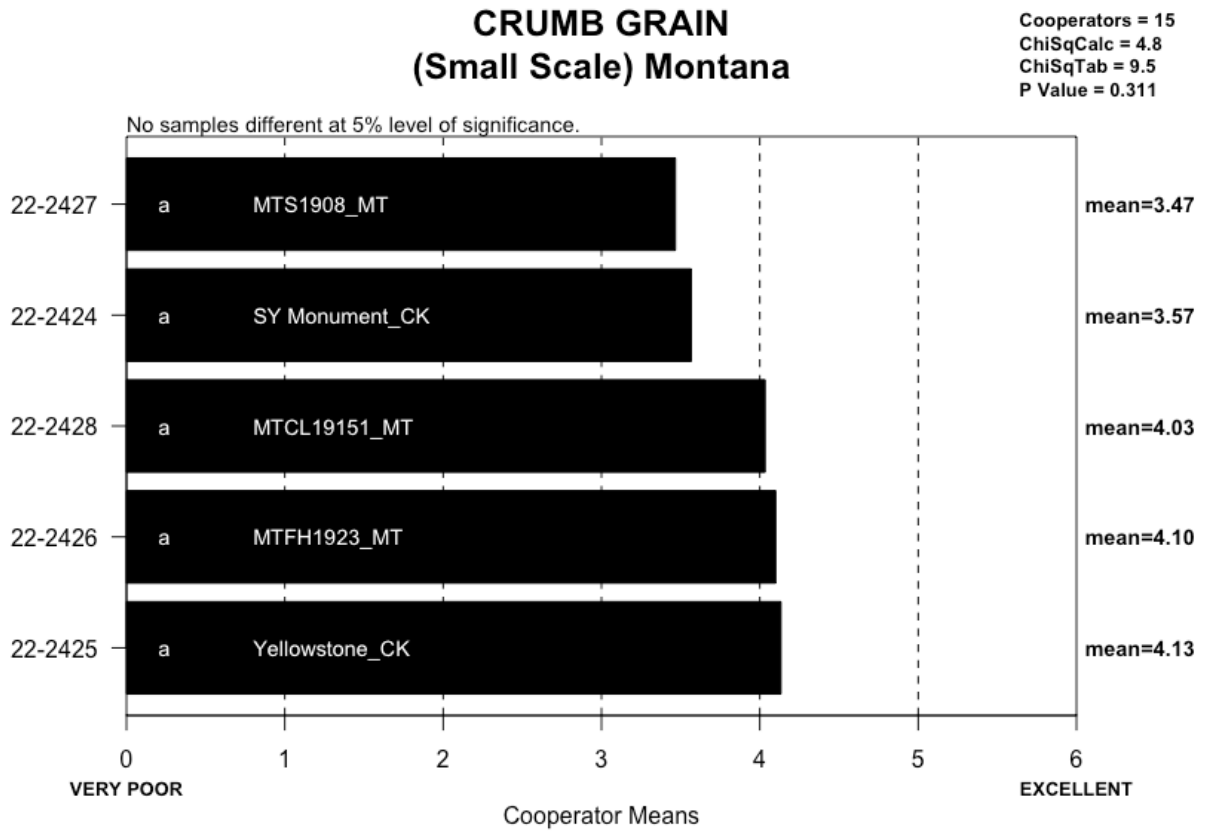

# DOUGH CHAR. 'OUT OF MIXER', DESCRIBED
## (Small Scale) Montana

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 5 | 2 | 3 | 4 | 1 |
| 22-2425 | Yellowstone_CK | 3 | 1 | 3 | 6 | 2 |
| 22-2426 | MTFH1923_MT | 3 | 1 | 2 | 8 | 1 |
| 22-2427 | MTS1908_MT | 3 | 1 | 2 | 7 | 2 |
| 22-2428 | MTCL19151_MT | 3 | 1 | 3 | 7 | 1 |




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

| IDCODE | ID | Sticky | Wet | Tough | Good | Excellent |
|---|---|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 3 | 0 | 5 | 6 | 1 |
| 22-2425 | Yellowstone_CK | 1 | 0 | 5 | 8 | 1 |
| 22-2426 | MTFH1923_MT | 2 | 0 | 3 | 8 | 2 |
| 22-2427 | MTS1908_MT | 1 | 0 | 5 | 8 | 1 |
| 22-2428 | MTCL19151_MT | 0 | 0 | 2 | 11 | 2 |

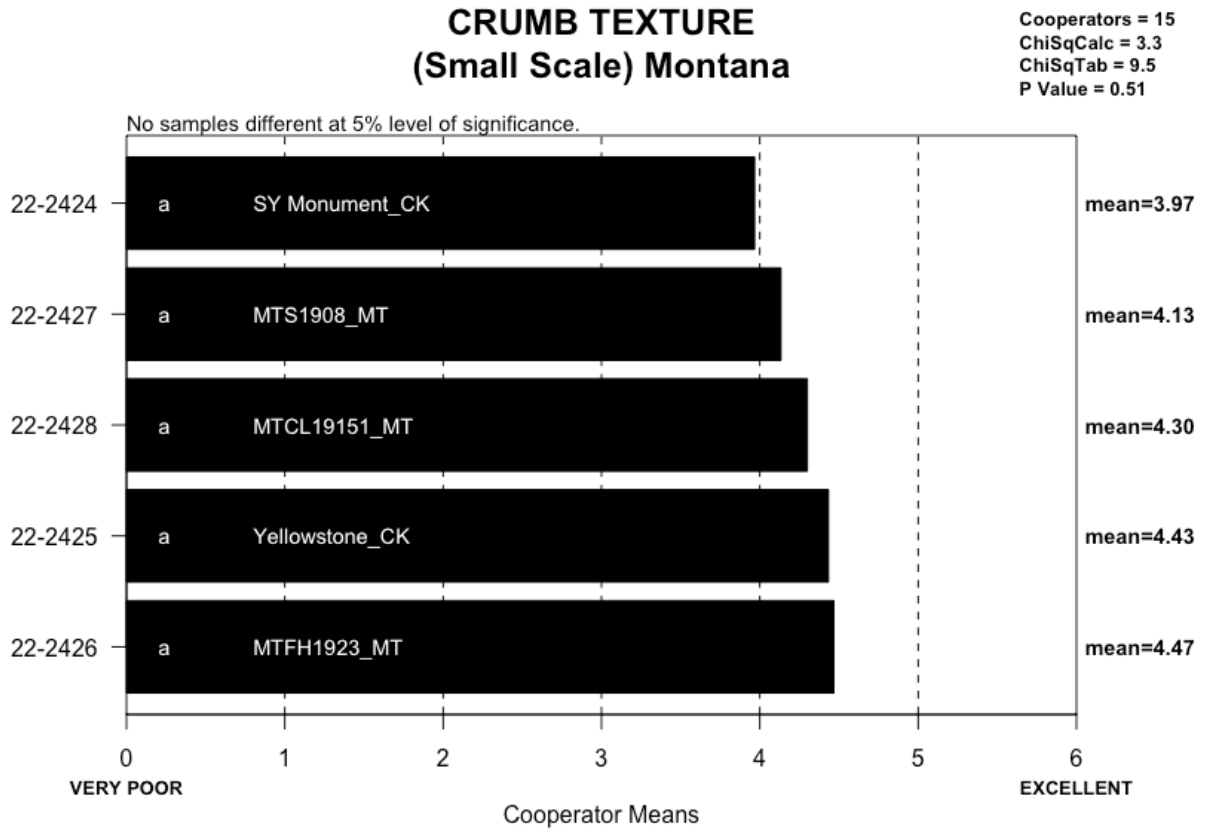



# CRUMB GRAIN, DESCRIBED
## (Small Scale) Montana

| IDCODE | ID | Open | Fine | Dense |
|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 10 | 3 | 2 |
| 22-2425 | Yellowstone_CK | 8 | 5 | 2 |
| 22-2426 | MTFH1923_MT | 9 | 5 | 1 |
| 22-2427 | MTS1908_MT | 9 | 5 | 1 |
| 22-2428 | MTCL19151_MT | 8 | 7 | 0 |

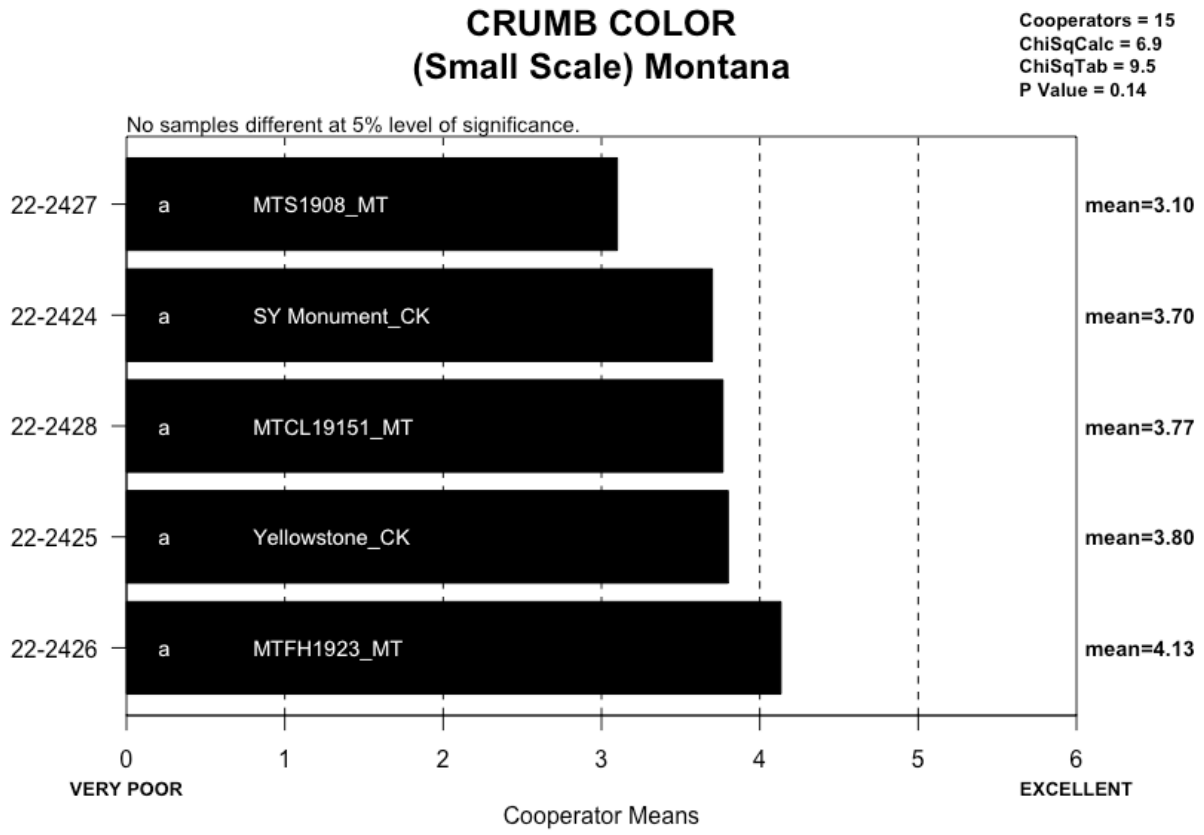
# CELL SHAPE, DESCRIBED
# (Small Scale) Montana

| IDCODE | ID | Round | Irregular | Elongated |
|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 3 | 9 | 3 |
| 22-2425 | Yellowstone_CK | 5 | 5 | 5 |
| 22-2426 | MTFH1923_MT | 6 | 6 | 3 |
| 22-2427 | MTS1908_MT | 5 | 8 | 2 |
| 22-2428 | MTCL19151_MT | 5 | 7 | 3 |




# CRUMB TEXTURE, DESCRIBED
# (Small Scale) Montana

| IDCODE | ID | Harsh | Smooth | Silky |
|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 4 | 7 | 4 |
| 22-2425 | Yellowstone_CK | 2 | 9 | 4 |
| 22-2426 | MTFH1923_MT | 2 | 8 | 5 |
| 22-2427 | MTS1908_MT | 2 | 10 | 3 |
| 22-2428 | MTCL19151_MT | 2 | 9 | 4 |




# CRUMB COLOR, DESCRIBED
# (Small Scale) Montana

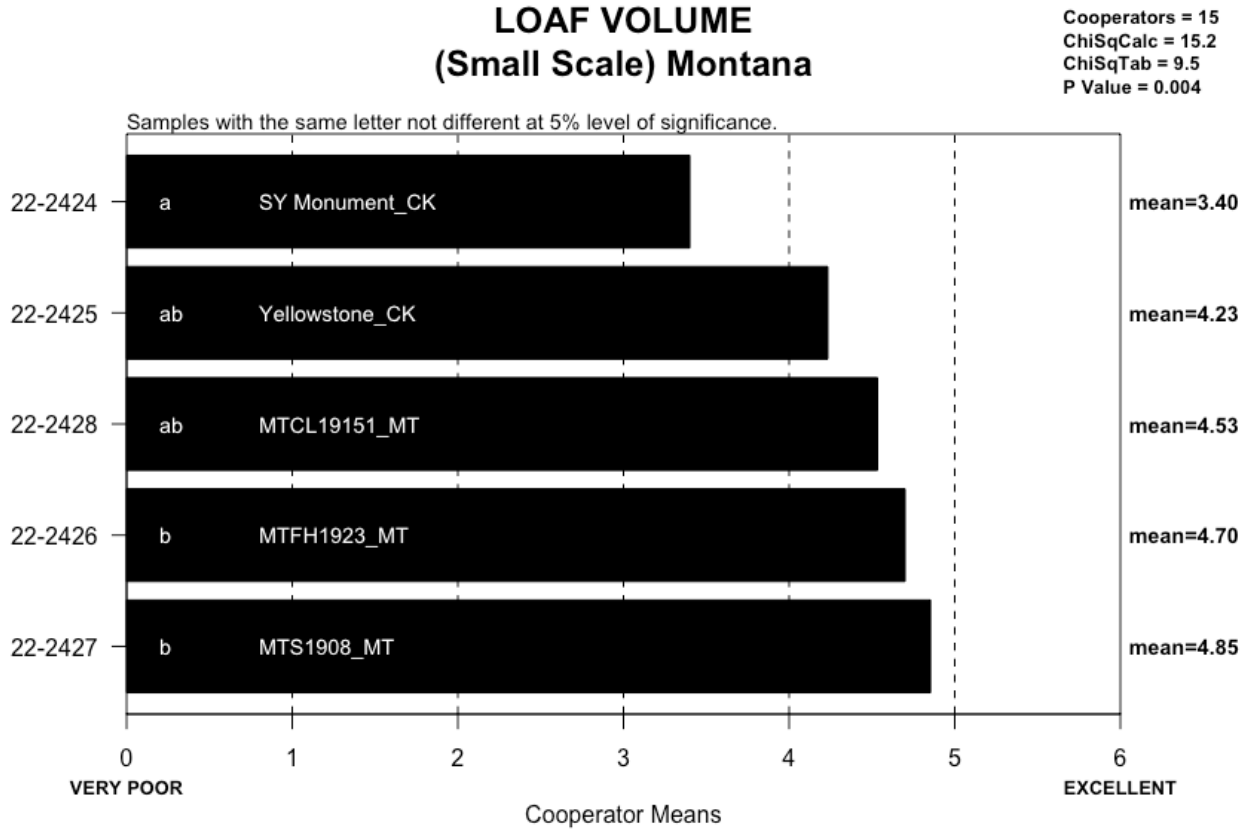
| IDCODE | ID | Gray | Dark_Yellow | Yellow | Dull | Creamy | White | Bright_White |
|---|---|---|---|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 0 | 1 | 3 | 1 | 6 | 4 | 0 |
| 22-2425 | Yellowstone_CK | 0 | 0 | 2 | 2 | 8 | 3 | 0 |
| 22-2426 | MTFH1923_MT | 0 | 0 | 0 | 3 | 6 | 6 | 0 |
| 22-2427 | MTS1908_MT | 0 | 2 | 4 | 2 | 6 | 1 | 0 |
| 22-2428 | MTCL19151_MT | 0 | 1 | 3 | 2 | 4 | 5 | 0 |

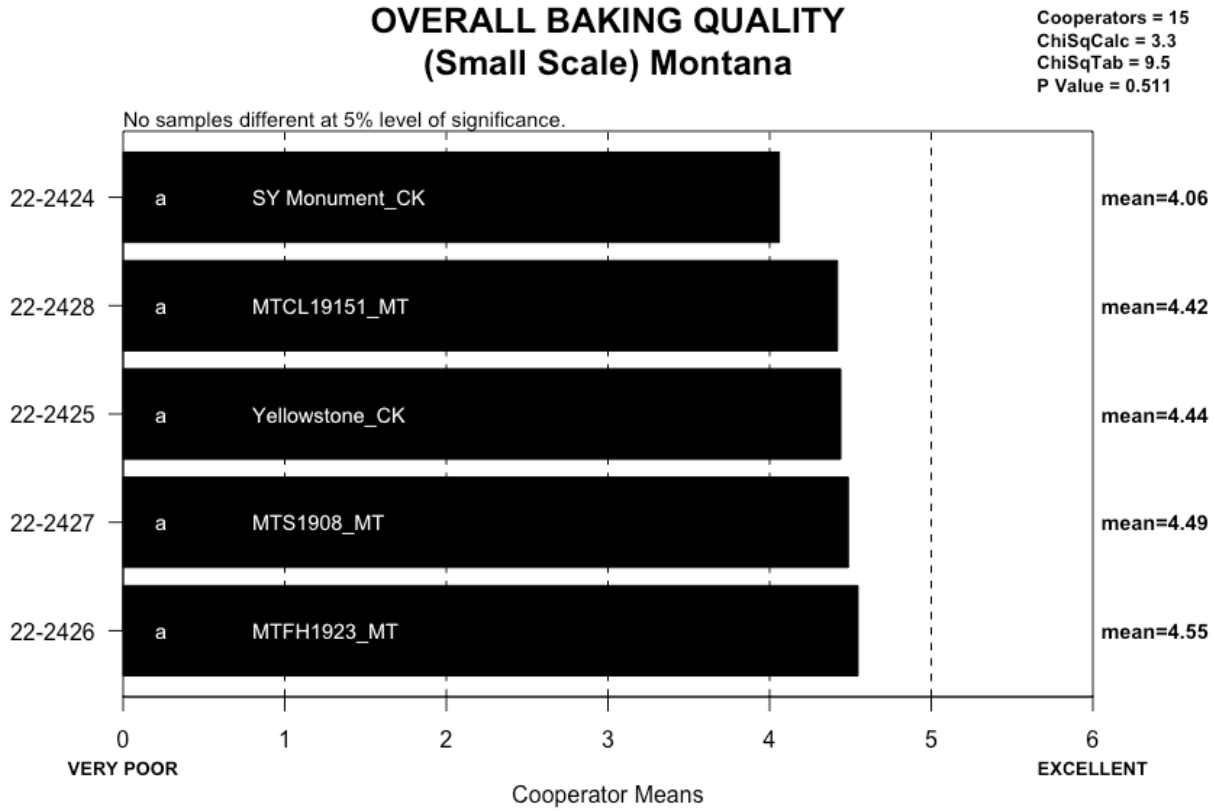
# LOAF WEIGHT, ACTUAL
# (Small Scale) Montana
# Cooperators A – O

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 420 | 152.7 | 141.5 | 139.7 | 147.3 | 148.0 | 454.5 | 481.6 | 154.3 | 447 | 456 | 136.5 | 144.6 | 422.1 | 465 |
| 22-2425 | Yellowstone_CK | 416 | 150.9 | 143.5 | 137.3 | 145.3 | 149.0 | 442.5 | 485.0 | 154.9 | 445 | 451 | 137.3 | 145.3 | 422.7 | 464 |
| 22-2426 | MTFH1923_MT | 416 | 154.6 | 142.9 | 136.7 | 141.9 | 149.4 | 445.0 | 480.0 | 155.9 | 445 | 456 | 135.9 | 144.0 | 420.3 | 462 |
| 22-2427 | MTS1908_MT | 418 | 153.9 | 140.3 | 137.1 | 142.9 | 148.1 | 446.0 | 477.3 | 153.9 | 436 | 457 | 130.8 | 145.2 | 428.1 | 462 |
| 22-2428 | MTCL19151_MT | 420 | 153.5 | 141.8 | 138.1 | 142.0 | 146.7 | 457.5 | 478.3 | 153.6 | 448 | 455 | 137.8 | 146.1 | 424.4 | 467 |

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

| IDCODE | ID | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22-2424 | SY Monument_CK | 2650 | 910 | 875 | 786 | 915 | 684 | 1860 | 2338 | 865 | 2109 | 2334 | 690 | 775 | 2900 | 2868 |
| 22-2425 | Yellowstone_CK | 2825 | 987 | 968 | 832 | 975 | 711 | 1907 | 2288 | 925 | 2227 | 2512 | 900 | 800 | 3000 | 2897 |
| 22-2426 | MTFH1923_MT | 2825 | 1009 | 950 | 875 | 1130 | 780 | 1791 | 2475 | 960 | 2524 | 2432 | 845 | 775 | 3000 | 3059 |
| 22-2427 | MTS1908_MT | 3050 | 1016 | 968 | 891 | 1115 | 808 | 1936 | 2550 | 1025 | 2416 | 2419 | 620 | 770 | 2925 | 2927 |
| 22-2428 | MTCL19151_MT | 2925 | 925 | 1000 | 836 | 1090 | 810 | 1747 | 2375 | 1000 | 2242 | 2480 | 890 | 825 | 2875 | 3104 |


LOAF VOLUME
(Small Scale) Montana
Cooperators = 15
ChiSqCalc = 15.2
ChiSqTab = 9.5
P Value = 0.004
Samples with the same letter not different at 5% level of significance.
22-2424
a
SY Monument_CK
mean=3.40
22-2425
ab
Yellowstone_CK
mean=4.23
22-2428
ab
MTCL19151_MT
mean=4.53
22-2426
b
MTFH1923_MT
mean=4.70
22-2427
b
MTS1908_MT
mean=4.85
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means


OVERALL BAKING QUALITY
(Small Scale) Montana
Cooperators = 15
ChiSqCalc = 3.3
ChiSqTab = 9.5
P Value = 0.511
No samples different at 5% level of significance.
22-2424
a
SY Monument_CK
mean=4.06
22-2428
a
MTCL19151_MT
mean=4.42
22-2425
a
Yellowstone_CK
mean=4.44
22-2427
a
MTS1908_MT
mean=4.49
22-2426
a
MTFH1923_MT
mean=4.55
0
1
2
3
4
5
6
VERY POOR
EXCELLENT
Cooperator Means

# COOPERATOR'S COMMENTS
## (Small Scale) Montana

**COOP. 22-2424 SY Monument_CK**

A. Strong tough dough out of mixer and make up, long mix, open grain, good loaf volume, creamy interior.
B. No comment.
C. Mid high water absorption, very long mix time, slight sticky and strong dough, high loaf volume, creamy crumb grain, fine elongate cells, good resilient and smooth texture.
D. No comment.
E. Long time to pick up, white dough, cap, dry??
F. Lower than average protein, long mix time, good crumb springiness.
G. No comment.
H. High absorption, average mixing time and tolerance, tough dough character, good grain, low volume.
I. Long mix time, high absorption, good mixing tolerance, average grain and volume.
J. No comment.
K. No comment.
L. Very small poor texture loaf.
M. No comment.
N. Fair protein. High absorption, mix tolerance, and volume.
O. High absorption, good mix time and stability and dough handling, good volume.

**COOP. 22-2425 Yellowstone_CK**

A. Strong tough dough out of mixer and make up, long mix, open grain, good loaf volume, creamy interior.
B. No comment.
C. High water absorption, very long mix time, slight sticky and strong dough, high loaf volume, creamy crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. Long time to pick up, excellent loaf externals.
F. Long mix time, good crumb springiness.
G. Irregular loaf shape, but other qualities okay.
H. Average absorption, strong mixing time, nice grain, very low volume.
I. Long mix time, very high absorption, good mixing tolerance, open grain, good volume.
J. No comment.
K. No comment.
L. Nice crumb with good texture.
M. No comment.
N. Good protein and absorption. High mix tolerance and volume.
O. High absorption, excellent mix time and stability, dough handling, good volume.

# COOPERATOR'S COMMENTS
## (Small Scale) Montana

**COOP. 22-2426 MTFH19132_MT**

A. Strong tough dough out of mixer and make up, long mix, open grain, good loaf volume, creamy interior.
B. No comment.
C. High water absorption, very long mix time, slight sticky and strong dough, high loaf volume, creamy crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. Long time to pick up, white dough, excellent loaf externals.
F. Long mix time, nice dough and crumb characteristics.
G. No comment.
H. Average absorption, average mix time and tolerance, tough dough at makeup.
I. Long mix time, very high absorption, good mixing tolerance, good volume.
J. No comment.
K. No comment.
L. No comment.
M. No comment.
N. Good protein and absorption. Good mix tolerance and high volume.
O. High absorption, excellent mix time and stability, dough handling and volume.

**COOP. 22-2427 MTS1908_MT**

A. Strong tough dough out of mixer and make up, long mix, open grain, good loaf volume, creamy interior.
B. No comment.
C. High water absorption, very long mix time, slight sticky and strong dough, high loaf volume, yellow crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. Long time to pick up, rough break and shred.
F. Average protein, long mix time, good loaf volume, yellow crumb color.
G. Domed top, holes.
H. High absorption, strong mix time and tolerance, good grain and volume.
I. Long mix time, very high absorption, strong mixing tolerance, dark yellow crumb, excellent volume.
J. No comment.
K. No comment.
L. Small, poor texture and grain with addition yellow color.
M. No comment.
N. Good protein and absorption. High mix tolerance and volume.
O. High absorption, excellent mix time and stability, dough handling and volume.

# COOPERATOR'S COMMENTS
## (Small Scale) Montana

**COOP.** **22-2428** **MTCL19151_MT**

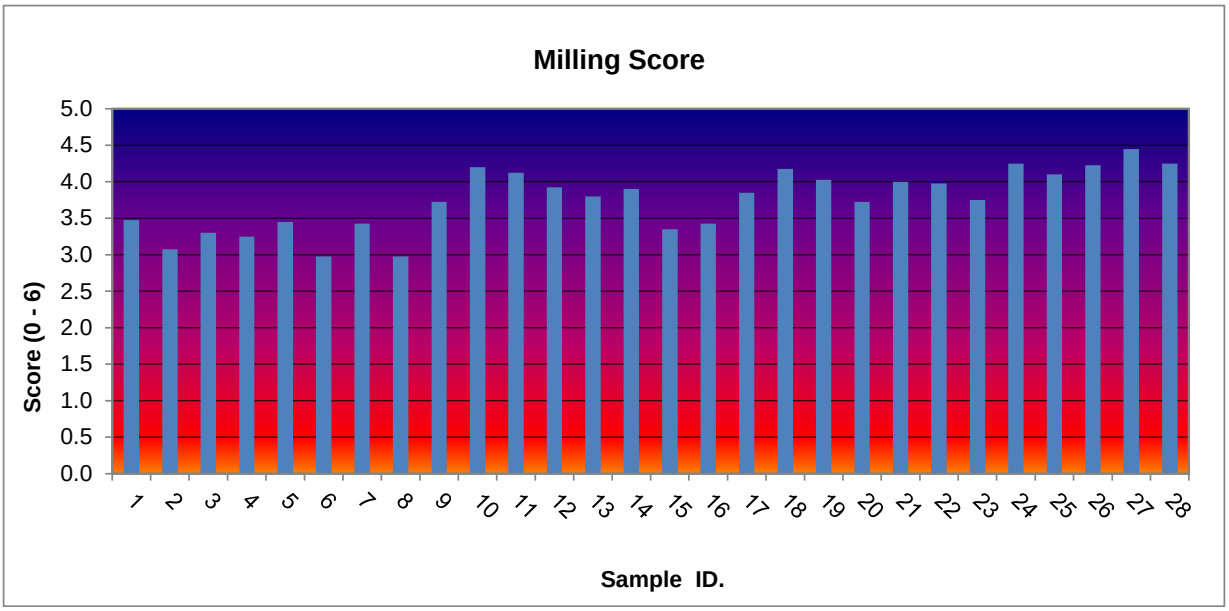
A. Strong tough dough out of mixer and make up, long mix, open grain, good loaf volume, creamy interior.
B. No comment.
C. High water absorption, long mix time, slight sticky and strong dough, very high loaf volume, creamy crumb grain, fine elongate cells, good resilient and silky texture.
D. No comment.
E. Excellent loaf externals.
F. Nice dough and crumb characteristics.
G. Gummy and irregular, potentially over absorbed, very asymmetrical.
H. High absorption, average mixing time and tolerance, low volume.
I. Long mix time, very high absorption, good mixing tolerance, dark yellow crumb, excellent volume.
J. No comment.
K. No comment.
L. Good symmetry with good crumb and grain.
M. No comment.
N. Good protein and absorption. Fair mix tolerance. High volume.
O. High absorption, excellent mix time and stability, dough handling and volume – best overall.

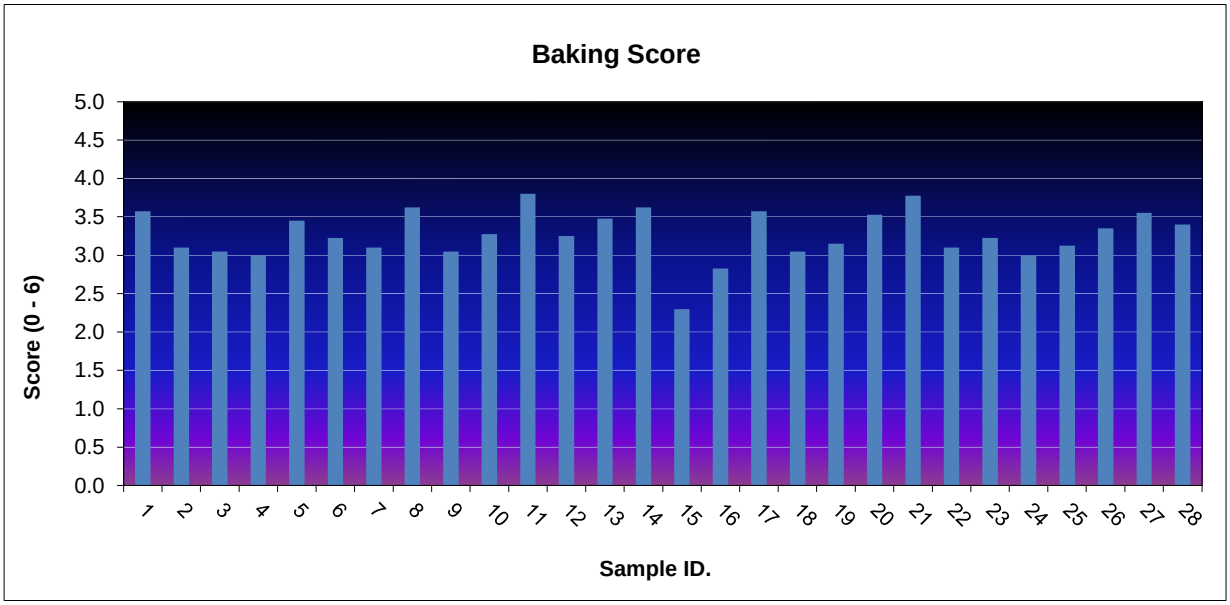
Notes: **A, G, H, J, N, and O** conducted sponge and dough bake tests

# *2022 WQC Milling and Baking Marketing Scores*

# 2022 WQC Milling & Baking Marketing Scores

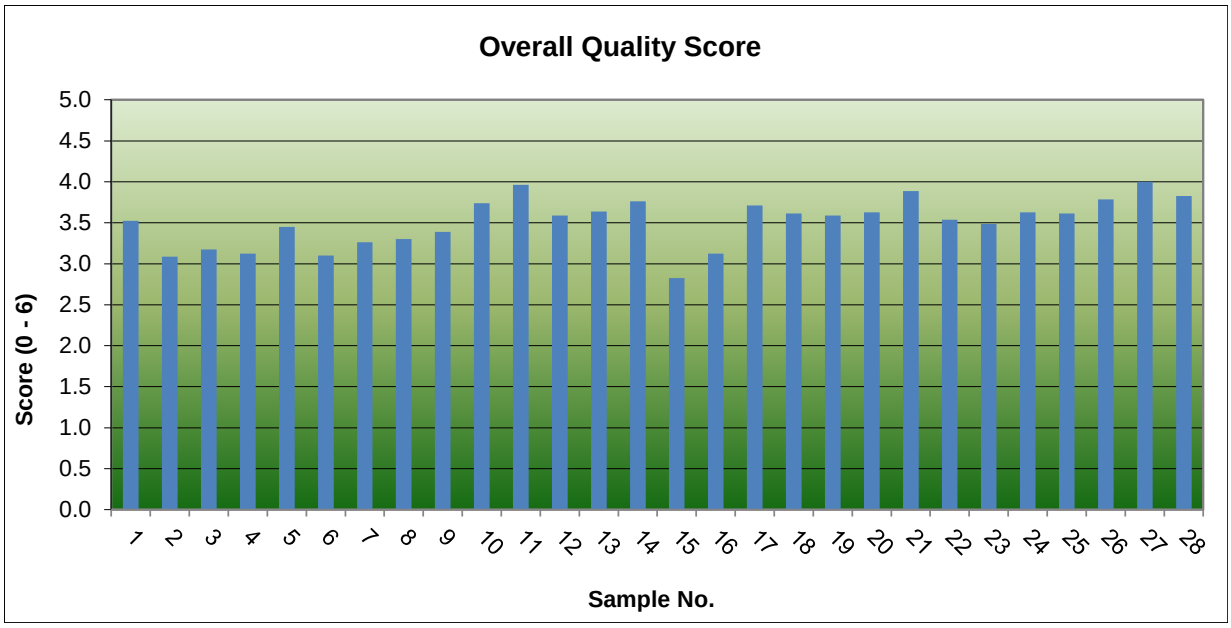
(Based upon HWWQL Quality Data and KSU Milling Data)



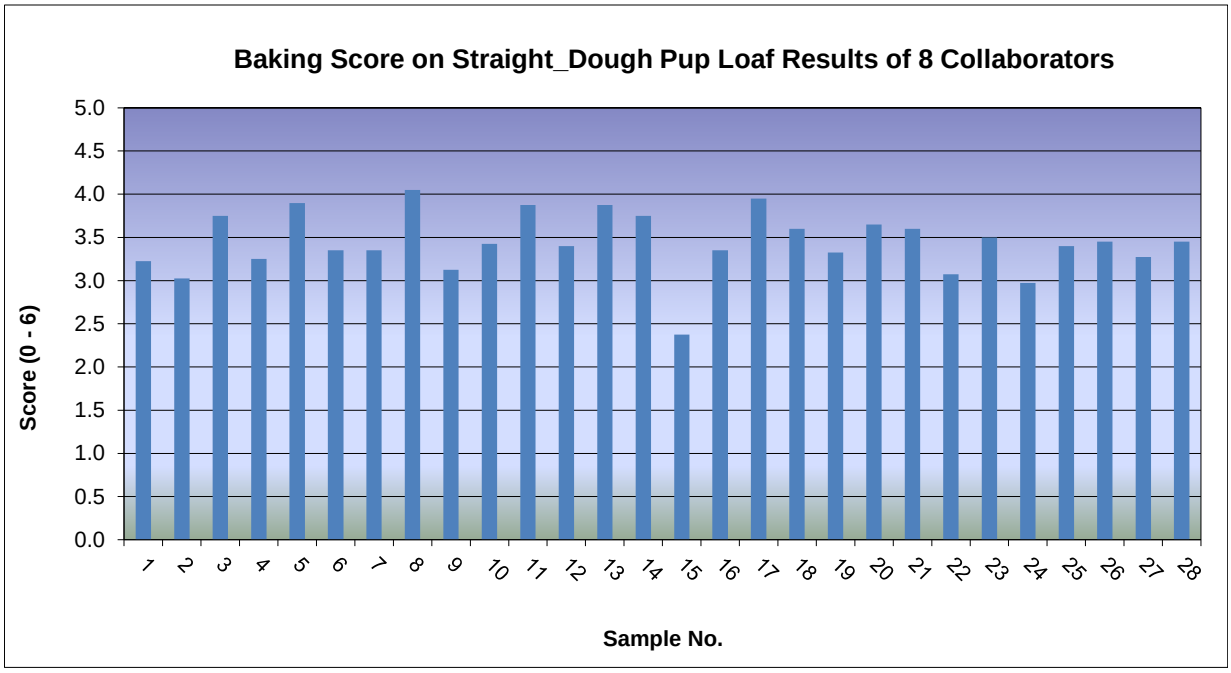
# 2022 WQC Milling & Baking Marketing Scores

(Based upon HWWQL Quality Data and KSU Milling Data)




# 2022 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
# 2022 WQC Hard Winter Wheat Entries

noodle

**USDA-ARS Hard Winter Wheat Quality Laboratory**
**1515 College Avenue**
**Manhattan, KS 66502**

Bradford W. Seabourn, **brad.seabourn@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 2022.

## Methods:

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

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

***Noodle Making:***

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

Procedure:

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

↓

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

↓

Rest for 30 min in a plastic bag

↓

Plug roll gap with plastic tubing and pour mixed dough

↓

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

↓

Cutting

***Measurement of Noodle Dough Color:***

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

***Cooking Noodles:***

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

***Measurement of Cooking Loss and Water Uptake:***

Cooking Loss:

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

Water Uptake:

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

***Texture Profile Analysis (TPA) of Noodle:***

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

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

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

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

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

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

## Results:

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

Table I shows the following:

***Noodle Color*** (*L* value, Higher is better.) ***at 0 hr***: 2415 (80.39), 2428(80.37), 2424 (80.24)

***Noodle Color*** (*L* value, Higher is better.) ***at 24 hr***: 2415 (69.85), 2428 (69.62), 2424 (68.36)

***Delta L*** (Change of *L* value, Lower absolute value is better.)
2415 (-10.55), 2428 (-10.76), 2424(-11.88)

***PPO*** (Lower is better.): 2428 (0.158), 2423 (0.173), 2415 (0.209)

Table II shows the following:

***Hardness***: 2408 (2.904), 2406 (2.795), 2407 (2.770)

***Springiness***: 2419 (0.913), 2428 (0.911), 2406 (0.909)

***Chewiness***: 2406 (1.706), 2408 (1.636), 2407 (1.606)

***Resilience***: 2411 (0.437), 2426 (0.433), 2410 (0.431)

***Cohesiveness***: 2419 (0.693), 2411 (0.691), 2428 (0.686)

***Water Uptake***: 2418 (91.61), 2421 (91.60), 2419 (89.60)

***Cooking Loss***: 2419 (6.00), 2418 (6.80), 2411 (7.20)

## Discussion

Sample 2428 had second highest L-value (brightness) at both 0 and 24 hrs, second lowest delta *L**value, the highest b-value at 24 hrs and the lowest PPO value. This sample also had second highest springiness and third highest 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, sample 2428 would be considered the most favourable variety overall for alkaline noodle quality.

Sample 2415 had the highest L-value (brightness) at both 0 and 24 hrs, the lowest delta *L**value and third lowest PPO value. This sample also had lower hardness and chewiness after cooking. Therefore, sample 2415 would be considered the most favorable variety overall for white salted noodles quality (Japanese Udon-type), which are preferred to have a bright, creamy white color, and smooth, soft texture.

Sample 2424 had third highest L-value (brightness) at both 0 and 24 hrs. This sample also had third lowest delta *L**value.

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

| Sample ID | *L** @ 0 | *L** @ 24 | *a** @ 0 | *a** @ 24 | *b** @ 0 | *b**@ 24 | delta *L** | delta *a** | delta *b** | PPO |
|---|---|---|---|---|---|---|---|---|---|---|
| 2401 | 76.00 | 61.48 | -0.38 | 1.98 | 21.15 | 23.52 | -14.53 | 2.36 | 2.37 | 0.594 |
| 2402 | 77.47 | 64.48 | -0.34 | 1.62 | 19.21 | 22.89 | -12.99 | 1.96 | 3.68 | 0.385 |
| 2403 | 77.73 | 64.07 | -0.58 | 1.90 | 19.92 | 25.11 | -13.67 | 2.48 | 5.19 | 0.232 |
| 2404 | 78.23 | 64.05 | -0.53 | 1.67 | 19.37 | 23.48 | -14.18 | 2.19 | 4.11 | 0.665 |
| 2405 | 76.70 | 60.90 | -0.46 | 1.77 | 19.46 | 22.10 | -15.80 | 2.23 | 2.65 | 0.689 |
| 2406 | 77.72 | 62.24 | -0.74 | 1.78 | 20.27 | 24.55 | -15.48 | 2.52 | 4.28 | 0.721 |
| 2407 | 78.38 | 63.03 | -0.65 | 1.61 | 17.89 | 22.43 | -15.35 | 2.26 | 4.54 | 0.760 |
| 2408 | 74.71 | 59.35 | -0.23 | 2.53 | 21.72 | 25.27 | -15.36 | 2.76 | 3.55 | 0.657 |
| 2409 | 77.47 | 62.57 | -0.36 | 2.14 | 19.49 | 23.14 | -14.90 | 2.49 | 3.66 | 0.292 |
| 2410 | 78.16 | 63.86 | -0.54 | 1.74 | 19.66 | 23.53 | -14.30 | 2.28 | 3.87 | 0.487 |
| 2411 | 77.44 | 62.04 | -0.51 | 2.13 | 20.64 | 23.78 | -15.40 | 2.64 | 3.14 | 0.648 |
| 2412 | 77.71 | 64.00 | -0.35 | 1.85 | 20.35 | 24.04 | -13.71 | 2.20 | 3.69 | 0.611 |
| 2413 | 74.11 | 59.06 | 0.01 | 2.94 | 23.29 | 24.79 | -15.05 | 2.93 | 1.50 | 0.522 |
| 2414 | 75.38 | 61.52 | -0.39 | 2.47 | 23.09 | 25.24 | -13.86 | 2.86 | 2.15 | 0.533 |
| 2415 | 80.39 | 69.85 | -1.18 | 0.75 | 21.28 | 24.91 | -10.55 | 1.93 | 3.64 | 0.209 |
| 2416 | 78.82 | 66.60 | -0.87 | 1.19 | 21.30 | 24.94 | -12.22 | 2.06 | 3.64 | 0.484 |
| 2417 | 75.29 | 60.84 | -0.47 | 2.25 | 22.42 | 24.70 | -14.45 | 2.72 | 2.28 | 0.510 |
| 2418 | 76.34 | 62.27 | -0.56 | 2.05 | 22.01 | 24.57 | -14.07 | 2.61 | 2.56 | 0.539 |
| 2419 | 77.82 | 63.84 | -0.65 | 1.60 | 19.44 | 21.90 | -13.98 | 2.24 | 2.46 | 0.530 |
| 2420 | 75.07 | 60.33 | -0.50 | 2.17 | 22.82 | 24.64 | -14.74 | 2.67 | 1.82 | 0.483 |
| 2421 | 76.12 | 60.72 | -0.64 | 2.32 | 21.97 | 24.48 | -15.40 | 2.95 | 2.52 | 0.619 |
| 2422 | 77.19 | 63.76 | -0.44 | 1.95 | 19.97 | 22.47 | -13.44 | 2.39 | 2.50 | 0.599 |
| 2423 | 76.38 | 64.06 | -0.32 | 2.17 | 22.31 | 26.29 | -12.33 | 2.49 | 3.99 | 0.173 |
| 2424 | 80.24 | 68.36 | -1.15 | 0.73 | 21.03 | 24.05 | -11.88 | 1.88 | 3.02 | 0.265 |
| 2425 | 77.89 | 65.34 | -0.30 | 2.27 | 21.40 | 25.89 | -12.55 | 2.57 | 4.49 | 0.407 |
| 2426 | 78.09 | 64.07 | -0.37 | 2.31 | 20.04 | 24.11 | -14.02 | 2.68 | 4.07 | 0.631 |
| 2427 | 75.77 | 62.84 | 0.09 | 2.38 | 24.63 | 26.53 | -12.94 | 2.29 | 1.90 | 0.215 |
| 2428 | 80.37 | 69.62 | -0.90 | 1.23 | 21.22 | 26.87 | -10.76 | 2.13 | 5.66 | 0.158 |
| Avg | 77.25 | 63.40 | -0.51 | 1.91 | 20.98 | 24.29 | -13.85 | 2.42 | 3.32 | 0.486 |

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

| Sample ID | Hardness | Springiness | Chewiness | Resilience | Cohesiveness | Water Uptake (%) | cooking loss(%) |
|---|---|---|---|---|---|---|---|
| 2401 | 2.609 | 0.886 | 1.563 | 0.399 | 0.676 | 85.20 | 7.20 |
| 2402 | 2.532 | 0.855 | 1.392 | 0.376 | 0.642 | 81.60 | 8.40 |
| 2403 | 2.567 | 0.851 | 1.413 | 0.375 | 0.647 | 86.00 | 8.40 |
| 2404 | 2.587 | 0.880 | 1.537 | 0.399 | 0.675 | 78.80 | 8.00 |
| 2405 | 2.502 | 0.878 | 1.475 | 0.390 | 0.672 | 82.80 | 7.60 |
| 2406 | 2.795 | 0.909 | 1.706 | 0.393 | 0.672 | 84.40 | 7.60 |
| 2407 | 2.770 | 0.865 | 1.606 | 0.403 | 0.670 | 82.80 | 8.40 |
| 2408 | 2.904 | 0.873 | 1.636 | 0.368 | 0.645 | 88.00 | 8.40 |
| 2409 | 2.589 | 0.869 | 1.504 | 0.410 | 0.668 | 81.20 | 7.60 |
| 2410 | 2.550 | 0.884 | 1.546 | 0.431 | 0.686 | 84.40 | 7.60 |
| 2411 | 2.437 | 0.892 | 1.503 | 0.437 | 0.691 | 84.40 | 7.20 |
| 2412 | 2.386 | 0.888 | 1.406 | 0.401 | 0.664 | 88.80 | 8.00 |
| 2413 | 2.546 | 0.855 | 1.459 | 0.402 | 0.670 | 79.20 | 8.00 |
| 2414 | 2.561 | 0.871 | 1.441 | 0.379 | 0.646 | 85.20 | 8.40 |
| 2415 | 2.414 | 0.863 | 1.362 | 0.399 | 0.653 | 88.80 | 8.40 |
| 2416 | 2.475 | 0.886 | 1.477 | 0.414 | 0.674 | 89.20 | 7.60 |
| 2417 | 2.522 | 0.876 | 1.464 | 0.389 | 0.663 | 85.60 | 8.40 |
| 2418 | 2.657 | 0.865 | 1.550 | 0.409 | 0.674 | 91.61 | 6.80 |
| 2419 | 2.476 | 0.913 | 1.567 | 0.425 | 0.693 | 89.60 | 6.00 |
| 2420 | 2.589 | 0.896 | 1.547 | 0.398 | 0.667 | 83.60 | 7.60 |
| 2421 | 2.522 | 0.882 | 1.473 | 0.413 | 0.662 | 91.60 | 8.00 |
| 2422 | 2.454 | 0.886 | 1.453 | 0.398 | 0.668 | 80.80 | 8.80 |
| 2423 | 2.426 | 0.861 | 1.369 | 0.385 | 0.655 | 81.20 | 8.80 |
| 2424 | 2.416 | 0.882 | 1.430 | 0.414 | 0.671 | 77.60 | 8.80 |
| 2425 | 2.587 | 0.888 | 1.539 | 0.404 | 0.670 | 80.80 | 8.40 |
| 2426 | 2.656 | 0.882 | 1.604 | 0.433 | 0.685 | 83.20 | 7.20 |
| 2427 | 2.449 | 0.888 | 1.484 | 0.415 | 0.682 | 81.20 | 8.00 |
| 2428 | 2.405 | 0.911 | 1.502 | 0.415 | 0.686 | 85.20 | 8.00 |
| Avg | 2.549 | 0.880 | 1.500 | 0.403 | 0.669 | 84.39 | 7.91 |

# TORTILLA BAKING TEST RESULTS of 2022 WQC SAMPLES

Cereal Quality Lab, Department Food Science and Technology
Texas A&M University, College Station, TX
(December 2022)

## SUMMARY

This report summarizes the physical attributes of tortillas produced on December 8th and 9th 2022 using 28 test wheat flours. Data on shelf-stability and physical properties of the tortillas was collected over 14 days.

Samples 2405, 2418, and 2421 created "Excellent" tortillas (Table 1) based on subjective rollability on day 14 (≥4.0) and final diameter (>160 mm). Subjective rollability is defined as having very little cracking when rolled 14 days after baking and indicates minimal staling and longer shelf-life. High rollability scores paired with large final tortilla diameter indicates a strong flour with good extensibility.

Samples 2401, 2404, 2406, 2410, 2411, 2412, 2413, 2414, 2422, 2423, 2425, and 2427 created “Good” tortillas with great rollability (≥4.0 = slight cracks visible) but diameter that just missed the cutoff for Excellent (<160 mm). Sample 2403 also made tortillas with “Good” classification, but with reduced day 14 rollability (3.5) but very high diameter (174 mm). This suggests excellent dough extensibility, but the increased surface area of the resulting tortilla caused the tortillas to dry out, resulting in less desirable shelf-life.

Samples 2402, 2407, 2409, 2419, 2424, 2426, and 2428 made “Fair” tortillas based on diameter (140 – 150 mm). This data suggests that these flours were strong, causing tortilla dough to shrink slightly when hot-pressed.

2415, 2417, and 2420 tortillas were classified as “Poor” and had acceptable diameters (≥150mm) but low rollability scores (≤3), indicative of weak flours.

## RESULTS

Table 1 – Physical properties of tortillas

| Test # | Moisture [%] | Weight [g] | Thickness [mm] | Diameter [mm] | Sp.Vol [$mm^3/g$] | Lightness [L*-value] | Rollability Day 7 | Rollability Day 14 | Rating* score |
|---|---|---|---|---|---|---|---|---|---|
| **2401** | 33.1 | 39.7 | 2.40 | 158 | 1.2 | 71.4 | 5.0 | 5.0 | Good |
| **2402** | 34.2 | 40.0 | 3.33 | 148 | 1.4 | 70.4 | 3.5 | 4.0 | Fair |
| **2403** | 32.6 | 38.5 | 2.15 | 174 | 1.3 | 70.9 | 5.0 | 3.5 | Good |
| **2404** | 30.8 | 39.1 | 2.42 | 159 | 1.2 | 71.3 | 4.5 | 5.0 | Good |
| **2405** | 27.1 | 39.3 | 2.63 | 164 | 1.4 | 72.4 | 5.0 | 4.5 | Excellent |
| **2406** | 34.1 | 39.9 | 2.75 | 154 | 1.3 | 69.8 | 5.0 | 5.0 | Good |
| **2407** | 33.7 | 40.3 | 2.98 | 144 | 1.2 | 73.2 | 5.0 | 4.5 | Fair |
| **2408** | 33.4 | 39.4 | 2.98 | 158 | 1.5 | 72.0 | 4.5 | 3.5 | Good |
| **2409** | 35.1 | 39.8 | 2.81 | 148 | 1.2 | 72.3 | 4.0 | 4.0 | Fair |
| **2410** | 35.4 | 39.6 | 2.90 | 151 | 1.3 | 72.0 | 5.0 | 4.0 | Good |
| **2411** | 34.5 | 38.9 | 2.54 | 158 | 1.3 | 73.0 | 5.0 | 4.5 | Good |
| **2412** | 35.4 | 39.4 | 3.03 | 153 | 1.4 | 72.8 | 5.0 | 4.5 | Good |
| **2413** | 34.0 | 39.3 | 2.88 | 156 | 1.4 | 73.2 | 4.5 | 4.5 | Good |
| **2414** | 34.4 | 39.4 | 3.00 | 157 | 1.5 | 70.6 | 4.0 | 4.0 | Good |
| **2415** | 34.7 | 39.1 | 2.83 | 159 | 1.4 | 71.9 | 4.0 | 2.5 | Poor |
| **2416** | 34.8 | 39.0 | 2.97 | 157 | 1.5 | 71.3 | 4.5 | 3.5 | Good |
| **2417** | 34.3 | 38.7 | 2.96 | 163 | 1.6 | 71.1 | 4.5 | 3.0 | Poor |
| **2418** | 34.9 | 38.9 | 2.59 | 165 | 1.4 | 72.3 | 5.0 | 4.5 | Excellent |
| **2419** | 34.7 | 39.7 | 2.79 | 147 | 1.2 | 71.0 | 4.5 | 5.0 | Fair |
| **2420** | 34.7 | 39.2 | 2.66 | 162 | 1.4 | 71.7 | 3.5 | 3.0 | Poor |
| **2421** | 34.6 | 39.1 | 2.87 | 162 | 1.5 | 69.4 | 4.0 | 4.0 | Excellent |
| **2422** | 36.6 | 39.5 | 2.76 | 152 | 1.3 | 71.8 | 3.5 | 4.0 | Good |
| **2423** | 34.5 | 39.5 | 2.89 | 152 | 1.3 | 73.4 | 4.5 | 4.0 | Good |
| **2424** | 33.1 | 39.9 | 3.00 | 144 | 1.2 | 73.4 | 5.0 | 4.0 | Fair |
| **2425** | 33.8 | 39.5 | 3.02 | 153 | 1.4 | 70.6 | 5.0 | 5.0 | Good |
| **2426** | 35.3 | 40.2 | 2.88 | 147 | 1.2 | 70.9 | 5.0 | 5.0 | Fair |
| **2427** | 35.8 | 39.6 | 3.00 | 154 | 1.4 | 72.5 | 5.0 | 5.0 | Good |
| **2428** | 35.6 | 39.8 | 2.79 | 147 | 1.2 | 75.2 | 4.5 | 5.0 | Fair |

*Subjective rating based primarily on diameter and rollability. Excellent ≥4.0 on day 14, >160 mm diameter. Good: rollability score >3.0 on day 14, 150-160 mm diameter. Fair: rollability score >3.0 on day 14, 140-150 mm diameter. Poor: rollability score ≤3.0 on day 14, any diameter.

# 2022 WQC HARD WINTER WHEAT FLOUR PROTEIN ANALYSIS

Michael Tilley, Ph.D. and Melanie Kessler-Mathieu, 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 2022 Crop Protein Analysis**

| | **High Molecular Weight Glutenin Subunits** | | | **Polymeric/Monomeric protein ratio** |
|---|---|---|---|---|
| | **Glu-A1** | **Glu-B1** | **Glu-D1** | |
| **22-0002401** | 1, 2* | 17+18 | 5+10 | 1.11 |
| **22-0002402 SY** | 2* | 7+9 | 5+10 | 1.00 |
| **22-0002403** | 2* | 7+9 | 5+10 | 1.01 |
| **22-0002404** | 2* | 7+9 | 5+10 | 0.95 |
| **22-0002405** | 2* | 7+9 | 5+10 | 1.07 |
| **22-0002406** | 2* | 7+9 | 5+10 | 1.02 |
| **22-0002407** | 2* | 7+8 | 5+10 | 0.86 |
| **22-0002408** | 2* | 20a+20b | 5+10 | 1.08 |
| **22-0002409** | 2* | 7+9 | 5+10 | 0.90 |
| **22-0002410** | 1, 2* | 17+18 | 5+10 | 1.09 |
| **22-0002411** | 2* | 7+9 | 5+10 | 0.96 |
| **22-0002412** | 2* | 7+9 | 5+10 | 1.04 |
| **22-0002413** | 1,2* | 7+9 | 5+10 | 0.83 |
| **22-0002414** | 1,2* | 17+18 | 2+12 | 1.02 |
| **22-0002415** | 2* | 7+9 | 5+10 | 1.02 |
| **22-0002416** | 2* | 7+9 (possible $7^{OE}$ | 5+10 | 0.99 |
| **22-0002417** | 2* | 7+8 | 5+10 | 0.96 |
| **22-0002418** | 2* | 7+8 | 5+10 | 0.94 |
| **22-0002419** | 2* | 17+18 | 5+10 | 1.02 |
| **22-0002420** | 2* | 7+9 | 5+10 | 0.98 |
| **22-0002421** | 2* | 7+9 | 5+10 | 0.79 |
| **22-0002422** | 2* | 7+9 | 5+10 | 0.84 |
| **22-0002423** | 2* | 7+8 | 5+10 | 0.71 |
| **22-0002424** | 2* | 7+9 | 5+10 | 0.96 |
| **22-0002425** | 1 | 7+8 | 5+10 | 0.94 |
| **22-0002426** | 1 | 7+8 | 5+10 | 1.00 |
| **22-0002427** | 1 | 7+8 | 5+10 | 0.88 |
| **22-0002428** | 2* | 7+9 | 5+10 | 0.98 |

# 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<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 |
| Bake Data Processing | Scott Haley at CSU<br>Ft. Collins, CO |

# CREDITS

## Wheat Breeders


**Katherine Frels**
University of Nebraska
Dept. of Agronomy and Horticulture
279 Plant Science Hall
Lincoln, NE 68583-0915
(402) 472-8709
kfrels2@unl.edu

**Marla Dale Barnett**
Limagrain Cereal Seeds LLC
6414 N Sheridan
Wichita, KS 67204
(316) 755-2042
Marla.barnett@Limagrain.com

**Brett Carver**
Oklahoma State University
Dept. of Plant and Soil Sciences
368 Ag Hall
Stillwater, OK 74078-6028
(405) 744-9580
Brett.carver@okstate.edu

**Esten Mason**
Colorado State University
Dept. of Soil and Crop Sciences
1170 Campus Delivery
Fort Collins, CO 80523-1170
(970) 732-7058
Esten.mason@colostate.edu

**Francois Marais/Bradley Bisek**
North Dakota State University
Loftsgard Hall 266H
Fargo, ND 58108
(701) 231-8155
Gideon.Marais@ndsu.edu

**Adam Bray**
Bayer U.S – Crop Science (Westbred)
BB4217-A
700 Chesterfield Pkwy W
Chesterfield, MO 63017
(314) 250-5076
Adam.bray@bayer.com

**Jackie Rudd and Amir Ibrahim**
Texas A&M University
Texas AgriLife Research Center
6500 Amarillo Blvd. W.
Amarillo, TX 79106
(806) 677-5644
j-rudd@tamu.edu

**Sunish Sehgal**
South Dakota State University
Agronomy, Horticulture & Plant Science
Box 2108, Jackrabbit Dr.
Brookings, SD 57007
(605) 688-5709
Sunish.Sehgal@sdstate.edu

**Allan Fritz**
Kansas State University
Dept of Agronomy
4012 Throckmorton
Manhattan, KS 66506
(785) 532-7245
akf@ksu.edu

**Josh Coltrain/Jon Rich**
Syngenta – Agripro
11783 Ascher Rd.
Junction, KS 66441
(785) 210-2118
Josh.Coltrain@syngenta.com

**Willian Berzonsky**
BASF Corporation
925 County Road 378
Beaver Crossing, NE 68313
(402) 523-6855
William.Berzonsky@basf.com

**Guorong Zhang**
Kansas State University
Ft. Hays Branch Exp. Station
1232 240th Ave.
Hays, KS 67601
(785) 625-3425
gzhang@k-state.edu

**Suchismita Mondal**
Montana State University
Dept of Plant Sci and Pathology
407 Leon Johnson Hall
(406)994-5127
Suchismita.mondal@montana.edu

# CREDITS

## Baking Collaborators

| Address | Collaborator Type | Contact |
|---|---|---|
| ADM Milling Co.<br>100 Paniplus Roadway<br>Olathe, KS 66061 | Miller | **Vickie Correll**<br>(913)491-7588<br>Vickie.Correll@adm.com |
| Ardent Mills<br>1875 Lawrence St. Suite 200<br>Denver, CO 80202 | Miller | **Austin Murray/Gang Guo**<br>(402) 250-0341<br>Austin.murray@ardentmills.com |
| Grain Craft I & Q Lab<br>1990 Kimball Ave.<br>Manhattan, KS 66502 | Miller | **Kathy Brower**<br>(785) 317-3901<br>kbrower@graincraft.com |
| Colorado State University<br>Dept. Soil and Crop Sciences<br>Ft. Collins, CO 80523 | Wheat Quality Lab | **John Stromberger**<br>(970)491-2664<br>John.Stromberger@colostate.edu |
| Kansas State University<br>Dept of Grain Science<br>Shellenberger Hall<br>Manhattan, KS 66506 | Wheat Quality Lab | **Yonghui Li**<br>(785)532-6194<br>Yonghui@ksu.edu |
| Limagrain Cereal Seeds LLC<br>7292 Greenridge Rd., Unit 106<br>Windsor, CO 80550 | Wheat Quality Lab | **Cathy Butti**<br>(970)498-2205<br>cathy.butti@limagrain.com |
| North Dakota State Univ.<br>Plant Science Department<br>1250 Bolley Drive<br>Harris Hall 118<br>Fargo, ND 58108 | Wheat Quality Lab | **DeLane Olsen**<br>(701)367-9031<br>DeLane.Olsen@ndsu.edu |

# CREDITS

## Baking Collaborators

| Address | Collaborator Type | Contact |
|---|---|---|
| Texas A&M University<br>Soil & Crop Science Dept<br>2474 TAMU<br>College Station, TX 77843-2472 | Wheat Quality Lab | **Joseph Awika**<br>(979) 845-2985<br>awika@tamu.edu |
| Univ. of Nebraska<br>Dept of Agronomy<br>180 Plant Science Bldg. | Wheat Quality Lab | **Lan Xu**<br>(402)472-6243<br>lxu4@unlnotes.unl.edu |
| USDA/ARS/HWWQL<br>1515 College Ave.<br>Manhattan, KS 66502 | Wheat Quality Lab | **Theresa Sutton**<br>(785) 776-2764<br>Theresa.Sutton@ars.usda.gov |
| USDA/ARS/WWQL<br>E-202 FSHN<br>Washington State Univ.<br>Pullman, WA 99614 | Wheat Quality Lab | **Alecia Marie Kiszonas**<br>(509) 335-4062<br>alecia.kiszonas@wsu.edu |
| Wheat Marketing Center<br>1200 NW Naito PRKWY<br>STE 230<br>Portland, OR 97209 | Wheat Quality Lab | **Liman Liu**<br>(503)295-0823<br>liman@wmcinc.org |
| USDA/ARS/HRSQL<br>Harris Hall<br>North Dakota State Univ.<br>Fargo, ND 58105 | Wheat Quality Lab | **Linda Dykes**<br>(701)239-1412<br>Linda.Dykes@usda.gov |
| Bay State Milling Co.<br>100 Congress St.<br>Quincy, MA 02169 | Miller | **Joseph Habib/Emily Ehlers**<br>(617)328-4400 x 5119<br>jhabib@bsm.com |

# CREDITS

## Baking Collaborators

| Address | Collaborator Type | Contact |
|---|---|---|
| Generla Mills<br>Grain and Flour Quality Lab<br>9000 Plymounth Ave.<br>N. Golden Valley, MN 55427 | Miller | **Aly Sharpe**<br>(763)764-7961<br>Aly.Wadley2@genmills.com |

# 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.

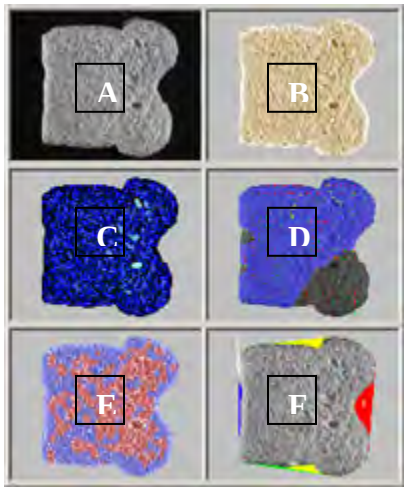
Similarly, cumulative protein curves are determined by arranging millstreams in ascending order of protein content, and tabulating the protein content of the total flour produced with the addition of successive millstreams. Wheat that gives high protein content at low extraction, and a fast rate of protein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

## 2022 WQC COLLABORATORS' BAKING TEST PROFILES AND OTHER INFORMATION

| Coop | No. | Test Methods | Est. Flour and Dough Wt (g) | Mixing Tolerance | Fermentation time (min) | Oven Temp (F) | Baking Time (min) |
|---|---|---|---|---|---|---|---|
| A | 1 | Sponge and dough | 600 g flour, 480 g dough | Other | 240 min (sponge time) and 45 min (fermentation) | 420 | 20 |
| B | 2 | Pup-loaf straight dough | 100 g flour, approx 175 g dough | Mixograph | 90 min | 425 | 21 |
| C | 3 | Pup-loaf straight dough | 100 g flour, approx. 175 g dough | Farinograph and Mixograph | 180 fermentation and 60 min proof time | 400 | 25 |
| D | 4 | Pup-loaf straight dough | 200g, 170 g dough | Mixograph | 180 min | 419 | 24 |
| E | 5 | Pup-loaf straight dough | 100 g, approx 170 g | Mixograph | 90 min | 400 | 25 |
| F | 6 | Pup-loaf straight dough | 100 g flour | Farinograph | 120 min | 390 | 25 |
| G | 7 | Sponge and dough | 700 g flour, 500 g dough | Farinograph | 180 min (sponge) and 70 min (fermentation) | 420 | 20 |
| H | 8 | Sponge and dough | 700 g flour, 524 g dough | Farinograph with mixing evalu | 240 min (sponge time) and 60 min (fermentation) | 420 | 20 |
| I | 9 | Pup-loaf straight dough | 100 g flour, approx 170 g dough | Mixograph | 120 min | 420 | 18 |
| J | 10 | Sponge and dough | 700 g flour, 500 g dough | Farinograph | 240 Sponge time | 425 | 25 |
| K | 11 | Straight dough | 700 g flour, 525 g dough | Mixing series | 120 min | 400 | 25 |
| L | 12 | Pup-loaf straight dough | 100 g flour, approx 160 g dough | Farinograph | 120 min | 425 | 20 |
| M | 13 | Pup-loaf straight dough | 100 g | Miograph | 90 min | 420 | 24 |
| N | 14 | Sponge and dough | 600 g flour, 160 g dough | Mixing series | 240 min | 425 | 16 |
| O | 15 | Sponge and dough | 675 g flour, 540 g dough | Mixing series | 210 min | 430 | 23 |

# APPENDIX B

HWWQC Technical Board and Goals for HWW Breeders

# Hard Winter Wheat Quality Council

## 2022 Technical Board Officers

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

VICE CHAIR: **Dale Nellor**, NAMA

SECRETARY: **Mark Hodges,** Plain Grain

MEMBER: **Shawn Thiele,** Kansas State University

MEMBER: **Gang Guo,** Ardent Mills

## 2022 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, 2022

# Minutes for 2022 Hard Winter Wheat Quality Council

February 23, 2022 – Embassy Suites Hotel KCI Airport, Kansas City MO

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

Review of 2021 Minutes – Dale Nellor, Secretary

Following the review, the minutes were approved and accepted by the council.

Nomination and election of new members – Rich Kendrick, Chair

Dale Nellor nominated Shawn Thiele of Kansas State University as a new member of the HWW Board. The nomination was approved by the council.

Announcing Board for 2022 -

| | | |
|---|---|---|
| Chairman | Chris Kirby | Oklahoma Wheat Commission |
| Vice Chairman (NAMA) | Dale Nellor | North American Millers' Association |
| Secretary | Mark Hodges | Plains Grains |
| Member | Shawn Thiele | Kansas State University |
| Member | Gang Guo | Ardent Mills |

Overview of Wheat Tours – Dave Green, WQC

The HWW tour this year will be the week of May 16-19 starting in Manhattan, KS with overnight stays in Colby, KS and Wichita, KS. There is hope participation can return to the 80-85 range.

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

21 samples were processed in Manhattan using the MIAG mill over a course of three weeks. Everything went well.

Wheat Quality Council HRW Report for 2021 – Richard Chen, USDA/ARS Manhattan

Due to the absence of Richard Chen, no update was provided.

Review of 2021 Wheat Crop – Mark Hodges, Plains Grains Inc.

The 2021 crop was short and in the bottom half of production and acres. Overall end-use quality and performance (mill/dough/bake) was good. 522 samples were collected from grain elevators from 40 reporting areas in 12 states after at least 30% of the local harvest was complete. Protein and thousand kernel weights were lower than what is normally seen in the PNW and Great Plains. The falling numbers were not a problem this year.

New Grow out Program for Hard Winter Wheat – Marla Barnett, Limagrain

Two regions were established with I-80 being the general dividing line between the north and south regions. A total of 21 composite entries were grown in 2021

with 10 composite entries including two checks from five breeding programs and three locations (ND, SD, and NE) in the northern grow out. In the southern grow out 11 composite entries were grown including two checks from six breeding programs and five locations (KS, CO, OK, TX, and Limagrain). An overview was provided of the grow out plans for the 2022 crop year.

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

In soft wheat, there were 23 entries and 4 groups. An overview of the collaborators and organizations involved in the 2021 crop was provided. An invitation was extended to attend the Soft Wheat Quality Council meeting on March 16. A review of the SWQC entries will occur during that meeting.

State Crop Reports were provided by the following on the current 2022 crop conditions:

Texas – Jackie Rudd, Texas A&M
Oklahoma – Mike Schulte, Oklahoma Wheat Commission
Kansas – Aaron Harries, Kansas State University
Nebraska – Royce Schaneman, Nebraska Wheat Board
Colorado – Brad Erker, Colorado Wheat
South Dakota – Reid Christopherson, South Dakota Wheat Commission
Montana – Cassidy Marn, Montana Wheat and Barley Committee

Financial Report – Dave Green, WQC

We are doing fine. The loss of meetings and tours the past couple years have reduced our income, but membership has been static and we have been able to operate the programs as necessary.

Exhibitor's Session (10 minutes) –

Introductions were given by the exhibitors supporting the meeting this year: Calibre C-Cell, Buchi, Midland Scientific, Perkin Elmer, CW Brabender, and Neogen.

Adjourn

# APPENDIX F

Historical WQC Hard Winter Wheat Entries from 2001 to 2022

# A History of WQC Hard Winter Wheat Entries

## 2022

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| 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 | | | | | 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 |
| LCH18-9027_LG | 22-2411 | | | | | Limagrain |
| TX16M9216_TX | 22-2412 | | | | | 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 | | | | | 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

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

| | | | | | | |
|---|---|---|---|---|---|---|
| CO16D1487 | 21-2418 | | | | | CSU |
| TX15M8024 | 21-2419 | HRW | yes | TX15M8024 | 2021 | Texas A&M |
| XE4101 | 21-2420 | | | | | Westbred(Bayer) |
| WB4401 | 21-2421 | | | | | Westbred(Bayer) |

## 2020

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

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| **2019** | | | | | | |
| Byrd | 19-2401 | HRW | check | | | Colorado |
| Jagalene (CC01) | 19-2402 | HRW | check | | | Colorado |
| CO13D0787 | 19-2403 | HRW | yes | Guardian | 2019 | Colorado |
| CO15SFD107 | 19-2404 | HRW | yes | Fortify SF | 2019 | Colorado |
| CO15D098R | 19-2405 | HRW | yes | Steamboat | 2020 | Colorado |
| TAM 114 | 19-2406 | | | | | Texas |
| TX14A001035 | 19-2407 | | | | | Texas |
| TX14M7061 | 19-2408 | | | | | Texas |
| Jagalene (CC02) | 19-2409 | | | | | Oklahoma |
| Ruby Lee | 19-2410 | | | | | Oklahoma |
| OK16D101089 | 19-2411 | HRW | yes | Uncharted | 2020 | Oklahoma |
| OK168512 | 19-2412 | HRW | yes | Breakthrough | 2020 | Oklahoma |
| OCW04S717T-6W | 19-2413 | HW | yes | Big Country | 2020 | Oklahoma |
| OK12912C-138407-2 | 19-2414 | HRW | yes | Strad CL+ | 2020 | Oklahoma |
| Jagalene (CC03) | 19-2415 | | | | | Limagrain |
| ERYTHR02420-2010 | 19-2416 | | | | | Limagrain |
| Jagalene (CC04) | 19-2417 | | | | | Kansas-Hays |
| KS15H116-6-1 | 19-2418 | HRW | yes | KS DALLAS | 2019 | Kansas-Hays |
| KS15H161-1-4 | 19-2419 | HRW | yes | KS WESTERN STAR | 2019 | Kansas-Hays |
| Danby | 19-2420 | | | | | Kansas-Hays |
| Jagalene (CC05) | 19-2421 | | | | | Monsanto |
| MODI4-5179 | 19-2422 | HRW | yes | WB4505 | 2019 | Monsanto |
| NEDI4-5304 | 19-2423 | HRW | yes | WB4309 | 2019 | Monsanto |
| Jagalene (CC06) | 19-2424 | | | | | Northern States |
| NW13493 | 19-2425 | HWW | 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 |
| 10BC107#115 | 18-2415 | | | | | Syngenta |
| SY Monument | 18-2416 | | | | | Syngenta |
| 08BC379-40-1 | 18-2417 | | | | | Syngenta |
| Jagalene (CC06) | 18-2418 | | | | | Oklahoma |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| Ruby Lee | 18-2419 | | | | | Oklahoma |
| OK12716-159319-13 | 18-2420 | HRW | yes | Showdown | 2018 | Oklahoma |
| OK13621 | 18-2421 | HRW | yes | Baker's Ann | 2018 | Oklahoma |
| OK12206-127206-2 | 18-2422 | HRW | yes | OK Corral | 2019 | Oklahoma |
| OK1059018-129332-5 | 18-2423 | HRW | no | | | Oklahoma |
| Jagalene (CC07) | 18-2424 | | | | | Northern States |
| NE10478-1 | 18-2425 | HRW | | LCS Valiant | 2019 | Nebraska |
| NHH144913-3 | 18-2426 | SRW | no | | | Nebraska |
| MT1564 | 18-2427 | HWW | yes | Flathead | 2019 | Montana |
| MTS1588 | 18-2428 | HRW | yes | Bobcat | 2019 | Montana |
| NORD58 | 18-2429 | HWW | no | | | North Dakota |
| NORD62 | 18-2430 | HWW | no | | | North Dakota |
| SD09227 | 18-2431 | HRW | yes | Thompson | 2017 | Sourth Dakota |
| SD14115-5 | 18-2432 | HRW | yes | Winner | 2019 | Sourth Dakota |
| **2017** | | | | | | |
| SY Monument | 17-2401 | HRW | | | | Syngenta |
| SY Achieve CL2 | 17-2402 | XWHT | yes | SY Achieve CL2 | 2017 | Syngenta |
| SY 517 CL2 | 17-2403 | HRW | yes | S 517 CL2 | 2017 | Syngenta |
| Jagalene (CC01) | 17-2404 | HRW | | | | Syngenta |
| Jagalene (CC02) | 17-2405 | HRW | | | | Texas |
| TAM 111 | 17-2406 | HRW | | | | Texas |
| TX11A001295 | 17-2407 | HRW | yes | TAM 115 | 2019 | Texas |
| TX12M4068 | 17-2408 | HRW | no | | | Texas |
| Byrd | 17-2409 | HRW | | | | Colorado |
| CO12D1770 | 17-2410 | HRW | yes | Canvas | 2018 | Colorado |
| Jagalene (CC03) | 17-2411 | HRW | | | | Colorado |
| CO13D1783 | 17-2412 | HRW | yes | Whistler | 2018 | Colorado |
| CO12D2011 | 17-2413 | HDWH | yes | Breck | 2017 | Colorado |
| Jagalene (CC04) | 17-2414 | HRW | | | | Kansas-Hays |
| KS13HW92-3 | 17-2415 | HDWH | yes | Venada | 2018 | Kansas-Hays |
| Danby | 17-2416 | HDWH | | | | Kansas-Hays |
| KS14HW106-6-6 | 17-2417 | HDWH | YES | KS SILVERADO | 2019 | Kansas-Hays |
| Yellowstone | 17-2418 | HRW | | | | Montana |
| MT1465 | 17-2419 | HRW | yes | FourOsix | 2018 | Montana |
| Jagalene (CC05) | 17-2420 | HRW | | | | Montana |
| MTW1491 | 17-2421 | HDWH | yes | Numont | 2020 | Montana |
| NI13706 | 17-2422 | HRW | no | | | Nebraska |
| NE12561 | 17-2423 | HRW | yes | Siege | 2020 | Nebraska |
| Jagalene (CC06) | 17-2424 | HRW | | | | Nebraska |
| Jagalene (CC07) | 17-2425 | HRW | | | | Monsanto |
| WB4623CLP | 17-2426 | HRW | yes | WB4623CLP | 2014 | Monsanto |
| WB4721 | 17-2427 | HRW | yes | WB4721 | 2015 | Monsanto |
| Ruby Lee | 17-2428 | HRW | | | | Oklahoma |
| OK13621 | 17-2429 | HRW | yes | Baker's Ann | 2018 | Oklahoma |
| OK12D22004-016 | 17-2430 | HRW | no | | | Oklahoma |
| OCW04S7171T-6W | 17-2431 | HDWH | pending | | 2020 | Oklahoma |
| Jagalene (CC08) | 17-2432 | HRW | | | | Oklahoma |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| **2016** | | | | | | |
| LCH13-048 | 16-2401 | HRW | | | | Limagrain |
| LCH13NEDH-12-27 | 16-2402 | HRW | | | | Limagrain |
| Jagalene (CC01) | 16-2403 | HRW | | | | Limagrain |
| PSB13NEDH-11-26 | 16-2404 | HRW | | | | Limagrain |
| LCI13-069 | 16-2405 | HWW | | | | Limagrain |
| PSB13NEDH-14-83 | 16-2406 | HWW | | | | Limagrain |
| KS1256-6-4 | 16-2407 | HRW | yes | Tatanka | 2016 | Kansas-Hays |
| Danby | 16-2408 | HWW | | | | Kansas-Hays |
| Jagalene (CC02) | 16-2409 | HRW | | | | Kansas-Hays |
| LCH13NEDH-14-53 | 16-2410 | HWW | no | | | Nebraska |
| Jagalene (CC03) | 16-2411 | HRW | | | | Nebraska |
| LCHNEDH-4-16 | 16-2412 | HWW | no | | | Nebraska |
| Postrock | 16-2413 | HRW | | | | Syngenta |
| Jagalene (CC04) | 16-2414 | HRW | | | | Syngenta |
| AP11T2409 | 16-2415 | HRW | | | | Syngenta |
| Jagalene (CC05) | 16-2416 | HRW | | | | Monsanto |
| HV9W10-0458 | 16-2417 | HRW | yes | WB4515 | 2015 | Monsanto |
| Jagalene (CC06) | 16-2418 | HRW | | | | Oklahoma |
| Ruby Lee | 16-2419 | HRW | | | | Oklahoma |
| OK10126 | 16-2420 | HRW | yes | Spirit Rider | 2017 | Oklahoma |
| OK12D22004-016 | 16-2421 | HRW | no | | | Oklahoma |
| OK12912C | 16-2422 | HRW | under Consideration | | | Oklahoma |
| OK13209 | 16-2423 | HRW | yes | Green Hammer | 2018 | Oklahoma |
| Everest | 16-2424 | HRW | | | | Kansas-Manhattan |
| Jagalene (CC07) | 16-2425 | HRW | | | | Kansas-Manhattan |
| Larry | 16-2426 | HRW | | | | Kansas-Manhattan |
| Zenda | 16-2427 | HRW | | | | Kansas-Manhattan |
| **2015** | | | | | | |
| Jagalene (CC01) | 15-2401 | HRW | | | | Kansas-Hays |
| Danby (IC) | 15-2402 | HRW | | | | Kansas-Hays |
| KS11HW39-5 | 15-2403 | HRW | yes | Joe | 2015 | Kansas-Hays |
| Jagalene (CC04) | 15-2404 | HRW | | | | Nebraska |
| NE1059 | 15-2405 | HRW | yes | Ruth | 2016 | Nebraska |
| Jagalene (CC06) | 15-2406 | HRW | | | | Monsanto |
| BZ9W09-2075 | 15-2407 | HWW | yes | WB4575 | 2015 | Monsanto |
| HV9W10-1002 | 15-2408 | HWW | yes | WB4303 | 2015 | Monsanto |
| Jagalene (CC09) | 15-2409 | HRW | | | | Colorado |
| Byrd (IC) | 15-2410 | HRW | | | | Colorado |
| CO11D1397 | 15-2411 | HRW | | | | Colorado |
| CO11D1539 | 15-2412 | HRW | | | | Colorado |
| CO11D1767 | 15-2413 | HRW | | | | Colorado |
| Jagalene (CC14) | 15-2414 | HRW | | | | Oklahoma |
| Gallagher (IC) | 15-2415 | HRW | | | | Oklahoma |
| OK11D25056 | 15-2416 | HRW | yes | Smith's Gold | 2017 | Oklahoma |
| OK13625 | 15-2417 | HRW | yes | Skydance | 2017 | Oklahoma |
| OK10728W | 15-2418 | HWW | yes | Stardust | 2017 | Oklahoma |
| Jagalene (CC19) | 15-2419 | HRW | | | | Montana |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| Yellowstone (IC) | 15-2420 | HRW | | | | Montana |
| MTS1224 | 15-2421 | HRW | yes | Loma | 2016 | Montana |
| MT1265 | 15-2422 | HRW | | | | Montana |
| Ideal (IC) | 15-2423 | HRW | | | | South Dakota |
| SD10257-2 | 15-2424 | HRW | yes | Oahe | 2016 | South Dakota |
| LCH13DH-20-87 | 15-2425 | HRW | yes | LCS Chrome | 2015 | Limagrain |
| **2014** | | | | | | |
| Jagalene (CC01) | 14-2401 | HRW | | | | Kansas_Hays |
| Danby (IC) | 14-2402 | HWW | | | | Kansas_Hays |
| KS11HW15-4 | 14-2403 | HWW | | | | Kansas_Hays |
| KS11W39-5 | 14-2404 | HWW | | | | Kansas_Hays |
| Jagalene (CC05) | 14-2405 | HRW | | | | Texas_Amarillo |
| TAM 111 (IC) | 14-2406 | HRW | | | | Texas_Amarillo |
| TX08A001249 | 14-2407 | HRW | | | | Texas_Amarillo |
| TX09A001194 | 14-2408 | HRW | | | | Texas_Amarillo |
| TX09D1172 | 14-2409 | HRW | | | | Texas_Amarillo |
| Jagalene (CC10) | 14-2410 | HRW | | | | Colorado |
| Byrd (IC) | 14-2411 | HRW | | | | Colorado |
| CO11D174 | 14-2412 | HRW | yes | Avery | 2015 | Colorado |
| CO11D446 | 14-2413 | HRW | yes | Langin | 2016 | Colorado |
| Jagalene (CC) | 14-2414 | HRW | | | | Nebraska |
| Camelot (IC) | 14-2415 | HRW | | | | Nebraska |
| NE07531 | 14-2416 | HRW | | | | Nebraska |
| NE09521 | 14-2417 | HRW | | | | Nebraska |
| Jagalene (CC18) | 14-2418 | HRW | | | | Montana |
| Yellowstone (IC) | 14-2419 | HRW | | | | Montana |
| MT1078 | 14-2420 | HRW | | | | Montana |
| MT1138 | 14-2421 | HRW | | | | Montana |
| Jagalene (CC22) | 14-2422 | HRW | | | | Oklahoma |
| Ruby Lee (IC) | 14-2423 | HRW | | | | Oklahoma |
| OK09125 | 14-2424 | HRW | yes | Bentley | 2015 | Oklahoma |
| OK10126 | 14-2425 | HRW | yes | Spirit Rider | 2017 | Oklahoma |
| Jagalene (CC26) | 14-2426 | HRW | | | | Kansas_Manhattan |
| KanMark | 14-2427 | HRW | | | | Kansas_Manhattan |
| 06BC722#25 | 14-2428 | HRW | yes | SY Flint | 2015 | Agripro |
| 06BC796#68 | 14-2429 | HRW | yes | SY Sunrise | 2015 | Agripro |
| **2013** | | | | | | |
| Check Blend (check) | 13-2401 | HRW | | | | Limagrain |
| LCH08-80 | 13-2402 | HRW | | | | Limagrain |
| lCS Mint | 13-2403 | HRW | yes | LCS Mint | 2012 | Limagrain |
| Danby (check) | 13-2404 | HWW | | | | Kansas-Hays |
| Oakley CL | 13-2405 | HRW | yes | Oakley CL | 2013 | Kansas-Hays |
| KS10HW78-1 | 13-2406 | HWW | | | | Kansas-Hays |
| Lyman (check) | 13-2407 | HRW | | | | South Dakota |
| SD08200 | 13-2408 | HRW | | | | South Dakota |
| SD09192 | 13-2409 | HRW | | | | South Dakota |
| Postorock (check) | 13-2410 | HRW | | | | Agripro |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| 04BC574-2 | 13-2411 | HRW | yes | SY Monument | 2014 | Agripro |
| Millennium (check) | 13-2412 | HRW | | | | Nebraska |
| NE09521 | 13-2413 | HRW | | | | Nebraska |
| NE08499 | 13-2414 | HRW | | | | Nebraska |
| Yellowstone (check) | 13-2415 | HRW | | | | Montana |
| MT1090 | 13-2416 | HRW | | | | Montana |
| MTW08168 | 13-2417 | HWW | yes | WB3768 | 2013 | Montana |
| Ruby Lee (check) | 13-2418 | HRW | | | | Oklahoma |
| Doublestop CL+ | 13-2419 | HRW | yes | Doublestop CL+ | 2013 | Oklahoma |
| OK09125 | 13-2420 | HRW | yes | Bentley | 2015 | Oklahoma |

## 2012

| | | | | | | |
|---|---|---|---|---|---|---|
| **WB-Stout (check)** | 12-2401 | HRW | | | | Westbred |
| HV9W07-1028 | 12-2402 | HRW | | | | Westbred |
| **Millennium (check)** | 12-2403 | HRW | | | | Nebraska |
| NW07505 | 12-2404 | HWW | | | | Nebraska |
| NE06545 | 12-2405 | HRW | yes | Freeman | 2012 | Nebraska |
| NE06607 | 12-2406 | HRW | | | | Nebraska |
| **Byrd (check)** | 12-2407 | HRW | | | | Colorado |
| **Snowmass (check)** | 12-2408 | HWW | | | | Colorado |
| CO07W245 | 12-2409 | HWW | yes | Antero | 2012 | Colorado |
| CO07W722-F5 | 12-2410 | HWW | | | | Colorado |
| **Billings (check)** | 12-2411 | HRW | | | | Oklahoma |
| Ruby Lee | 12-2412 | HRW | | | | Oklahoma |
| Gallagher (OK07214) | 12-2413 | HRW | yes | | 2012 | Oklahoma |
| Iba (OK07209) | 12-2414 | HRW | yes | | 2012 | Oklahoma |
| OK09634 | 12-2415 | HRW | no | | | Oklahoma |
| **Lyman (check)** | 12-2416 | HRW | | | | South Dakota |
| SD08080 | 12-2417 | HRW | | | | South Dakota |
| SD06158 | 12-2418 | HRW | yes | Redfield | 2013 | South Dakota |
| **Yellowstone (check)** | 12-2419 | HRW | | | | Montana |
| MT08172 | 12-2420 | HRW | yes | Colter | 2012 | Montana |
| MT0978 | 12-2421 | HRW | yes | Northern | 2015 | Montana |
| **TAM 111 (check)** | 12-2422 | HRW | | | | Texas |
| TX07A001505 | 12-2423 | HRW | | | | Texas |
| TX03A0563-07 | 12-2424 | HRW | | | | Texas |

## 2011

| | | | | | | |
|---|---|---|---|---|---|---|
| **Danby (check)** | 11-2401 | HWW | | | | Kansas-Hays |
| Tiger | 11-2402 | HWW | yes | | | Kansas-Hays |
| KS08HW35-1 | 11-2403 | HWW | yes | Clara CL | 2011 | Kansas-Hays |
| **PostRock (check)** | 11-2404 | HRW | | | | AgriPro |
| SY Wolf | 11-2405 | HRW | yes | | | AgriPro |
| Syngenta Exp 138-45 | 11-2406 | HRW | yes | SY Southwind | 2012 | AgriPro |
| **Fuller (check)** | 11-2407 | HRW | | | | Kansas-Manhattan |
| KS020319-7-3 | 11-2408 | HRW | yes | 1863 | 2012 | Kansas-Manhattan |
| KS020633M-13 | 11-2409 | HRW | no | | | Kansas-Manhattan |
| **McGill (check)** | 11-2410 | HRW | | | | Nebraska |
| NE05496 | 11-2411 | HRW | no | | | Nebraska |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| NE05548 | 11-2412 | HRW | no | | | Nebraska |
| NI08708 | 11-2413 | HRW | no | | | Nebraska |
| **Jagalene (check)** | 11-2414 | HRW | | | | Westbred |
| HV9W06-509 | 11-2415 | HWW | yes | WB-Grainfield | 2012 | Westbred |
| **Yellowstone (check)** | 11-2416 | HRW | | | | Montana |
| MTS0808 | 11-2417 | HRW | yes | Warhorse | 2013 | Montana |
| MT0871 | 11-2418 | HRW | no | | | Montana |
| **Lyman (check)** | 11-2419 | HRW | | | | South Dakota |
| SD06158 | 11-2420 | HRW | yes | Redfield | | South Dakota |
| SD07184 | 11-2421 | HRW | no | | | South Dakota |

## 2010

| | | | | | | |
|---|---|---|---|---|---|---|
| **Lyman (check)** | 10-2401 | HRW | | | | SDSU |
| SD05118-1 | 10-2402 | HRW | yes | Ideal | 2011 | SDSU |
| SD06158 | 10-2403 | HRW | yes | Redfield | | SDSU |
| **Hatcher (check)** | 10-2404 | HRW | | | | CSU |
| CO050303-2 | 10-2405 | HRW | yes | Denali | 2011 | CSU |
| CO06052 | 10-2406 | HRW | yes | Brawl CL Plus | 2011 | CSU |
| CO06424 | 10-2407 | HRW | yes | Byrd | 2011 | CSU |
| **Millennium (check)** | 10-2408 | HRW | | | | NU |
| NE03490 | 10-2409 | HRW | no | | | NU |
| NE04490 | 10-2410 | HRW | no | | | NU |
| **Billings (check)** | 10-2411 | HRW | | | | OSU |
| OK05526 | 10-2412 | HRW | yes | Ruby Lee | 2011 | OSU |
| OK05212 | 10-2413 | HRW | yes | Garrison | 2011 | OSU |
| OK07231 | 10-2414 | HRW | no | | | OSU |
| **Smoky Hill (check)** | 10-2415 | HRW | | | | Westbred |
| HV9W06-262R | 10-2416 | HRW | no | | | Westbred |
| HV9W06-218W | 10-2417 | HWW | no | | | Westbred |
| **Yellowstone (check)** | 10-2418 | HRW | | | | MSU |
| MTS0721 | 10-2419 | HRW | yes | Bearpaw | 2011 | MSU |
| **TAM 111 (check)** | 10-2420 | HRW | | | | TAMU |
| TX05A001822 | 10-2421 | HRW | no | | | TAMU |
| TX06A001263 | 10-2422 | HRW | no | | | TAMU |

## 2009

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

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| **Yellowstone (check)** | 09-2414 | HRW | | | | MSU |
| MT06103 | 09-2415 | HRW | no | | | MSU |
| MTS0713 | 09-2416 | HRW | yes | Judee | 2011 | MSU |
| **TAM 111 (check)** | 09-2417 | HRW | | | | TAMU |
| TX02A0252 | 09-2418 | HRW | yes | TAM 113 | 2010 | TAMU |
| **Millennium (check)** | 09-2419 | HRW | | | | NU |
| NE01481 | 09-2420 | HRW | yes | McGill | 2010 | NU |
| NI04421 | 09-2421 | HRW | yes | Robidoux | 2010 | NU |

## 2008

| | | | | | | |
|---|---|---|---|---|---|---|
| **Jagalene (check)** | 08-2401 | HRW | | | | AgriPro |
| Art | 08-2402 | HRW | yes | | | AgriPro |
| Hawken | 08-2403 | HRW | yes | | | AgriPro |
| NuDakota | 08-2404 | HRW | yes | | | AgriPro |
| **Hatcher (check)** | 08-2405 | HRW | | | | CSU |
| Thunder CL | 08-2406 | HWW | yes | Thunder CL | 2008 | CSU |
| CO03W054 | 08-2407 | HWW | yes | Snowmass | | CSU |
| CO03064 | 08-2408 | HRW | no | | | CSU |
| **Danby (check)** | 08-2409 | HWW | | | | KSU-Hays |
| Tiger | 08-2410 | HWW | yes | | | KSU-Hays |
| **Karl 92 (check)** | 08-2411 | HRW | | | | KSU-Manhattan |
| KS970093-8-9-#1 | 08-2412 | HRW | yes | Everest | 2009 | KSU-Manhattan |
| **OK Bullet (check)** | 08-2413 | HRW | | | | OSU |
| OK03305 | 08-2414 | HRW | yes | Pete | 2009 | OSU |
| OK03522 | 08-2415 | HRW | yes | Billings | 2009 | OSU |
| OK03825-5403-6 | 08-2416 | HRW | | | | OSU |
| **Tandem (check)** | 08-2417 | HRW | yes | STARS0601W | 2006 | SDSU |
| SD05W030 | 08-2418 | HWW | no | | | SDSU |

## 2007

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

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| MT0495 | 07-2418 | HRW | no | | | MSU |
| MTS04114 | 07-2419 | HRW | no | | | MSU |
| **2006** | | | | | | |
| **Overley (check)** | 06-2401 | HRW | | | | KSU-Manhattan |
| Fuller | 06-2402 | HRW | yes | | | KSU-Manhattan |
| KS990498-3-&~2 | 06-2403 | HRW | no | | | KSU-Manhattan |
| KS970274-14*9 | 06-2404 | HRW | no | | | KSU-Manhattan |
| **Overley (check)** | 06-2405 | HRW | | | | Westbred |
| Smoky Hill | 06-2406 | HRW | yes | | | Westbred |
| Aspen | 06-2407 | HRW | yes | | | Westbred |
| **Millennium (check)** | 06-2408 | HRW | | | | NU |
| NW98S097 | 06-2409 | HRW | yes | Anton | 2008 | NU |
| N02Y5117 | 06-2410 | HRW | yes | Mace | 2007 | NU |
| NE01643 | 06-2411 | HRW | yes | Overland | 2007 | NU |
| NE02584 | 06-2412 | HRW | no | | | NU |
| **OK Bullet (check)** | 06-2413 | HRW | | | | OSU |
| Duster | 06-2414 | HRW | yes | | | OSU |
| OK01420 | 06-2415 | HRW | no | | | OSU |
| OK02405 | 06-2416 | HRW | no | | | OSU |
| OK02522W | 06-2417 | HWW | yes | OK Rising | 2008 | OSU |
| **Tandem (check)** | 06-2418 | HRW | | | | SDSU |
| SD96240-3-1 | 06-2419 | HRW | no | | | SDSU |
| SD01122 | 06-2420 | HRW | no | | | SDSU |
| SD01W065 | 06-2421 | HWW | no | | | SDSU |
| **TAM 111 (check)** | 06-2422 | HRW | | | | TAMU |
| TAM 112 | 06-2423 | HRW | yes | | | TAMU |
| TX01A5936 | 06-2424 | HRW | no | | | TAMU |
| TX01D3232 | 06-2425 | HRW | yes | TAM 304 | 2006 | TAMU |
| TX01V5314 | 06-2426 | HRW | yes | TAM 203 | 2007 | TAMU |
| **2005** | | | | | | |
| **Akron (check)** | 05-2401 | HRW | | | | CSU |
| CO00016 | 05-2402 | HRW | yes | Ripper | 2006 | CSU |
| **Jagger (check)** | 05-2403 | HRW | | | | KSU-Hays |
| 2137 | 05-2404 | HRW | yes | | | KSU-Hays |
| KS03HW6-6 | 05-2405 | HWW | no | | | KSU-Hays |
| KS03HW158-1 | 05-2406 | HWW | yes | RonL | | KSU-Hays |
| **Jagger (check)** | 05-2407 | HRW | | | | AgriPro |
| Neosho | 05-2408 | HRW | yes | | | AgriPro |
| W03-20 | 05-2409 | HRW | yes | Postrock | 2005 | AgriPro |
| **Goodstreak (check)** | 05-2410 | HRW | | | | NU |
| Infinity CL | 05-2411 | HRW | yes | | | NU |
| **OK Bullet (check)** | 05-2412 | HRW | | | | OSU |
| OK93p656H3299-2c04 | 05-2413 | HRW | yes | Duster | 2006 | OSU |
| OK01307 | 05-2414 | HRW | no | | | OSU |
| OK03918C | 05-2415 | HRW | yes | Centerfield | 2006 | OSU |
| OK00611W | 05-2416 | HWW | no | | | OSU |
| **Tandem (check)** | 05-2417 | HRW | | | | SDSU |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| Crimson | 05-2418 | HRW | yes | | | SDSU |
| SD97059-2 | 05-2419 | HRW | no | | | SDSU |
| SD01W064 | 05-2420 | HWW | no | | | SDSU |
| **2004** | | | | | | |
| **Jagger (check)** | 04-2401 | HRW | | | | KSU-Hays |
| 2137 | 04-2402 | HRW | yes | | | KSU-Hays |
| KS02HW34 | 04-2403 | HWW | yes | Danby | 2005 | KSU-Hays |
| KS02HW35-5 | 04-2404 | HWW | no | | | KSU-Hays |
| KS03HW158 | 04-2405 | HWW | yes | RonL | 2006 | KSU-Hays |
| **Antelope (check)** | 04-2406 | HRW | | | | NE-USDA-ARS |
| Arrowsmith | 04-2407 | HRW | yes | | | NE-USDA-ARS |
| NW99L7068 | 04-2408 | HRW | no | | | NE-USDA-ARS |
| **Millennium (check)** | 04-2409 | HRW | | | | NU |
| NE99495 | 04-2410 | HRW | yes | NE99495 | 2005 | NU |
| **OK102 (check)** | 04-2411 | HRW | | | | OSU |
| OK00618W | 04-2412 | HWW | yes | Guymon | 2005 | OSU |
| OK99212 | 04-2413 | HRW | no | | | OSU |
| OK00514 | 04-2414 | HRW | yes | OK Bullet | 2005 | OSU |
| OK02909C | 04-2415 | HRW | yes | Okfield | 2005 | OSU |
| **Tandem (check)** | 04-2416 | HRW | | | | SDSU |
| SD97W609 | 04-2417 | HWW | yes | Alice | 2006 | SDSU |
| SD97538 | 04-2418 | HRW | no | | | SDSU |
| SD98102 | 04-2419 | HRW | yes | Darrell | 2006 | SDSU |
| **2003** | | | | | | |
| **Akron (check)** | 03-2401 | HRW | | | | CSU |
| CO980607 | 03-2402 | HRW | yes | Hatcher | 2004 | CSU |
| CO00D007 | 03-2403 | HRW | yes | Bond CL | 2004 | CSU |
| **Jagger (check)** | 03-2404 | HRW | | | | KSU-Hays |
| 2137 | 03-2405 | HRW | yes | | | KSU-Hays |
| KS01HW152-6 | 03-2406 | HWW | no | | | KSU-Hays |
| KS01HW163-4 | 03-2407 | HWW | no | | | KSU-Hays |
| KS02HW34 | 03-2408 | HWW | yes | Danby | 2005 | KSU-Hays |
| **Jagger (check)** | 03-2409 | HRW | | | | KSU-Manhattan |
| 2137 | 03-2410 | HRW | yes | | | KSU-Manhattan |
| Overley | 03-2411 | HRW | yes | | | KSU-Manhattan |
| KS940786-6-9 | 03-2412 | HRW | no | | | KSU-Manhattan |
| **OK 102 (check)** | 03-2413 | HRW | | | | OSU |
| OK94P549-11 | 03-2414 | HRW | yes | Endurance | 2004 | OSU |
| OK98690 | 03-2415 | HRW | yes | Deliver | 2004 | OSU |
| **Crimson (check)** | 03-2416 | HRW | | | | SDSU |
| SD97W604 | 03-2417 | HWW | yes | Wendy | 2004 | SDSU |
| SD92107-5 | 03-2418 | HRW | no | | | SDSU |
| **2002** | | | | | | |
| **Jagger (check)** | 02-2401 | HRW | | | | AgriPro |
| Cutter | 02-2402 | HRW | yes | | | AgriPro |
| Dumas | 02-2403 | HRW | yes | | | AgriPro |

| Entry ID | Entry No. | Entry Class | Released | Release Name | Release Year | Program |
|---|---|---|---|---|---|---|
| Jagalene | 02-2404 | HRW | yes | | | AgriPro |
| **G1878 (check)** | 02-2405 | HRW | | | | Cargill |
| G980723 | 02-2406 | HRW | no | | | Cargill |
| G970252W | 02-2407 | HWW | no | | | Cargill |
| **Prowers (check)** | 02-2408 | HRW | | | | CSU |
| CO980376 | 02-2409 | HRW | no | | | CSU |
| CO980607 | 02-2410 | HRW | yes | Hatcher | 2004 | CSU |
| CO980630 | 02-2411 | HRW | no | | | CSU |
| **Jagger (check)** | 02-2412 | HRW | | | | KSU-Manhattan |
| KS940748-2-2 | 02-2413 | HRW | no | | | KSU-Manhattan |
| KS940786-6-7 | 02-2414 | HRW | yes | Overley | 2003 | KSU-Manhattan |
| KS940786-6-9 | 02-2415 | HRW | no | | | KSU-Manhattan |
| **Millennium (check)** | 02-2416 | HRW | | | | NU |
| NE97V121 | 02-2417 | HRW | no | | | NU |
| NE98466 | 02-2418 | HRW | no | | | NU |
| NE98471 | 02-2419 | HRW | yes | Hallam | 2004 | NU |
| NI98439 | 02-2420 | HRW | no | | | NU |
| **2174 (check)** | 02-2421 | HRW | | | | OSU |
| OK102 | 02-2422 | HRW | yes | | | OSU |
| OK95548-54 | 02-2423 | HRW | no | | | OSU |
| OK95616-56 | 02-2424 | HRW | no | | | OSU |
| OK96705-38 | 02-2425 | HRW | no | | | OSU |
| OK98699 | 02-2426 | HRW | no | | | OSU |
| **2001** | | | | | | |
| **Jagger (check)** | 01-2401 | HRW | | | | Cargill |
| G970380A | 01-2402 | HRW | no | | | Cargill |
| G970209W | 01-2403 | HWW | no | | | Cargill |
| **Prowers 99 (check)** | 01-2404 | HRW | | | | CSU |
| CO970547 | 01-2405 | HRW | no | | | CSU |
| **Millennium (check)** | 01-2406 | HRW | | | | NU |
| NE97426 | 01-2407 | HRW | no | | | NU |
| NE97465 | 01-2408 | HRW | yes | Goodstreak | 2002 | NU |
| NE97638 | 01-2409 | HRW | yes | Empire | 2002 | NU |
| NE97669 | 01-2410 | HRW | no | | | NU |
| NE97689 | 01-2411 | HRW | yes | Harry | 2002 | NU |
| **2174 (check)** | 01-2412 | HRW | | | | OSU |
| OK96717-99-6756 | 01-2413 | HRW | no | | | OSU |
| OK97508 | 01-2414 | HRW | yes | Ok102 | 2002 | OSU |

Thank you for reviewing this report of 2022 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