PGI

Plains Grains Inc.

# Hard Red Winter Wheat

## 2017 Regional Quality Survey

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127 Noble Research Center
Stillwater, OK 74078

ph 405.744.9333

pgiadmin@plainsgrains.org

www.plainsgrains.org

PGI

PLAINS GRAINS INC.

Colorado Wheat
Administrative Committee
www.coloradowheat.org

Idaho Wheat Commission
www.idahowheat.org

Oklahoma Wheat Commission
www.wheat.state.ok.us

Kansas Wheat Commission
www.kswheat.com

North Dakota
Wheat Commission
www.ndwheat.com

South Dakota
Wheat Commission
www.sdwheat.org

Nebraska Wheat Board
www.nebraskawheat.com

Washington Grain Commission
www.washingtongrainalliance.com

Texas Wheat Producers
Board and Association
www.texaswheat.org

Montana Wheat & Barley
Committee
wbc.agr.mt.gov

Oregon Wheat Commission
www.owgl.org

Wyoming Wheat
Growers Association
www.wyomingwheat.com

# Plains Grains, Inc.

Plains Grains, Inc., a non-profit, private quality based marketing initiative, was formed in 2004 through the Oklahoma Wheat Commission, the Oklahoma Department of Agriculture, Food and Forestry, the Oklahoma State University Division of Agricultural Sciences and Natural Resources.

PGI was designed to bridge the gap between wheat producers, grain companies and foreign and domestic flour millers to benefit all segments of the wheat industry.

PGI facilitates the appropriate wheat quality tracking needed to provide millers with the quality information they need to purchase U.S. wheat. While state data is important, it is critical to Plains Grains marketing goals to have quality data for the entire HRW wheat production area. Each state may be able to produce the quality needed by foreign buyers, but it will take multiple states to achieve the critical mass needed to meet the quantity needs. By working together as a region we can meet both quality and quantity demands.

In 2004, PGI's crop quality survey included the Oklahoma HRW wheat crop. Designed as a regional marketing entity, PGI then brought five other HRW wheat producing states on board for the crop quality survey in 2005. Due to the welcome reception and success of PGI in the foreign marketplace, the entire Great Plains HRW wheat production region now subscribes to the PGI crop quality survey.


Visit our website at **www.plainsgrains.org** for up-to-date information, interactive maps and more!

# Feeding the World

Wheat is one of the oldest and most widely used food crops in the nation and it supplies approximately 20 percent of food calories for the world's population. Whole grains contain protective anti-oxidants in amounts near or exceeding those in fruits and vegetables.

Wheat is the United State's leading export crop and the fourth leading field crop. The most common class produced in the United States is Hard Red Winter (HRW) wheat. The class a variety fits into is determined by its hardness, the color of its kernels and by its planting time. Other classes are: Durum, Hard Red Spring, Soft Red Winter, Hard White and Soft White.

Almost 50 percent of the U.S.'s total wheat production is exported. Approximately one-third of the HRW produced is exported. Nigeria is the number one importer of U.S. HRW, with a little over 75 percent of its total imports coming from the U.S.

Wheat flour is the major ingredient in many favorite foods found across the globe. More foods are made from wheat than any other cereal grain. Wheat has the ability to produce a widely diverse range of end-use products because each class of wheat has distinct characteristics that create unique functionality.

HRW wheat is a versatile wheat with excellent milling and baking characteristics for pan breads. Principally used to make bread flour, HRW is also a choice wheat for Asian noodles, hard rolls, flat breads and as a blending improver.

Hard Red Winter wheat accounts for about 40 percent of total U.S. wheat production and is grown primarily in the Great Plains states of Colorado, Kansas, Nebraska, Oklahoma, Texas, Montana, South Dakota, North Dakota, Wyoming, and the Pacific Northwest.

# National Wheat Overview

## Wheat Major Classes

The six major classes of U.S. wheat are Hard Red Winter, Hard Red Spring, Soft Red Winter, Soft White, Hard White and Durum. Each class has a somewhat different end use and production tends to be region-specific. This region is mostly limited to production of Hard Red Winter and Hard White wheat classes, therefore the data in this publication will focus on the quality of those classes for the current crop year.

> *Hard Red Winter wheat accounts for about 40 percent of total U.S. wheat production*

**Hard Red Winter (HRW)** wheat accounts for about 40 percent of total U.S. wheat production, dominates the U.S. wheat export market and is grown primarily in the Great Plains, stretching from the Mississippi River to the Pacific Ocean and from Canada to Mexico.

This fall seeded wheat is a versatile wheat with moderately high protein content and excellent milling and baking characteristics. Principally used to make bread flour, HRW is also a choice wheat for Asian noodles, hard rolls, flat breads and is commonly used as an improver for blending.

**Hard White (HW)** is the newest class of wheat, used for the same basic products as HRW wheat, can provide higher milling extraction and requires less sweetener in whole-wheat products due to its milder, sweeter flavor.

HW, which is closely related to Red wheats, receives enthusiastic reviews when used for Asian noodles, hard rolls, bulgar, tortillas, whole wheat or high extraction applications, pan breads or flat breads.

## Weather and Harvest

Planted area for the 2017 hard red winter (HRW) crop fell to the lowest level in over 100 years, pressured by the poor income potential from wheat. The 2017 HRW production, estimated at 20.4 million metric tons (MMT), is down from 29.4 MMT in 2016 and well below the 5-year average. Large beginning stocks partially offset the sharp production decline. USDA estimated the HRW supply (excluding imports) at 36.5 MMT, down 13% from 2016. Variable conditions challenged the crop, but moisture remained adequate, or even excessive in some areas, resulting generally in better than expected yields, lower than average protein, but otherwise good milling and processing characteristics. In the Southern and Central Plains, a warmer than normal winter favored diseases and insect pests and prevented vernalization in Texas and parts of southern Oklahoma. An unusually late 20-inch snowfall caused significant lodging in western Kansas, eastern Colorado and parts of Nebraska, Oklahoma and Texas. Higher disease and insect pressure followed and reduced yield potential. Late season rain benefited Kansas, Colorado and Nebraska, but was too late for Texas and Oklahoma.

The start of winter was mild and dry across the Pacific Northwest (PNW) and Northern Plains, but February through April was extremely wet with erratic temperatures. However, a hot, dry late spring caused inconsistent crop development. Eastern Montana, South Dakota and western North Dakota suffered severe drought conditions with devastating effects on yield.

## Samples and Methods

Sample collection and analysis were conducted in a collaborative effort between the USDA/ARS Hard Winter Wheat Quality Lab, Manhattan, Kansas and Plains Grains, Inc., a private non-profit company designed to do quality testing of the Hard Red Winter Wheat crop. 492 (94% of the long-term average due to environment production factors) samples were collected from grain elevators when at least 30% of the local harvest was completed in the 11 states of Texas, Oklahoma, Kansas, Colorado, Nebraska, Wyoming, South Dakota, Montana, Washington, Oregon and Idaho.

Official grade and non-grade parameters were determined on each sample. 90 composites were then formed based on production regions and protein ranges of < 11.5%, 11.5%–12.5%, and >12.5% and milling, dough functionality and bake tests were run on composites. Results by protein ranges were then segregated by export region and reported by tributary as well as overall. Sampling was targeted at testing over 80% of the Hard Red Winter Wheat production in the 11 states referenced above with weighting factors based on production calculated. The analytical methods used to define the reported parameters are described in the Analysis Methods section of this book.

## Wheat and Grade Data

The overall composite 2017 HRW crop official grade averaged 92% Grade #2 or better (Gulf tributary averaging 86% and PNW tributary averaging 100%) when considering all samples. The overall dockage level of 0.6% is comparable to last year's average of 0.5% and equal to the 5-year average of 0.6%. Total defects of 1.2% are well below last year's average of 1.4% and 5-year average of 1.6%. Foreign material is 0.1% and is below last year's 0.2% while shrunken and broken (0.9%) is equal to last year and below the 5-year average (0.9% and 1.2% respectively). Wheat ash (14% mb) is 1.50% and comparable to last year's 1.49% and below the 5-year average of 1.53%. Overall test weight averaged 60.5 lb/bu (79.6 kg/hl) which is above the 5-year average of 60.3 lb/bu (79.3 kg/hl) and is equal to last year's average of 60.5 lb/bu (79.6 kg/hl). The overall average thousand kernel weight of 31.0 g significantly exceeds the 5-year average of 29.1 g. Average kernel diameter is 2.56 mm is below last year and 5-year average (2.66 mm and 2.60 mm respectively). The average protein of 11.4% is similar to last year (11.5%), but significantly lower than the 5-year average of 12.6%. Overall kernel characteristics were outstanding in the 2017 crop with protein quantity being of the most concern. Protein content splits varied across the testing region and by tributary with approximately 56% of samples being in the < 11.5% protein content category, 28% in the 11.5%– 12.5% category and 16% in the < 12.5% category. The average wheat falling number for this crop is 378 seconds, and is comparable to the 2016 average of 392 seconds and the 5-year average of 401 seconds and is indicative of sound wheat.

## Flour and Baking Data

The Buhler flour yield overall averaged 78.1% and significantly exceeds the 2016 average of 76.6% and the 5-year average of 75.2%. However, flour ash (14% mb) is significantly higher this year (0.64%) as compared to 2016 (0.56%) and the 5-year average (0.56%). Gluten index values averaged 93% which is equal to last year (93%) and is equal to the 5-year average (93%). The W value of 199 (10-4 J) is slightly lower than last year's average of 211 (10-4 J) and well below the 5-year average of 239 (10-4 J). Overall average bake absorption is 62.8% which slightly below the 2016 absorption of 62.9% and slightly above the 5-year average of 62.7%. Farinograph development time and stability times are 4.5 minutes and 6.1 minutes respectively as compared to last year's 4.0 minutes and 6.7 minutes respectively and both are significantly lower than the 5-year averages of 5.2 minutes and 9.2 minutes respectively. Overall loaf volume averaged 806cc and is comparable to 2016 (821cc) and the 5-year average of 840cc.

## Summary

The 2017 HRW wheat crop was very similar to last year's crop in many ways. Generally, both crops were planted and developed in a favorable environment until late in the growing season. The 2016 and 2017 HRW wheat crops had abundant moisture and no stress during the grainfill period (with the exceptions noted above in areas of the PNW, Dakotas and eastern Montana). The result in 2016 were record wheat yields and a crop that depleted most soil profile nitrogen (N) reserves and no market signals were in place to entice producers to supply additional fertilizer in 2017. The wheat crop in both years exhibited a "protein dilution" effect resulting in lower quantities of protein in the wheat and flour (increases in nitrogen is recognized as enhancing grain protein concentration). Both crop years exhibited very good kernel characteristics from a milling standpoint, but with generally low protein. However, testing would also indicate that even though mix times and tolerances are shorter than the five-year averages, the loaf volumes achieved indicate there is adequate protein quality to make good quality bread. This crop meets or exceeds typical HRW contract specifications and provides high value to the customer.

# Hard Red Winter Wheat Production Charts

**English Units**

## Hard Winter Wheat Production (1,000 bu.)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 105,750 | 78,000 | 83,250 | 43,500 | 89,300 | 79,180 | 105,120 | 86,860 | 83,870 |
| Kansas | 360,000 | 276,500 | 387,000 | 328,000 | 246,400 | 321,900 | 467,400 | 333,600 | 340,100 |
| Montana | 93,600 | 89,790 | 81,320 | 96,750 | 91,840 | 91,020 | 105,350 | 66,780 | 89,556 |
| North Dakota | 17,600 | 13,875 | 38,500 | 13,440 | 27,195 | 8,360 | 5,760 | 1,295 | 15,753 |
| Nebraska | 64,070 | 65,250 | 55,440 | 41,760 | 71,050 | 45,980 | 70,740 | 46,920 | 57,651 |
| Oklahoma | 120,900 | 70,400 | 155,400 | 115,500 | 47,600 | 98,800 | 136,500 | 98,600 | 105,463 |
| Pacific NW | 19,869 | 22,004 | 37,990 | 35,330 | 28,350 | 28,543 | 36,707 | 33,800 | 30,324 |
| South Dakota | 63,700 | 66,780 | 62,400 | 25,350 | 59,400 | 42,680 | 63,800 | 20,800 | 50,614 |
| Texas | 127,500 | 49,400 | 91,450 | 64,000 | 67,500 | 106,500 | 89,600 | 68,150 | 83,013 |
| Wyoming | 4,640 | 4,420 | 3,000 | 2,640 | 3,375 | 4,160 | 4,250 | 2,940 | 3,678 |
| Regional Total | 977,629 | 736,419 | 995,750 | 766,270 | 732,010 | 827,123 | 1,085,227 | 759,745 | 860,022 |

## Hard Winter Wheat Harvested Acres (1,000 Acres)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 2,350 | 2,000 | 2,250 | 1,500 | 2,350 | 2,140 | 2,190 | 2,020 | 2,100 |
| Kansas | 8,000 | 7,900 | 9,000 | 8,200 | 8,800 | 8,700 | 8,200 | 6,950 | 8,219 |
| Montana | 1,950 | 2,190 | 2,140 | 2,150 | 2,240 | 2,220 | 2150 | 1,590 | 2,079 |
| North Dakota | 320 | 375 | 700 | 320 | 555 | 190 | 120 | 35 | 327 |
| Nebraska | 1,490 | 1,450 | 1,320 | 1,160 | 1,450 | 1,210 | 1,310 | 1,020 | 1,301 |
| Oklahoma | 3,900 | 3,200 | 4,200 | 3,500 | 2,800 | 3,800 | 3,500 | 2,900 | 3,475 |
| Pacific NW | 289 | 293 | 535 | 530 | 417 | 434 | 456 | 451 | 426 |
| South Dakota | 1,300 | 1,590 | 1,300 | 650 | 1,080 | 970 | 1,100 | 520 | 1,064 |
| Texas | 3,750 | 1,900 | 2,950 | 2,000 | 2,250 | 3,550 | 2,800 | 2,350 | 2,694 |
| Wyoming | 145 | 130 | 120 | 120 | 125 | 130 | 125 | 105 | 125 |
| Regional Total | 23,494 | 21,028 | 24,515 | 20,130 | 22,067 | 23,344 | 21,951 | 17,941 | 21,809 |

## Hard Winter Wheat Yield (bu/ac)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 45 | 39 | 37 | 29 | 38 | 37 | 48 | 43 | 40 |
| Kansas | 45 | 45 | 43 | 40 | 28 | 37 | 57 | 48 | 43 |
| Montana | 48 | 41 | 38 | 45 | 41 | 41 | 49 | 42 | 43 |
| North Dakota | 55 | 37 | 55 | 42 | 49 | 44 | 48 | 37 | 46 |
| Nebraska | 43 | 45 | 42 | 36 | 49 | 38 | 54 | 46 | 44 |
| Oklahoma | 31 | 22 | 37 | 33 | 17 | 26 | 39 | 34 | 30 |
| Pacific NW | 68 | 76 | 75 | 68 | 66 | 70 | 82 | 75 | 73 |
| South Dakota | 49 | 42 | 48 | 39 | 55 | 44 | 58 | 40 | 47 |
| Texas | 34 | 26 | 31 | 32 | 30 | 30 | 32 | 29 | 31 |
| Wyoming | 32 | 34 | 25 | 22 | 27 | 32 | 34 | 28 | 29 |
| Regional Avg | 45 | 41 | 43 | 39 | 40 | 40 | 50 | 42 | 42 |

*** Some data derived from Crop Production report issued by USDA NASS updated September 30, 2016.*

# Hard Red Winter Wheat Production Charts

**Metric Units**

## Hard Winter Wheat Production (MMT)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 2.88 | 2.12 | 2.27 | 1.18 | 2.43 | 2.16 | 2.86 | 2.36 | 2.28 |
| Kansas | 9.80 | 7.53 | 10.53 | 8.93 | 6.71 | 8.76 | 12.72 | 9.08 | 9.26 |
| Montana | 2.55 | 2.44 | 2.21 | 2.63 | 2.50 | 2.48 | 2.87 | 1.82 | 2.44 |
| North Dakota | 0.48 | 0.38 | 1.05 | 0.37 | 0.74 | 0.23 | 0.16 | 0.04 | 0.43 |
| Nebraska | 1.74 | 1.78 | 1.51 | 1.14 | 1.93 | 1.25 | 1.93 | 1.28 | 1.57 |
| Oklahoma | 3.29 | 1.92 | 4.23 | 3.14 | 1.30 | 2.69 | 3.72 | 2.68 | 2.87 |
| Pacific NW | 0.54 | 0.60 | 1.03 | 0.96 | 0.77 | 0.78 | 1.00 | 0.92 | 0.83 |
| South Dakota | 1.73 | 1.82 | 1.70 | 0.69 | 1.62 | 1.16 | 1.74 | 0.57 | 1.38 |
| Texas | 3.47 | 1.34 | 2.49 | 1.74 | 1.84 | 2.90 | 2.44 | 1.85 | 2.26 |
| Wyoming | 0.13 | 0.12 | 0.08 | 0.07 | 0.09 | 0.11 | 0.12 | 0.08 | 0.10 |
| Regional Total | 26.61 | 20.04 | 27.10 | 20.86 | 19.92 | 22.51 | 29.54 | 20.68 | 23.41 |

## Hard Winter Wheat Harvested Acres (1,000 ha)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 951 | 810 | 911 | 607 | 951 | 866 | 887 | 818 | 850 |
| Kansas | 3,239 | 3,198 | 3,644 | 3,320 | 3,563 | 3,522 | 3,320 | 2,814 | 3,327 |
| Montana | 789 | 887 | 866 | 870 | 907 | 899 | 870 | 644 | 842 |
| North Dakota | 130 | 152 | 283 | 130 | 225 | 77 | 49 | 14 | 132 |
| Nebraska | 603 | 587 | 534 | 470 | 587 | 490 | 530 | 413 | 527 |
| Oklahoma | 1,579 | 1,296 | 1,700 | 1,417 | 1,134 | 1,538 | 1,417 | 1,174 | 1,407 |
| Pacific NW | 117 | 119 | 217 | 215 | 169 | 176 | 185 | 183 | 172 |
| South Dakota | 526 | 644 | 526 | 263 | 437 | 393 | 445 | 211 | 431 |
| Texas | 1,518 | 769 | 1,194 | 810 | 911 | 1,437 | 1,134 | 951 | 1,091 |
| Wyoming | 59 | 53 | 49 | 49 | 51 | 53 | 51 | 43 | 51 |
| Regional Total | 9,512 | 8,513 | 9,925 | 8,150 | 8,934 | 9,451 | 8,887 | 7,264 | 8,829 |

## Hard Winter Wheat Yield (tons/ha)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 3.03 | 2.62 | 2.49 | 1.95 | 2.56 | 2.49 | 3.23 | 2.89 | 2.66 |
| Kansas | 3.03 | 3.03 | 2.89 | 2.69 | 1.88 | 2.49 | 3.83 | 3.23 | 2.88 |
| Montana | 3.23 | 2.76 | 2.56 | 3.03 | 2.76 | 2.76 | 3.30 | 2.82 | 2.90 |
| North Dakota | 3.70 | 2.49 | 3.70 | 2.82 | 3.30 | 2.96 | 3.23 | 2.49 | 3.09 |
| Nebraska | 2.89 | 3.03 | 2.82 | 2.42 | 3.30 | 2.56 | 3.63 | 3.09 | 2.97 |
| Oklahoma | 2.08 | 1.48 | 2.49 | 2.22 | 1.14 | 1.75 | 2.62 | 2.29 | 2.01 |
| Pacific NW | 4.57 | 5.11 | 5.04 | 4.57 | 4.44 | 4.71 | 5.51 | 5.04 | 4.88 |
| South Dakota | 3.30 | 2.82 | 3.23 | 2.62 | 3.70 | 2.96 | 3.90 | 2.69 | 3.15 |
| Texas | 2.29 | 1.75 | 2.08 | 2.15 | 2.02 | 2.02 | 2.15 | 1.95 | 2.05 |
| Wyoming | 2.15 | 2.29 | 1.68 | 1.48 | 1.82 | 2.15 | 2.29 | 1.88 | 1.97 |
| Regional Avg | 30.26 | 27.37 | 28.98 | 25.96 | 26.90 | 26.83 | 33.69 | 28.38 | 28.55 |

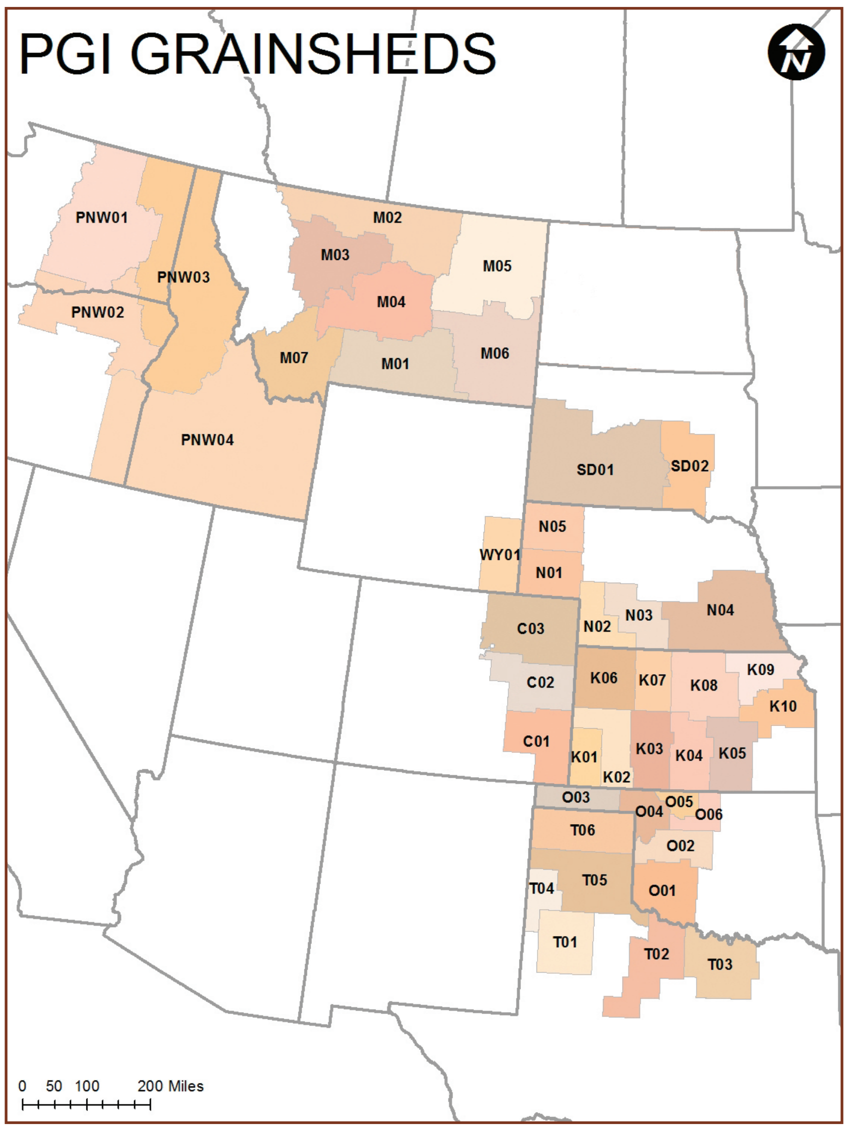
*** Some data derived from Crop Production report issued by USDA NASS updated September 30, 2016.*

# Survey Methodology

Plains Grains Inc. (PGI) is an Oklahoma-based regional wheat marketing entity that has designed a wheat quality survey to provide end-use quality information to the U.S. wheat buyer. PGI facilitates collection and testing of wheat samples at harvest in order to provide data that specifically describes the quality of U.S. wheat.

PGI facilitates quality testing on a "grainshed" basis. Grainsheds are defined by identifying key loading facilities and outlining the production region which contributes to that facility's grain supply. By defining the production areas in this manner, PGI's survey is able to more accurately represent and determine the quality of wheat that will come from a specific regional terminal, thereby giving buyers a truer picture of the product available to compose a shipment of HRW wheat.

The quality of wheat originating from a grainshed is determined by pulling samples from country and terminal elevators located within each defined grainshed. These samples are then immediately sent to the USDA, ARS Hard Winter Wheat Quality Lab in Manhattan, Kansas, where they are analyzed and tested for more than 25 quality parameters. Official grade is determined at the Federal Grain Inspection Service office in Enid, Oklahoma.



# Wheat Grading Characteristics

The Federal Grain Inspection Service (FGIS) of the USDA Grain Inspection, Packers and Stockyards Administration (GIPSA) sets the standard for U.S. grain grades and grade requirements. U.S. grain grades are reflective of the general quality and condition of a representative sample of U.S. wheat. These grades are based on characteristics such as test weight and include limits on damaged kernels, foreign material, shrunken and broken kernels, and wheat of contrasting classes. Each determination is made on the basis of the grain free of dockage. Grades issued under U.S. standards represent a sum of these factors.

## Official U.S. Grades and Grade Requirements

| Grading Factors | Grades | | | | |
|---|---|---|---|---|---|
| | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 |
| **Hard Red Winter – Minimum Test Weights** | | | | | |
| LB/BU | 60.0 | 58.0 | 56.0 | 54.0 | 51.0 |
| **Maximum Percent Limits Of:** | | | | | |
| DEFECTS | | | | | |
| Damaged Kernels | | | | | |
| Heat (part total) | 0.2 | 0.2 | 0.5 | 1.0 | 3.0 |
| Total | 2.0 | 4.0 | 7.0 | 10.0 | 15.0 |
| Foreign Material | 0.4 | 0.7 | 1.3 | 3.0 | 5.0 |
| Shrunken and Broken Kernels | 3.0 | 5.0 | 8.0 | 12.0 | 20.0 |
| Total* | 3.0 | 5.0 | 8.0 | 12.0 | 20.0 |
| WHEAT OF OTHER CLASSES** | | | | | |
| Contrasting classes | 1.0 | 2.0 | 3.0 | 10.0 | 10.0 |
| Total*** | 3.0 | 5.0 | 10.0 | 10.0 | 10.0 |
| Stones | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Maximum Count Limits Of:** | | | | | |
| OTHER MATERIAL (1,000 gram sample) | | | | | |
| Animal Filth | 1 | 1 | 1 | 1 | 1 |
| Castor Beans | 1 | 1 | 1 | 1 | 1 |
| Crotalaria Seeds | 2 | 2 | 2 | 2 | 2 |
| Glass | 0 | 0 | 0 | 0 | 0 |
| Stones | 3 | 3 | 3 | 3 | 3 |
| Unknown Foreign Substance | 3 | 3 | 3 | 3 | 3 |
| Total**** | 4 | 4 | 4 | 4 | 4 |
| INSECT DAMAGED KERNELS (in 100 grams) | 31 | 31 | 31 | 31 | 31 |

Note: U.S. Sample grade is wheat that:
(a) Does not meet the requirements for U.S. Nos. 1, 2, 3, 4, or 5; or
(b) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic); or
(c) Is heating or of distinctly low quality.

*Includes damaged kernels (total), foreign materials, and shrunken and broken kernels.
**Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.
***Includes contrasting classes.
****Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, or unknown foreign substance.

# Wheat Grading Data

Each determination of heat-damaged kernels, damaged kernels, foreign material, wheat of other classes, contrasting classes, and subclasses is made on the basis of the grain when free from dockage and shrunken and broken kernels.

**Defects** are damaged kernels, foreign materials, and shrunken and broken kernels. The sum of these three factors may not exceed the limit for the factor defects for each numerical grade.

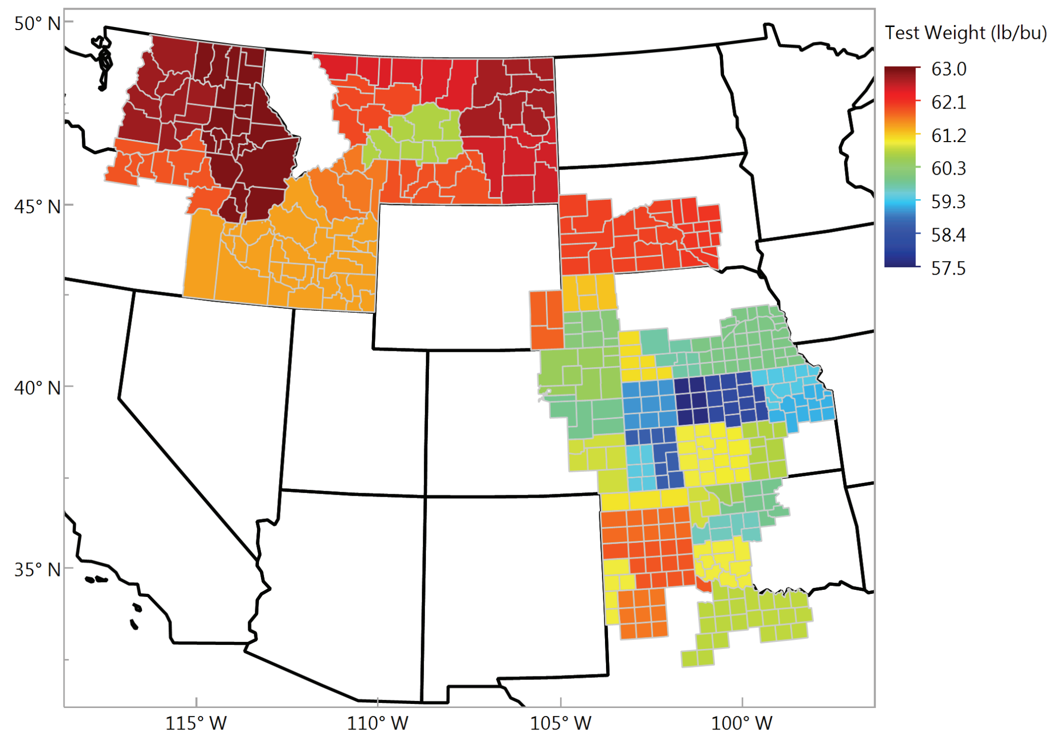
**Foreign material** is all matter other than wheat that remains in the sample after the removal of dockage and shrunken and broken kernels.

**Shrunken and broken kernels** are all matter that passes through a 0.064 x 3/8-inch oblong-hole sieve after sieving according to procedures prescribed in the FGIS instructions.

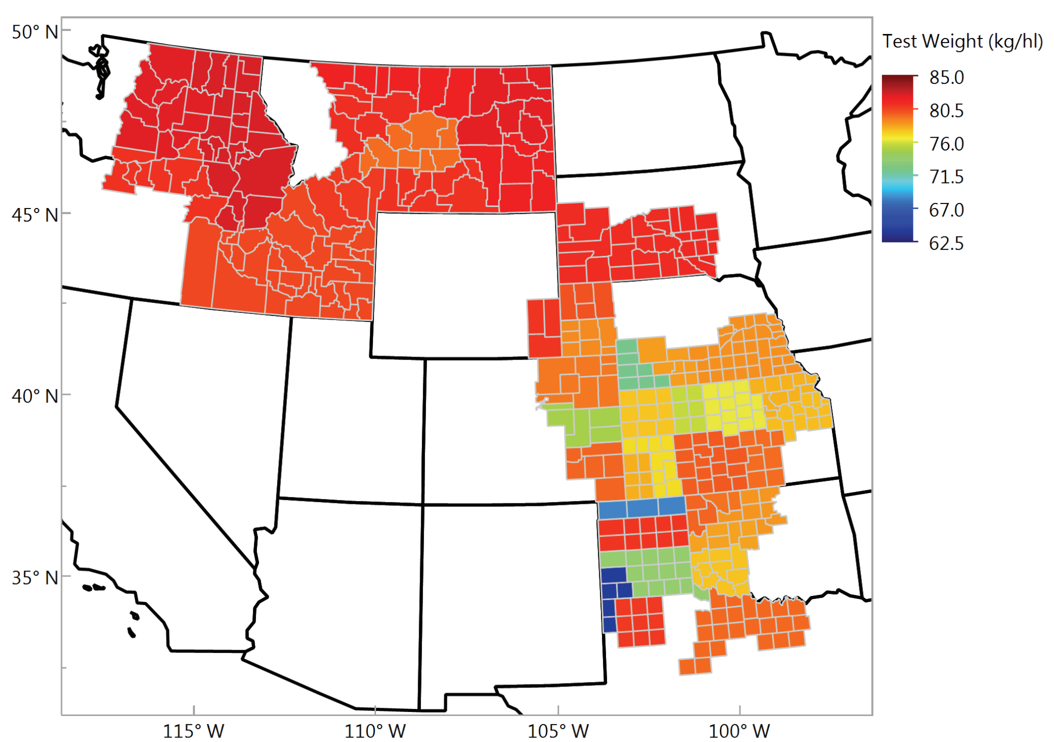
**Damaged kernels** are kernels, pieces of wheat kernels, and other grains that are badly ground-damaged, badly weather damaged, diseased, frost-damaged, germ damaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged, or otherwise materially damaged.

**Test Weight** is a measure of the density of the sample and may be an indicator of milling yield and the general condition of the sample, as problems that occur during the growing season or at harvest often reduce test weight.

# Test Weight (lb/bu)




# Test Weight (kg/hl)



# Wheat Grading Data

| Location | | Official Grade (U.S. NO.) | Dockage (%) | Test Wt (lb/bu) | Test Wt (kg/hl) | Damage Kernels Total (%) | Shrunken & Broken Kernels (%) | Foreign Material (%) |
|---|---|---|---|---|---|---|---|---|
| Colorado | C01 | 1 | 0.4 | 60.8 | 80.0 | 0.1 | 1.2 | 0.0 |
| | C02 | 2 | 0.6 | 59.9 | 78.8 | 0.1 | 1.1 | 0.1 |
| | C03 | 1 | 0.6 | 60.5 | 79.5 | 0.1 | 2.0 | 0.1 |
| Kansas | K01 | 2 | 1.3 | 59.5 | 78.2 | 0.0 | 0.6 | 0.0 |
| | K02 | 2 | 0.7 | 58.8 | 77.4 | 0.2 | 1.2 | 0.1 |
| | K03 | 1 | 0.5 | 60.9 | 80.1 | 0.1 | 0.9 | 0.1 |
| | K04 | 1 | 0.5 | 61.0 | 80.2 | 0.3 | 0.6 | 0.1 |
| | K05 | 1 | 0.5 | 60.7 | 79.8 | 0.2 | 1.1 | 0.1 |
| | K06 | 2 | 0.4 | 59.1 | 77.7 | 0.3 | 0.8 | 0.3 |
| | K07 | 2 | 0.5 | 57.6 | 75.9 | 0.2 | 0.7 | 0.1 |
| | K08 | 2 | 0.4 | 58.1 | 76.5 | 0.3 | 0.7 | 0.1 |
| | K09 | 2 | 0.3 | 59.4 | 78.2 | 0.2 | 1.2 | 0.0 |
| | K10 | 2 | 0.5 | 59.2 | 77.9 | 0.2 | 0.9 | 0.1 |
| Montana | M01 | 1 | 0.6 | 61.9 | 81.4 | 0.0 | 1.5 | 0.1 |
| | M02 | 1 | 0.3 | 62.4 | 82.1 | 0.0 | 0.7 | 0.1 |
| | M03 | 1 | 0.5 | 62.0 | 81.5 | 0.0 | 0.8 | 0.1 |
| | M04 | 1 | 0.3 | 60.7 | 79.8 | 0.0 | 1.2 | 0.1 |
| | M05 | 1 | 0.2 | 62.8 | 82.5 | 0.0 | 0.7 | 0.1 |
| | M06 | 1 | 0.2 | 62.5 | 82.2 | 0.0 | 0.4 | 0.2 |
| | M07 | 1 | 0.3 | 61.7 | 81.1 | 0.0 | 0.3 | 0.0 |
| Nebraska | N01 | 1 | 0.6 | 60.1 | 79.1 | 0.1 | 1.4 | 0.2 |
| | N02 | 1 | 0.3 | 61.1 | 80.3 | 0.1 | 0.9 | 0.1 |
| | N03 | 2 | 1.5 | 59.8 | 78.7 | 0.2 | 1.2 | 0.2 |
| | N04 | 1 | 0.4 | 60.0 | 78.9 | 0.2 | 0.9 | 0.1 |
| | N05 | 1 | 0.6 | 61.2 | 80.5 | 0.1 | 1.0 | 0.1 |
| Oklahoma | O01 | 1 | 0.8 | 61.0 | 80.2 | 0.1 | 1.0 | 0.4 |
| | O02 | 2 | 0.8 | 59.7 | 78.5 | 0.0 | 3.7 | 0.2 |
| | O03 | 1 | 0.5 | 61.1 | 80.3 | 0.3 | 0.9 | 0.2 |
| | O04 | 1 | 0.8 | 60.8 | 80.0 | 0.1 | 1.1 | 0.1 |
| | O05 | 1 | 1.1 | 60.5 | 79.6 | 0.2 | 0.8 | 0.2 |
| | O06 | 2 | 0.7 | 59.9 | 78.8 | 0.1 | 0.9 | 0.2 |
| | O07 | 2 | 0.5 | 59.9 | 78.8 | 0.0 | 0.9 | 0.2 |
| Pacific Northwest | PNW01 | 1 | 0.4 | 62.8 | 82.6 | 0.0 | 0.6 | 0.0 |
| | PNW02 | 1 | 0.4 | 61.9 | 81.4 | 0.1 | 0.5 | 0.0 |
| | PNW03 | 1 | 0.3 | 63.0 | 82.8 | 0.0 | 0.4 | 0.0 |
| | PNW04 | 1 | 0.6 | 61.4 | 80.8 | 0.0 | 0.7 | 0.0 |
| South Dakota | SD01 | 1 | 0.4 | 62.0 | 81.5 | 0.1 | 1.1 | 0.1 |
| | SD02 | 1 | 0.3 | 62.1 | 81.6 | 0.1 | 1.2 | 0.1 |
| Texas | T01 | 1 | 0.4 | 61.7 | 81.1 | 0.0 | 0.9 | 0.1 |
| | T02 | 1 | 0.9 | 60.7 | 79.9 | 0.2 | 1.2 | 0.2 |
| | T03 | 1 | 0.7 | 61.0 | 80.3 | 0.2 | 0.8 | 0.1 |
| | T04 | 1 | 0.7 | 61.0 | 80.2 | 0.4 | 0.8 | 0.1 |
| | T05 | 1 | 0.6 | 61.9 | 81.3 | 0.1 | 1.0 | 0.2 |
| | T06 | 1 | 0.7 | 61.7 | 81.2 | 0.1 | 1.0 | 0.1 |
| Wyoming | W01 | 1 | 0.5 | 61.8 | 81.2 | 0.1 | 1.0 | 0.2 |

# Kernel Quality Data

| Location | | Total Defects (%) | Kernel Size Large (%) | Kernel Size Med (%) | Kernel Size Small (%) | Thousand Kernal Wt (g) | SKCS Avg Diam (mm) |
|---|---|---|---|---|---|---|---|
| Colorado | C01 | 1.3 | 63.0 | 35.5 | 1.5 | 29.0 | 2.46 |
| | C02 | 1.3 | 66.4 | 32.4 | 1.2 | 29.8 | 2.47 |
| | C03 | 2.3 | 62.2 | 35.9 | 1.9 | 28.9 | 2.45 |
| Kansas | K01 | 0.7 | 69.9 | 28.9 | 1.2 | 32.2 | 2.56 |
| | K02 | 1.1 | 69.0 | 29.9 | 1.1 | 30.4 | 2.54 |
| | K03 | 1.0 | 72.7 | 26.3 | 0.9 | 30.8 | 2.55 |
| | K04 | 1.0 | 72.0 | 27.1 | 0.9 | 31.5 | 2.58 |
| | K05 | 1.4 | 71.6 | 27.5 | 0.9 | 30.7 | 2.56 |
| | K06 | 1.4 | 72.9 | 26.0 | 1.0 | 31.8 | 2.58 |
| | K07 | 0.9 | 69.0 | 29.9 | 1.1 | 30.2 | 2.53 |
| | K08 | 1.1 | 72.1 | 26.9 | 1.0 | 32.1 | 2.60 |
| | K09 | 1.5 | 73.4 | 25.3 | 1.3 | 32.5 | 2.60 |
| | K10 | 1.2 | 76.5 | 22.6 | 1.0 | 32.5 | 2.61 |
| Montana | M01 | 1.6 | 64.6 | 34.0 | 1.5 | 32.4 | 2.53 |
| | M02 | 0.8 | 56.6 | 42.8 | 0.6 | 32.3 | 2.59 |
| | M03 | 0.9 | 61.2 | 38.0 | 0.9 | 33.1 | 2.59 |
| | M04 | 1.3 | 43.5 | 55.2 | 1.4 | 30.0 | 2.46 |
| | M05 | 0.8 | 65.5 | 34.0 | 0.3 | 33.1 | 2.65 |
| | M06 | 0.6 | 66.9 | 32.8 | 0.4 | 34.2 | 2.61 |
| | M07 | 0.3 | 76.5 | 23.4 | 0.1 | 36.3 | 2.68 |
| Nebraska | N01 | 1.7 | 61.2 | 37.2 | 1.6 | 28.8 | 2.46 |
| | N02 | 1.0 | 73.9 | 25.4 | 0.7 | 31.7 | 2.58 |
| | N03 | 1.6 | 67.2 | 31.2 | 1.5 | 29.7 | 2.50 |
| | N04 | 1.2 | 66.1 | 32.5 | 1.3 | 30.1 | 2.51 |
| | N05 | 1.3 | 67.2 | 31.8 | 1.1 | 30.4 | 2.55 |
| Oklahoma | O01 | 1.6 | 66.2 | 32.3 | 1.4 | 29.4 | 2.56 |
| | O02 | 3.8 | 67.9 | 29.4 | 2.7 | 30.8 | 2.55 |
| | O03 | 1.3 | 68.7 | 29.8 | 1.4 | 31.5 | 2.58 |
| | O04 | 1.4 | 65.7 | 32.7 | 1.6 | 29.9 | 2.52 |
| | O05 | 1.2 | 70.5 | 28.4 | 1.1 | 30.7 | 2.60 |
| | O06 | 1.2 | 66.3 | 32.4 | 1.3 | 29.0 | 2.55 |
| | O07 | 1.1 | 55.2 | 43.0 | 1.9 | 26.5 | 2.43 |
| Pacific Northwest | PNW01 | 0.6 | 80.6 | 18.9 | 0.5 | 37.4 | 2.74 |
| | PNW02 | 0.5 | 79.9 | 16.3 | 0.4 | 37.7 | 2.79 |
| | PNW03 | 0.4 | 84.0 | 15.7 | 0.3 | 38.3 | 2.80 |
| | PNW04 | 0.7 | 76.2 | 23.1 | 0.6 | 34.8 | 2.66 |
| South Dakota | SD01 | 1.3 | 46.4 | 52.1 | 1.4 | 29.8 | 2.46 |
| | SD02 | 1.3 | 56.3 | 42.3 | 1.4 | 32.3 | 2.53 |
| Texas | T01 | 1.0 | 69.7 | 29.3 | 1.0 | 30.8 | 2.54 |
| | T02 | 1.5 | 59.0 | 39.5 | 1.5 | 28.8 | 2.51 |
| | T03 | 1.1 | 76.5 | 22.6 | 0.9 | 31.8 | 2.56 |
| | T04 | 1.0 | 58.4 | 40.5 | 1.1 | 29.0 | 2.51 |
| | T05 | 1.4 | 66.5 | 31.5 | 1.9 | 31.0 | 2.56 |
| | T06 | 1.1 | 71.5 | 27.4 | 1.0 | 32.1 | 2.60 |
| Wyoming | W01 | 1.3 | 65.8 | 32.8 | 1.4 | 31.0 | 2.56 |

# Other Wheat Characteristics

In addition to the U.S. grade factors, there are other characteristics at work to determine the value of the wheat. Examples include dockage, wheat moisture, wheat protein content, thousand-kernel weight (TKW), and falling number.

**Moisture content** is an indicator of grain condition and storability. Wheat or flour with low moisture content is more stable during storage. Moisture content is often standardized (12 or 14 percent moisture basis) for other tests that are affected by moisture content.

**Protein content** relates to many important processing properties, such as water absorption and gluten strength, and to finished product attributes such as texture and appearance. Higher protein dough usually absorbs more water and takes longer to mix. HRW wheat generally has a medium to high protein content, making it most suitable for all purpose flour and chewy-texture breads.

**Ash content** also indicates milling performance and how well the flour separates from the bran. Millers need to know the overall mineral content of the wheat to achieve desired or specified ash levels in flour. Ash content can affect flour color. White flour has low ash content, which is often a high priority among millers.

**Thousand-kernel weight** and kernel diameter provide measurements of kernel size and density important for milling quality. Simply put, it measures the mass of the wheat kernel. Millers tend to prefer larger berries, or at least berries with a consistent size. Wheat with a higher TKW can be expected to have a greater potential flour extraction.

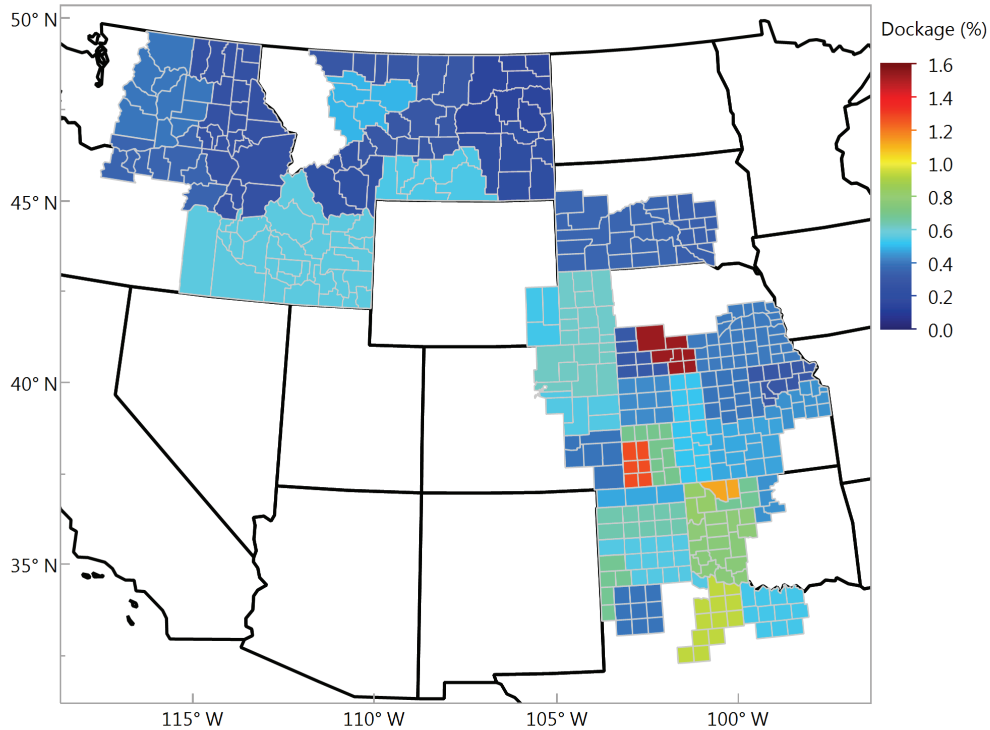
**Falling number** is an index of enzyme activity in wheat or flour and is expressed in seconds. Falling numbers above 300 are desirable, as they indicate little enzyme activity and a sound quality product. Falling numbers below 300 are indicative of more substantial enzyme activity and sprout damage.

**Dockage** is all matter other than wheat that can be removed from the original sample by use of an approved device according to procedures prescribed in FGIS instructions.

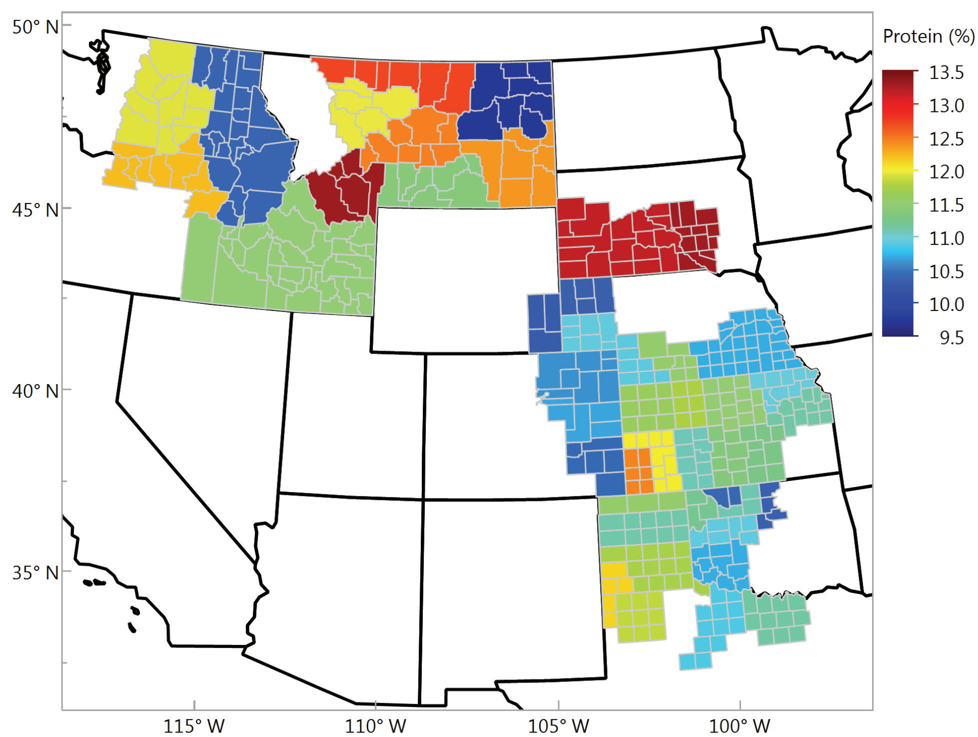
**Kernel Size** is a measure of the percentage by weight of large, medium and small kernels in a sample. Large kernels or more uniform kernel size may help improve milling yield.

**Single Kernel Characterization System (SKCS)** measures 300 individual kernels from a sample for size (diameter), weight, hardness (based on the force needed to crush) and moisture.

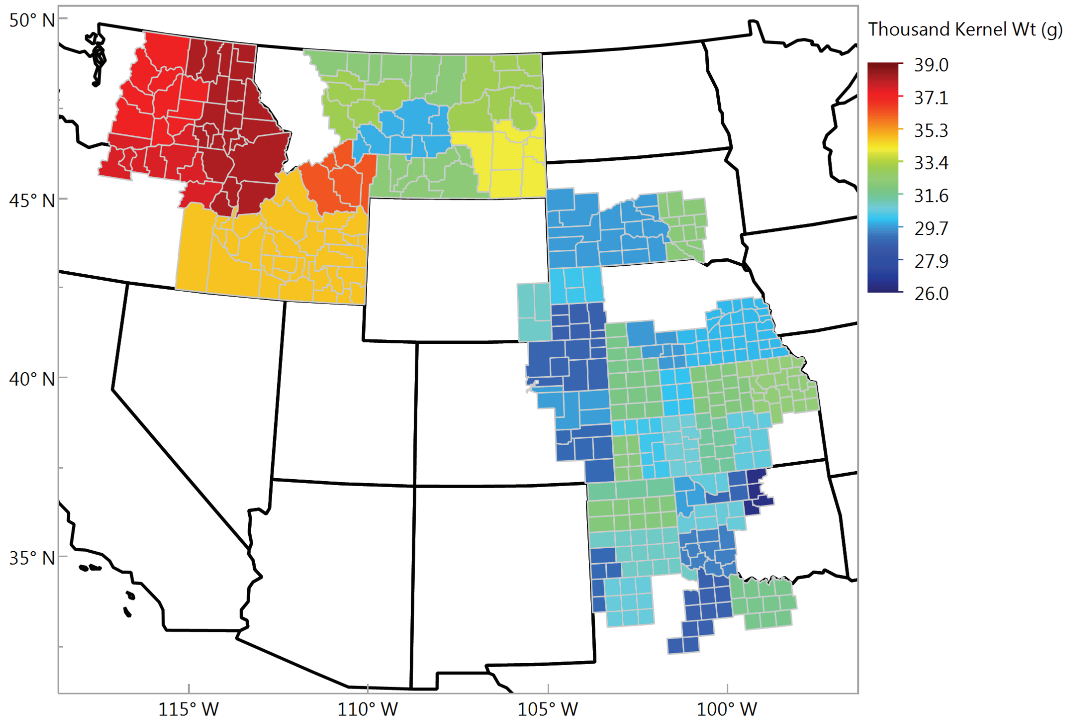
# Dockage (%)



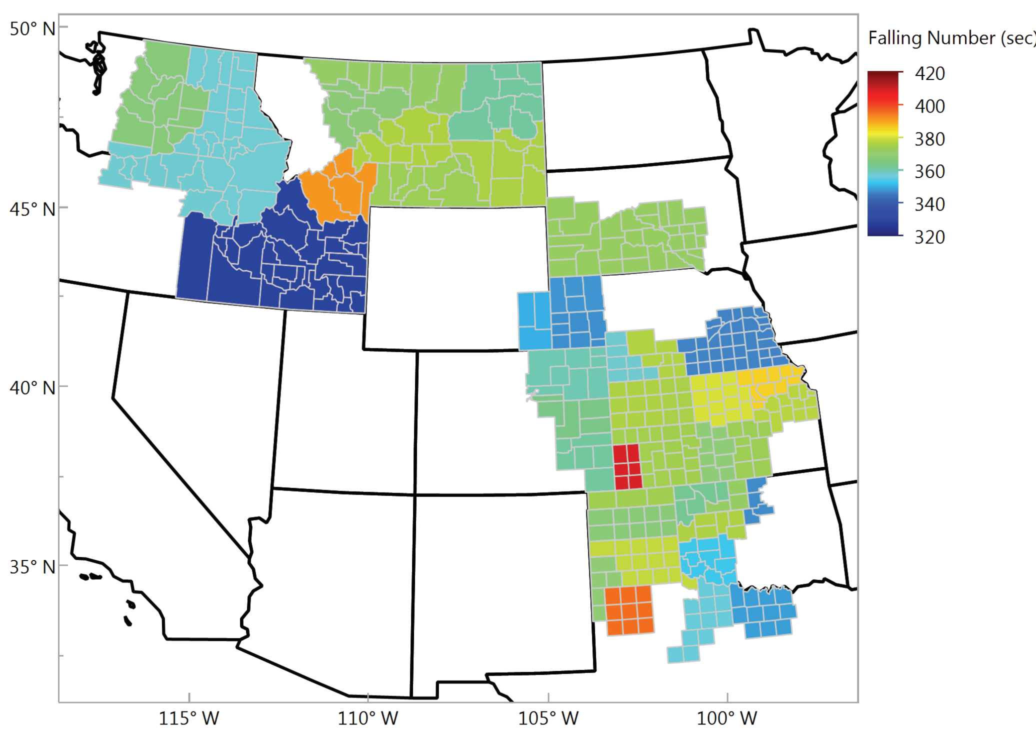

# Protein (%)



# Thousand Kernel Weight (g)




# Falling Number (seconds)



# Other Wheat Characteristics (non-grade data)

| Location | | Wheat Protein (12% mb) | Indv Wheat Ash (12% mb) | Falling Number (sec) | Moisture (%) | SKCS Avg Hard |
|---|---|---|---|---|---|---|
| Colorado | C01 | 10.4 | 1.50 | 362 | 9.5 | 57 |
| | C02 | 10.7 | 1.54 | 364 | 10.4 | 54 |
| | C03 | 10.6 | 1.57 | 360 | 10.4 | 58 |
| Kansas | K01 | 12.5 | 1.60 | 410 | 11.1 | 66 |
| | K02 | 11.9 | 1.60 | 374 | 11.3 | 61 |
| | K03 | 11.2 | 1.56 | 377 | 11.5 | 67 |
| | K04 | 11.4 | 1.54 | 369 | 11.6 | 68 |
| | K05 | 11.3 | 1.55 | 374 | 9.5 | 65 |
| | K06 | 11.6 | 1.57 | 377 | 11.0 | 50 |
| | K07 | 11.8 | 1.59 | 376 | 11.3 | 55 |
| | K08 | 11.5 | 1.53 | 381 | 11.3 | 50 |
| | K09 | 11.0 | 1.50 | 386 | 11.9 | 54 |
| | K10 | 11.2 | 1.50 | 378 | 11.3 | 52 |
| Montana | M01 | 11.4 | 1.41 | 374 | 8.8 | 70 |
| | M02 | 12.8 | 1.28 | 372 | 10.4 | 76 |
| | M03 | 12.0 | 1.35 | 368 | 9.6 | 73 |
| | M04 | 12.5 | 1.46 | 377 | 9.6 | 68 |
| | M05 | 9.8 | 1.40 | 362 | 9.4 | 66 |
| | M06 | 12.4 | 1.23 | 377 | 8.6 | 72 |
| | M07 | 13.4 | 1.28 | 392 | 9.7 | 74 |
| Nebraska | N01 | 10.9 | 1.55 | 348 | 10.9 | 62 |
| | N02 | 10.9 | 1.57 | 358 | 11.0 | 59 |
| | N03 | 11.6 | 1.61 | 377 | 11.8 | 60 |
| | N04 | 10.7 | 1.58 | 346 | 10.7 | 52 |
| | N05 | 10.4 | 1.56 | 348 | 10.8 | 64 |
| Oklahoma | O01 | 10.7 | 1.57 | 353 | 12.5 | 72 |
| | O02 | 10.9 | 1.59 | 377 | 12.5 | 70 |
| | O03 | 11.6 | 1.62 | 375 | 10.4 | 77 |
| | O04 | 11.2 | 1.57 | 363 | 10.9 | 72 |
| | O05 | 10.4 | 1.48 | 363 | 12.0 | 61 |
| | O06 | 11.1 | 1.50 | 372 | 12.5 | 66 |
| | O07 | 10.4 | 1.59 | 347 | 11.8 | 61 |
| Pacific Northwest | PNW01 | 12.0 | 1.41 | 367 | 8.7 | 69 |
| | PNW02 | 12.2 | 1.36 | 358 | 8.5 | 70 |
| | PNW03 | 10.4 | 1.38 | 358 | 8.0 | 66 |
| | PNW04 | 11.5 | 1.61 | 328 | 8.9 | 69 |
| South Dakota | SD01 | 13.2 | 1.67 | 373 | 10.3 | 62 |
| | SD02 | 13.3 | 1.63 | 372 | 11.1 | 63 |
| Texas | T01 | 11.9 | 1.56 | 397 | 10.1 | 74 |
| | T02 | 10.9 | 1.50 | 357 | 13.0 | 78 |
| | T03 | 11.4 | 1.65 | 351 | 13.1 | 56 |
| | T04 | 12.1 | 1.52 | 369 | 8.9 | 72 |
| | T05 | 11.8 | 1.54 | 379 | 10.2 | 74 |
| | T06 | 11.1 | 1.54 | 368 | 10.6 | 76 |
| Wyoming | W01 | 10.3 | 1.58 | 351 | 10.9 | 69 |

# Flour Characteristics

Flour is analyzed for indicators of milling efficiency and functionality properties. These include: flour yield, ash content, falling number and flour protein.

**Flour yield** is expressed as a percentage and represents the portion of the wheat kernel that can be milled into flour, which is a significant indicator of milling profitability. Millers need to know the mineral content in wheat to achieve the desired ash levels in flour.

**Ash content** is an indication of how well flour separates from the bran. Flour ash is expressed as a percentage of the initial sample weight, and is usually expressed on a 14 percent moisture basis.

**Flour falling number** is an index of undesirable enzyme activity that normally occurs when the kernel sprouts or germinates. A high falling number indicates minimal activity, whereas a low falling number indicates more substantial enzyme activity. Too much activity means that too much sugar and too little starch are present in the flour. Starch provides the supporting structure of bread, so high activity results in sticky dough and poor texture in the finished product.

**Wet Gluten Index** is a measurement that indicates whether the gluten is weak, normal or strong. A weak gluten would be represented by a gluten index of 0 and the strongest gluten index is 100.

**Minolta Color** results are reported with the values L*, a*, and b*. L* ranges from 100 (white) to 0 (black) a* ranges from +60 (red) to -60 (green) b* ranges from +60 (yellow) to -60 (blue).

# Flour Data

| Location | | Buhler Flour Yield (%) | Zeleny Sedimen Test (cc) | NIR Flour Protein (14% mb) | Flour Ash (14% mb) | Gluten Index | Flour Color L* | Flour Color a* | Flour Color b* |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | C01 | 78.7 | 40.4 | 9.6 | 0.64 | 96.8 | 90.6 | -1.2 | 10.2 |
| | C02 | 80.2 | 43.2 | 9.4 | 0.67 | 98.4 | 90.2 | -1.1 | 9.8 |
| | C03 | 79.3 | 44.2 | 9.7 | 0.67 | 97.3 | 90.2 | -1.1 | 10.2 |
| Kansas | K01 | 78.4 | 41.0 | 11.7 | 0.69 | 81.7 | 90.2 | -1.2 | 10.3 |
| | K02 | 79.4 | 44.1 | 11.3 | 0.69 | 92.4 | 89.5 | -1.1 | 10.4 |
| | K03 | 79.6 | 40.5 | 10.3 | 0.64 | 94.4 | 89.8 | -1.2 | 10.5 |
| | K04 | 80.3 | 39.3 | 10.4 | 0.63 | 85.6 | 89.9 | -1.2 | 10.7 |
| | K05 | 80.1 | 38.7 | 10.4 | 0.64 | 92.3 | 89.7 | -1.2 | 10.5 |
| | K06 | 79.5 | 39.8 | 10.5 | 0.65 | 92.9 | 89.8 | -1.0 | 10.1 |
| | K07 | 78.9 | 41.0 | 10.7 | 0.69 | 91.3 | 89.6 | -1.0 | 10.3 |
| | K08 | 79.8 | 39.0 | 10.4 | 0.67 | 92.7 | 89.7 | -1.1 | 10.1 |
| | K09 | 80.3 | 33.5 | 9.7 | 0.67 | 95.3 | 89.5 | -1.2 | 10.4 |
| | K10 | 79.7 | 36.9 | 10.2 | 0.66 | 95.0 | 89.7 | -1.1 | 10.2 |
| Montana | M01 | 75.7 | 44.8 | 10.3 | 0.54 | 97.5 | 90.1 | -1.1 | 10.2 |
| | M02 | 75.7 | 57.6 | 12.5 | 0.50 | 92.1 | 90.3 | -1.2 | 10.4 |
| | M03 | 74.7 | 47.0 | 11.1 | 0.55 | 95.1 | 90.2 | -1.2 | 10.7 |
| | M04 | 74.2 | 52.6 | 11.3 | 0.60 | 95.3 | 90.4 | -1.1 | 10.3 |
| | M05 | 76.2 | 48.5 | 10.9 | 0.53 | 92.4 | 90.4 | -1.3 | 10.3 |
| | M06 | 76.0 | 52.9 | 11.1 | 0.49 | 98.1 | 90.1 | -1.1 | 10.0 |
| | M07 | 74.9 | 49.6 | 12.2 | 0.56 | 87.1 | 89.8 | -1.1 | 10.8 |
| Nebraska | N01 | 75.5 | 42.1 | 10.3 | 0.67 | 97.1 | 89.8 | -0.9 | 10.2 |
| | N02 | 78.6 | 39.1 | 10.0 | 0.63 | 97.6 | 90.2 | -1.1 | 10.3 |
| | N03 | 79.6 | 35.7 | 10.6 | 0.68 | 95.0 | 89.4 | -0.9 | 10.2 |
| | N04 | 79.2 | 41.7 | 9.7 | 0.63 | 96.7 | 89.9 | -1.0 | 10.0 |
| | N05 | 75.9 | 36.8 | 9.2 | 0.62 | 96.8 | 90.3 | -1.3 | 10.2 |
| Oklahoma | O01 | 75.2 | 41.4 | 9.5 | 0.58 | 94.7 | 90.5 | -1.5 | 10.5 |
| | O02 | 78.0 | 41.5 | 9.8 | 0.62 | 94.6 | 90.2 | -1.4 | 10.7 |
| | O03 | 77.6 | 41.9 | 10.6 | 0.62 | 88.6 | 90.1 | -1.2 | 10.5 |
| | O04 | 79.5 | 39.6 | 10.5 | 0.66 | 89.3 | 89.9 | -1.1 | 10.4 |
| | O05 | 76.4 | 44.4 | 9.3 | 0.51 | 96.9 | 90.9 | -1.7 | 10.6 |
| | O06 | 80.7 | 38.2 | 10.3 | 0.65 | 93.2 | 89.1 | -1.1 | 10.6 |
| | O07 | 79.6 | 38.2 | 9.4 | 0.63 | 95.7 | 89.4 | -1.3 | 10.7 |
| Pacific Northwest | PNW01 | 77.7 | 45.5 | 11.4 | 0.58 | 97.2 | 89.8 | -0.9 | 9.8 |
| | PNW02 | 78.6 | 51.0 | 11.5 | 0.56 | 94.5 | 89.8 | -0.8 | 9.8 |
| | PNW03 | 77.9 | 42.5 | 10.2 | 0.57 | 97.5 | 89.9 | -0.8 | 9.8 |
| | PNW04 | 78.2 | 39.1 | 10.8 | 0.64 | 93.3 | 89.5 | -0.8 | 10.0 |
| South Dakota | SD01 | 75.4 | 56.5 | 12.3 | 0.63 | 92.1 | 90.0 | -0.8 | 9.4 |
| | SD02 | 75.7 | 58.6 | 13.3 | 0.64 | 87.4 | 89.7 | -0.9 | 9.1 |
| Texas | T01 | 79.0 | 46.9 | 11.0 | 0.64 | 92.9 | 89.4 | -1.0 | 10.1 |
| | T02 | 79.5 | 40.3 | 10.0 | 0.67 | 96.4 | 88.9 | -0.9 | 10.5 |
| | T03 | 78.8 | 45.6 | 9.8 | 0.65 | 91.6 | 89.9 | -1.1 | 10.2 |
| | T04 | 78.1 | 46.7 | 11.8 | 0.63 | 85.4 | 89.9 | -1.1 | 10.3 |
| | T05 | 77.8 | 45.5 | 10.6 | 0.61 | 92.0 | 90.4 | -1.2 | 10.1 |
| | T06 | 78.0 | 43.1 | 10.1 | 0.62 | 93.8 | 90.1 | -1.2 | 10.3 |
| Wyoming | W01 | 75.0 | 41.8 | 9.8 | 0.68 | 96.3 | 90.3 | -1.2 | 10.0 |

# Dough Characteristics

The strength and mixing properties of dough help the baker determine the value of the flour they purchase. Flour specifications often require specialized testing to determine how flour will perform during processing.

**Farinograph** testing is one of the most common flour quality tests in the world. Farinograph results are used to determine dough strength and processing requirements.

**Absorption** is a measurement of the amount of water required for the flour to be optimally processed into the finished product. Peak time indicates the time it takes for the dough to develop from the moment the water is added until maximum consistency is achieved. This measurement is expressed in minutes.

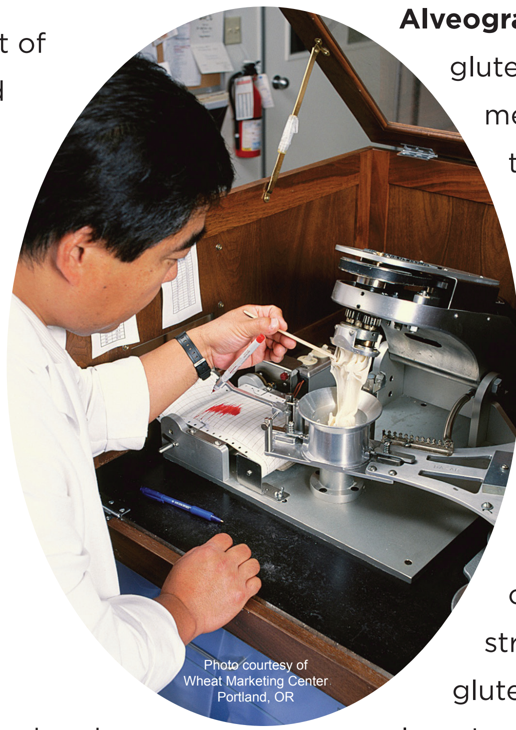


Photo courtesy of Wheat Marketing Center Portland, OR

**Stability** is an indication of dough strength, as it is a measurement of how long the dough maintains maximum consistency. Stability is also expressed in minutes. Weak gluten flour has a lower water absorption and shorter stability time than strong gluten flour.

**Peak time** represents dough development time by measuring the length of time from the moment water is added until the dough reaches maximum consistency. This measurement indicates optimum mixing time for the dough under standardized conditions.

**Mixing Tolerance Index** is the resistance of the dough to breakdown during continued mixing. It is the difference in Brabender Unit (BU) value at the top of the curve at peak time and the value at the top of the curve five minutes after the peak. This indicates tolerance to over-mixing and is expressed as a numerical score based on comparison to a control.

**Alveograph** testing determines the gluten strength of dough by measuring the force required to blow and break a bubble of dough. The results of the test are used by millers to ensure a more consistent product. "P" relates to the force required to blow the bubble of dough; "L" relates to the extensibility of the dough; "W" is a combination of dough strength and extensibility. Weak gluten flour with low P value and long L value is preferred for cakes, where as strong gluten flour used for breads will have a higher P value.

**Development Time** is the time interval from the first addition of water to the maximum consistency immediately prior to the first indication of weakening. Long peak times indicate strong gluten and dough properties while short peak times may indicate weak gluten.

# Dough Data

PGI

| Location | | ALVEOGRAPH | | | | FARINOGRAPH | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | | P (mm) | L (mm) | W (10-4 J) | P/L Ratio | Abs (14%mb) | Development Time (min) | Stability (min) | MTI (BU) |
| Colorado | C01 | 72 | 86 | 196 | 0.84 | 55.9 | 4.5 | 7.5 | 38.0 |
| | C02 | 70 | 76 | 178 | 0.92 | 55.6 | 4.7 | 7.7 | 39.0 |
| | C03 | 73 | 79 | 181 | 0.92 | 56.9 | 4.2 | 6.1 | 52.0 |
| Kansas | K01 | 94 | 70 | 211 | 1.34 | 62.2 | 4.4 | 6.1 | 34.0 |
| | K02 | 75 | 89 | 186 | 0.84 | 60.2 | 4.8 | 5.3 | 44.8 |
| | K03 | 81 | 69 | 175 | 1.17 | 59.9 | 4.2 | 5.1 | 54.3 |
| | K04 | 83 | 69 | 170 | 1.20 | 61.1 | 4.2 | 4.0 | 59.0 |
| | K05 | 83 | 72 | 184 | 1.15 | 59.9 | 5.0 | 5.4 | 56.5 |
| | K06 | 71 | 75 | 165 | 0.94 | 58.4 | 4.4 | 5.9 | 47.8 |
| | K07 | 73 | 81 | 173 | 0.91 | 59.3 | 4.6 | 6.0 | 40.9 |
| | K08 | 75 | 73 | 169 | 1.03 | 58.5 | 4.3 | 5.4 | 55.4 |
| | K09 | 77 | 66 | 169 | 1.17 | 57.5 | 4.0 | 6.0 | 53.0 |
| | K10 | 82 | 66 | 177 | 1.23 | 58.5 | 3.9 | 6.6 | 44.8 |
| Montana | M01 | 114 | 45 | 209 | 2.53 | 61.6 | 2.9 | 6.3 | 29.0 |
| | M02 | 100 | 79 | 273 | 1.27 | 64.4 | 6.0 | 7.9 | 30.0 |
| | M03 | 110 | 57 | 232 | 1.92 | 62.0 | 5.2 | 7.0 | 37.0 |
| | M04 | 98 | 69 | 249 | 1.42 | 62.0 | 5.3 | 10.5 | 23.3 |
| | M05 | 99 | 72 | 246 | 1.38 | 61.6 | 4.8 | 6.4 | 40.0 |
| | M06 | 101 | 69 | 265 | 1.46 | 61.9 | 5.5 | 8.7 | 32.0 |
| | M07 | 109 | 55 | 219 | 1.98 | 64.4 | 5.1 | 5.7 | 46.0 |
| Nebraska | N01 | 81 | 71 | 189 | 1.14 | 58.4 | 4.6 | 5.8 | 44.5 |
| | N02 | 79 | 63 | 176 | 1.25 | 57.7 | 4.0 | 7.0 | 35.0 |
| | N03 | 78 | 71 | 178 | 1.09 | 58.6 | 5.1 | 6.4 | 49.7 |
| | N04 | 80 | 63 | 179 | 1.27 | 57.1 | 2.4 | 5.7 | 36.1 |
| | N05 | 91 | 58 | 187 | 1.57 | 58.6 | 4.6 | 7.1 | 40.0 |
| Oklahoma | O01 | 90 | 70 | 209 | 1.29 | 60.4 | 4.8 | 6.2 | 52.0 |
| | O02 | 101 | 56 | 200 | 1.80 | 61.4 | 5.3 | 6.7 | 44.0 |
| | O03 | 96 | 68 | 214 | 1.41 | 62.0 | 4.8 | 5.6 | 48.7 |
| | O04 | 78 | 68 | 160 | 1.14 | 61.2 | 4.3 | 4.2 | 53.6 |
| | O05 | 78 | 84 | 210 | 0.93 | 58.7 | 2.5 | 7.1 | 31.0 |
| | O06 | 76 | 65 | 151 | 1.17 | 60.5 | 4.1 | 4.4 | 54.8 |
| | O07 | 64 | 76 | 139 | 0.84 | 57.8 | 4.2 | 4.9 | 60.0 |
| Pacific Northwest | PNW01 | 106 | 76 | 271 | 1.39 | 62.8 | 4.0 | 6.8 | 31.0 |
| | PNW02 | 108 | 70 | 261 | 1.54 | 63.4 | 5.2 | 6.9 | 39.0 |
| | PNW03 | 110 | 52 | 215 | 2.12 | 61.5 | 4.0 | 5.6 | 49.0 |
| | PNW04 | 108 | 54 | 213 | 2.00 | 62.7 | 5.0 | 5.7 | 43.0 |
| South Dakota | SD01 | 94 | 83 | 257 | 1.13 | 62.4 | 7.2 | 7.6 | 34.0 |
| | SD02 | 100 | 80 | 261 | 1.25 | 64.0 | 6.0 | 6.8 | 32.0 |
| Texas | T01 | 109 | 65 | 226 | 1.68 | 63.8 | 4.4 | 4.7 | 55.1 |
| | T02 | 109 | 47 | 192 | 2.32 | 61.6 | 5.7 | 7.4 | 37.0 |
| | T03 | 100 | 56 | 199 | 1.79 | 60.5 | 4.3 | 5.8 | 49.0 |
| | T04 | 91 | 78 | 205 | 1.17 | 63.2 | 4.0 | 3.9 | 50.5 |
| | T05 | 101 | 64 | 215 | 1.57 | 62.9 | 3.7 | 5.1 | 41.4 |
| | T06 | 112 | 51 | 208 | 2.20 | 62.9 | 4.5 | 4.9 | 54.0 |
| Wyoming | W01 | 86 | 73 | 204 | 1.18 | 59.0 | 4.0 | 6.8 | 35.5 |

# Baking Characteristics

Baking tests are the final laboratory testing method in the evaluation of wheat quality. Generally, the amount and type of protein present determines baking performance, though starch quality can also have an influence.

Technicians evaluate loaves for their volume, or size, and the interior appearance of the loaf such as crumb grain and crumb color. Other performance factors include dough absorption, or bake absorption, and the optimum mixing time of the dough.

**Baking Absorption** is the amount of water added to achieve properly hydrated dough. It is expressed as a percentage, with higher values being better.

**Crumb Grain and Texture** measures the cell size and shape. It is rated on a scale of one to 10 and higher numbers are preferred.

**Bake Mix Time** represents mixing time when all normal ingredients are added for producing an end product (in addition to water and flour) prior to baking.

# Baking Data

| Location | | Bake Mix (min) | Bake Abs (14% mb) | Loaf Volume (cc) | Crumb Grain (1–10) | Crumb Texture (1–10) | Crumb Color |
|---|---|---|---|---|---|---|---|
| Colorado | C01 | 6.0 | 62.0 | 760 | 6.3 | 7.0 | Dull |
| | C02 | 6.4 | 61.8 | 775 | 6.3 | 5.5 | Dull |
| | C03 | 6.0 | 61.9 | 715 | 4.8 | 7.0 | Dull |
| Kansas | K01 | 3.8 | 63.6 | 865 | 6.5 | 6.0 | Dull |
| | K02 | 4.2 | 62.7 | 854 | 6.7 | 6.1 | Dull |
| | K03 | 4.7 | 61.8 | 802 | 6.5 | 6.5 | Dull |
| | K04 | 4.3 | 62.0 | 770 | 5.5 | 5.5 | Dull |
| | K05 | 4.8 | 62.9 | 798 | 5.9 | 5.5 | Dull |
| | K06 | 4.8 | 61.8 | 802 | 7.0 | 7.0 | Dull |
| | K07 | 4.4 | 61.9 | 847 | 6.5 | 7.0 | Dull |
| | K08 | 4.5 | 62.1 | 806 | 5.2 | 6.0 | Dull |
| | K09 | 5.1 | 60.2 | 765 | 6.3 | 7.0 | Dull |
| | K10 | 5.3 | 61.3 | 791 | 6.3 | 7.0 | Dull |
| Montana | M01 | 6.4 | 62.3 | 785 | 4.8 | 7.0 | Dull |
| | M02 | 4.5 | 65.0 | 905 | 6.3 | 7.0 | Dull |
| | M03 | 4.9 | 64.1 | 807 | 5.3 | 7.0 | Dull |
| | M04 | 5.7 | 62.4 | 798 | 6.5 | 6.0 | Dull |
| | M05 | 5.1 | 63.8 | 795 | 8.5 | 7.0 | Dull |
| | M06 | 5.5 | 64.6 | 835 | 8.5 | 7.0 | Dull |
| | M07 | 4.8 | 63.3 | 783 | 5.5 | 7.0 | Dull |
| Nebraska | N01 | 5.7 | 62.3 | 810 | 6.3 | 6.3 | Dull |
| | N02 | 5.9 | 62.6 | 810 | 7.0 | 7.0 | Dull |
| | N03 | 5.3 | 61.8 | 800 | 6.3 | 7.0 | Dull |
| | N04 | 6.2 | 60.9 | 783 | 6.8 | 6.5 | Dull |
| | N05 | 6.4 | 60.1 | 835 | 4.0 | 7.0 | Dull |
| Oklahoma | O01 | 4.4 | 62.2 | 795 | 6.3 | 7.0 | Dull |
| | O02 | 4.4 | 63.7 | 785 | 4.0 | 7.0 | Dull |
| | O03 | 4.2 | 63.8 | 850 | 8.0 | 7.5 | Dull |
| | O04 | 3.8 | 62.3 | 795 | 7.0 | 5.8 | Dull |
| | O05 | 5.3 | 62.3 | 810 | 7.0 | 7.0 | Dull |
| | O06 | 4.1 | 63.0 | 805 | 6.3 | 6.4 | Dull |
| | O07 | 4.0 | 61.2 | 780 | 6.3 | 5.5 | Dull |
| Pacific Northwest | PNW01 | 5.3 | 64.6 | 810 | 7.8 | 7.0 | Dull |
| | PNW02 | 5.1 | 64.8 | 805 | 7.0 | 7.0 | Dull |
| | PNW03 | 5.5 | 63.6 | 740 | 7.0 | 7.0 | Dull |
| | PNW04 | 5.0 | 63.6 | 760 | 7.0 | 7.0 | Dull |
| South Dakota | SD01 | 4.4 | 64.8 | 720 | 8.5 | 7.0 | Dull |
| | SD02 | 4.0 | 65.3 | 920 | 8.5 | 8.5 | Dull |
| Texas | T01 | 4.0 | 63.5 | 803 | 6.0 | 6.5 | Dull |
| | T02 | 5.0 | 62.6 | 765 | 4.0 | 5.5 | Dull |
| | T03 | 4.5 | 62.7 | 760 | 4.8 | 5.5 | Dull |
| | T04 | 3.4 | 63.5 | 830 | 6.7 | 7.8 | Dull |
| | T05 | 4.1 | 63.9 | 812 | 7.7 | 7.8 | Dull |
| | T06 | 4.5 | 64.7 | 780 | 7.0 | 7.0 | Dull |
| Wyoming | W01 | 5.4 | 61.9 | 810 | 7.0 | 7.0 | Dull |

# Methods

## The harvest samples were evaluated using these methods:

**Grade**: Official U.S. Standards for Grain.

**Dockage**: Official USDA procedure using the Carter Dockage Tester.

**Test Weight**: AACC Method 55-10; the weight Per Winchester Bushel (2150.42 in3) as determined using an approved device, USDA approved. The test weight is mathematically converted to hectoliter weight: kg/hl = lb/bu x 1.292 + 1.419.

**Moisture**: DJ Gac 2100.

**Protein**: NIRT method

**Ash**: AACC Method 08-01 expressed on a 14 percent moisture basis.

**Falling Number**: AACC Method 56-81B. An average value is a simple mean of sample results.

**Kernel Size Distribution**: Cereal Foods World (Cereal Science Today) 5:71-71, 75 (1960). Wheat  is sifted with a RoTap sifter using a Tyler No. 7 screen (2.82 mm) and a Tyler No. 9 Screen (2.00 mm). Kernels retained on the No. 7 screen are classified as “Large.” Kernels passing through the No. 7 screen and retained on the No. 9 screen are “Medium.” Kernels passing through the No. 9 screen are “Small”.

**Single Kernel Characterization**: AACC Method 55-31 using SKCS Model 4100.

**Extraction**: Samples cleaned and tempered according to AACC Method 26-10A. All were milled with identical mill settings on a Buhler laboratory mill as follows: AACC Method 26-21A.

**Moisture**: NIR Protein: NIR Ash: AACC Method 08-01 expressed on a 14 percent moisture basis.

**Falling Number**: AACC Method 56-81B.

**Wet Gluten & Gluten Index**: AACC Method 38-12

**Farinograph:** AACC Method 54-21 with 50-gram bowl.

**Absorption** is reported on 14 percent moisture basis.

**Alveograph**: AACC Method 54-30A.

**Loaf Volume:** AACC Method 10-10B producing two loaves per batch using wet compressed yeast and ascorbic acid. After mixing, dough is divided into two equal portions, fermented for 160 minutes, proofed and baked in “pup loaf” pans. Loaf volume is measured immediately after baking by rapeseed displacement.