PGI

Plains Grains Inc.

# 2013 Hard Red Winter Wheat Regional Quality Survey

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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 Committe
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.

PGI

Plains Grains Inc.

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 subscribed to the PGI crop quality survey in 2006.

Visit our web site 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 antioxidants 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 2009 crop year.

**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.

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

This fall seeded wheat is a versatile wheat with moderatly high protein content and excellent milling and baking characteristicsD. 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*

Planting dates and crop conditions (especially early spring through grain maturity) for the 2013 HRW crop were again highly variable across the production region, as were the previous 2 crops. Generally, planting conditions and emergence were delayed in all areas due to an ongoing drought in all production areas with the exception of the Pacific Northwest. The drought of 2011 and 2012 spread northward out of the southern Great Plains into the central Plains and parts of Montana. Timely moisture extending from central Texas through central Nebraska during later stages of plant development helped boost final yields in those areas of Texas, Oklahoma, Kansas and Nebraska. However, the drought persisted in most areas of western Texas, eastern Colorado, western Nebraska, Wyoming and all of South Dakota.

Montana found some drought relief during the spring and summer, but that precipitation was accompanied by large areas of severe weather and hail during multiple storms. As a result, losses due to these storms were reported in many wheat producing areas of Montana ranging in magnitude from 30% to 50% of the crop. Many areas of northern Montana also experienced below normal temperatures during the final stages of maturity which significantly delayed HRW harvest.

Overall, these conditions significantly affected not only the final yield from all production regions (below average), but also had an impact on kernel characteristics and quality. Generally, kernels were smaller with lower test weight and thousand kernel weight when considering 2012 or the 5-year average. In contrast, overall protein in wheat and flour significantly exceeded last year and the 5-year average.

## *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. 534 samples were collected from grain elevators when at least 30% of the local harvest was completed in the 12 states of Texas, Oklahoma, Kansas, Colorado, Nebraska, Wyoming, South Dakota, North Dakota, Montana, Washington, Oregon and Idaho.

Official grade and non-grade parameters were determined on each sample. 68 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 each of the 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 12 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 2013 HRW crop official grade averaged 49% Grade #1 (Gulf tributary averaging 45% and PNW tributary averaging 56%) when considering all protein levels and weighting for the production. The overall dockage level of 0.6% was slightly above last year's average and the 5-year average of 0.5%.. Total defects of 2.0% are significantly above last year's average of 1.4% and 5-year average of 1.5%. The increase can be attributed to the large area of adverse weather conditions that existed during final the final stages of crop maturity. Foreign material, shrunken

and broken, and wheat ash contents were also equal to or exceeding the 5-year average for the same reason. Overall test weight averaged 59.9 lbs/bu (78.8 kg/hl) which is below the 5-year average of 60.8 lbs/bu (79.9 kg/hl) and below the 2012 average of 61.1 lbs/bu (80.4 kg/hl). The overall average thousand kernel weight of 26.0 g is significantly lower than the 2012 average of 29.0 g and the 5-year average of 29.8 g. Average kernel diameter of 2.50 mm was also smaller than the 2012 average of 2.60 mm, but similar to the 5-year average of 2.55 mm. The kernel characteristics were generally uniform across the production region. The average protein of 13.4% is almost a full point above the 2012 average of 12.6% and over a full percentage point above the 5-year average of 12.2%. Protein content splits across the testing region and tributaries were very consistent with approximately 15% of samples being in the < 11.5% protein content category, 25% in the 11.5% – 12.5% category and 60% in the < 12.5% category. Average falling number for this crop was 421 sec, comparable to the 5-year average of 414 sec and indicative of sound wheat.

## *Flour and Baking Data*

The Buhler flour yield overall averaged (76.1%), and while above the 2012 average of 75.2% and significantly above the 5-year average, the difference in the 5-year average is mostly attributable to the instillation of a new tandem Buhler Experimental mill used for testing. The resulting flour ash contents, while higher than desired, are still within acceptable ranges. Protein loss during flour conversion averaged 1.1% (when wheat is converted to 14% mb), this was below the 5-year average of 1.3%. Gluten index values averaged 93.3% which was lower than the 5-year average of 95.1%. The W value of 250 (10-4 J) was comparable to 2012 and the 5-year average. Overall average water absorption (WA) was 59.8% which was higher than the 2012 absorption of 58.9% and is significantly higher than the 5-year average of 57.9%. Farinograph development time and stability were 5.6 min and 12.3 min respectively, and were comparable to 2012 and the 5-year average. Overall loaf volume averaged 860 cc, this was significantly higher than in 2012 (789 cc) and the 5 year average of 804 cc. When evaluating gluten index, W value, water absorption, development time, stability and loaf volume, it would appear there is protein quantity and quality present in the 2013 HRW crop.

## *Summary*

This year's crop can be characterized as one with very good wheat protein that translates into high flour protein which has functionality. Water absorption and loaf volumes are very good and significantly exceed long-term averages. Kernel characteristics are average to slightly below average, but are still well within traditional typical HRW contract specs.

# Hard Red Winter Wheat Production Charts

## English Units

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

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 39,900 | 94,000 | 57,000 | 98,000 | 105,750 | 78,000 | 83,250 | 43,500 | 74,925 |
| Kansas | 291,200 | 283,800 | 356,000 | 369,600 | 360,000 | 276,500 | 387,000 | 328,000 | 331,513 |
| Montana | 82,560 | 83,220 | 94,380 | 89,540 | 93,600 | 89,790 | 81,320 | 96,750 | 88,895 |
| North Dakota | 7,920 | 22,250 | 22,550 | 26,160 | 17,600 | 13,875 | 38,500 | 13,440 | 20,287 |
| Nebraska | 61,200 | 84,280 | 73,480 | 76,800 | 64,070 | 65,250 | 55,440 | 41,760 | 65,285 |
| Oklahoma | 81,600 | 98,000 | 166,500 | 77,000 | 120,900 | 70,400 | 155,400 | 115,500 | 110,663 |
| Pacific NW | 19,368 | 17,841 | 16,246 | 16,194 | 19,869 | 22,004 | 37,990 | 35,330 | 23,105 |
| South Dakota | 41,400 | 95,040 | 103,950 | 64,260 | 63,700 | 66,780 | 62,400 | 25,350 | 65,360 |
| Texas | 33,600 | 140,600 | 99,000 | 61,250 | 127,500 | 49,400 | 91,450 | 64,000 | 83,350 |
| Wyoming | 3,645 | 3,250 | 3,780 | 5,016 | 4,640 | 4,420 | 3,000 | 2,640 | 3,799 |
| Regional Total | 662,393 | 922,281 | 992,886 | 883,820 | 977,629 | 736,419 | 995,750 | 766,270 | 867,181 |

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

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 1,900 | 2,350 | 1,900 | 2,450 | 2,350 | 2,000 | 2,250 | 1,500 | 2,088 |
| Kansas | 9,100 | 8,600 | 8,900 | 8,800 | 8,000 | 7,900 | 9,000 | 8,200 | 8,563 |
| Montana | 1,920 | 2,190 | 2,420 | 2,420 | 1,950 | 2,190 | 2,140 | 2,150 | 2,173 |
| North Dakota | 180 | 445 | 550 | 545 | 320 | 375 | 700 | 320 | 429 |
| Nebraska | 1,700 | 1,960 | 1,670 | 1,600 | 1,490 | 1,450 | 1,320 | 1,160 | 1,544 |
| Oklahoma | 3,400 | 3,500 | 4,500 | 3,500 | 3,900 | 3,200 | 4,200 | 3,500 | 3,713 |
| Pacific NW | 299 | 294 | 258 | 276 | 289 | 293 | 535 | 530 | 347 |
| South Dakota | 1,150 | 1,980 | 1,890 | 1,530 | 1,300 | 1,590 | 1,300 | 650 | 1,424 |
| Texas | 1,400 | 3,800 | 3,300 | 2,450 | 3,750 | 1,900 | 2,950 | 2,000 | 2,694 |
| Wyoming | 135 | 125 | 135 | 132 | 145 | 130 | 120 | 120 | 130 |
| Regional Total | 21,184 | 25,244 | 25,523 | 23,703 | 23,494 | 21,028 | 24,515 | 20,130 | 23,103 |

### Hard Winter Wheat Yield (bu/ac)

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Colorado | 21 | 40 | 30 | 40 | 45 | 39 | 37 | 29 | 35 |
| Kansas | 32 | 33 | 40 | 42 | 45 | 45 | 43 | 40 | 40 |
| Montana | 43 | 38 | 39 | 37 | 48 | 41 | 38 | 45 | 41 |
| North Dakota | 44 | 50 | 41 | 48 | 55 | 37 | 55 | 42 | 47 |
| Nebraska | 36 | 43 | 44 | 48 | 43 | 45 | 42 | 36 | 42 |
| Oklahoma | 24 | 28 | 37 | 22 | 31 | 22 | 37 | 33 | 29 |
| Pacific NW | 60 | 59 | 57 | 58 | 68 | 76 | 75 | 68 | 65 |
| South Dakota | 36 | 48 | 55 | 42 | 49 | 42 | 48 | 39 | 45 |
| Texas | 24 | 37 | 30 | 25 | 34 | 26 | 31 | 32 | 30 |
| Wyoming | 27 | 26 | 28 | 38 | 32 | 34 | 25 | 22 | 29 |
| Regional Total | 35 | 40 | 40 | 40 | 45 | 41 | 43 | 39 | 40 |

*** Some data derived from Crop Production report issued by USDA NASS updated September 30, 2013.*

# Hard Red Winter Wheat Production Charts

## Metric Units

| Hard Winter Wheat Production (MMT) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Average |
| Colorado | 1.09 | 2.56 | 1.55 | 2.67 | 2.88 | 2.12 | 2.27 | 1.18 | 2.04 |
| Kansas | 7.93 | 7.72 | 9.69 | 10.06 | 9.80 | 7.53 | 10.53 | 8.93 | 9.02 |
| Montana | 2.25 | 2.27 | 2.57 | 2.44 | 2.55 | 2.44 | 2.21 | 2.63 | 2.42 |
| North Dakota | 0.22 | 0.61 | 0.61 | 0.71 | 0.48 | 0.38 | 1.05 | 0.37 | 0.55 |
| Nebraska | 1.67 | 2.29 | 2.00 | 2.09 | 1.74 | 1.78 | 1.51 | 1.14 | 1.78 |
| Oklahoma | 2.22 | 2.67 | 4.53 | 2.10 | 3.29 | 1.92 | 4.23 | 3.14 | 3.01 |
| Pacific NW | 0.53 | 0.49 | 0.44 | 0.44 | 0.54 | 0.60 | 1.03 | 0.96 | 0.63 |
| South Dakota | 1.13 | 2.59 | 2.83 | 1.75 | 1.73 | 1.82 | 1.70 | 0.69 | 1.78 |
| Texas | 0.91 | 3.83 | 2.69 | 1.67 | 3.47 | 1.34 | 2.49 | 1.74 | 2.27 |
| Wyoming | 0.10 | 0.09 | 0.10 | 0.14 | 0.13 | 0.12 | 0.08 | 0.07 | 0.10 |
| Regional Total | 18.03 | 25.10 | 27.02 | 24.06 | 26.61 | 20.04 | 27.10 | 20.86 | 23.60 |

| Hard Winter Wheat Harvested Acres (1,000 ha) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Average |
| Colorado | 769 | 951 | 769 | 992 | 951 | 810 | 911 | 607 | 845 |
| Kansas | 3,684 | 3,482 | 3,603 | 3,563 | 3,239 | 3,198 | 3,644 | 3,320 | 3,467 |
| Montana | 777 | 887 | 980 | 980 | 789 | 887 | 866 | 870 | 880 |
| North Dakota | 73 | 180 | 223 | 221 | 130 | 152 | 283 | 130 | 174 |
| Nebraska | 688 | 794 | 676 | 648 | 603 | 587 | 534 | 470 | 625 |
| Oklahoma | 1,377 | 1,417 | 1,822 | 1,417 | 1,579 | 1,296 | 1,700 | 1417 | 1,503 |
| Pacific NW | 121 | 119 | 104 | 112 | 117 | 119 | 217 | 215 | 140 |
| South Dakota | 466 | 802 | 765 | 619 | 526 | 644 | 526 | 263 | 576 |
| Texas | 567 | 1,538 | 1,336 | 992 | 1,518 | 769 | 1,194 | 810 | 1,091 |
| Wyoming | 55 | 51 | 55 | 53 | 59 | 53 | 49 | 49 | 53 |
| Regional Total | 8,577 | 10,220 | 10,333 | 9,596 | 9,512 | 8,513 | 9,925 | 8,150 | 9,353 |

| Hard Winter Wheat Yield (tons/ha) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Average |
| Colorado | 1.41 | 2.69 | 2.02 | 2.69 | 3.03 | 2.62 | 2.49 | 1.95 | 2.36 |
| Kansas | 2.15 | 2.22 | 2.69 | 2.82 | 3.03 | 3.03 | 2.89 | 2.69 | 2.69 |
| Montana | 2.89 | 2.56 | 2.62 | 2.49 | 3.23 | 2.76 | 2.56 | 3.03 | 2.77 |
| North Dakota | 2.96 | 3.36 | 2.76 | 3.23 | 3.70 | 2.49 | 3.70 | 2.82 | 3.13 |
| Nebraska | 2.42 | 2.89 | 2.96 | 3.23 | 2.89 | 3.03 | 2.82 | 2.42 | 2.83 |
| Oklahoma | 1.61 | 1.88 | 2.49 | 1.48 | 2.08 | 1.48 | 2.49 | 2.22 | 1.97 |
| Pacific NW | 4.04 | 3.97 | 3.83 | 3.90 | 4.57 | 5.11 | 5.04 | 4.57 | 4.38 |
| South Dakota | 2.42 | 3.23 | 3.70 | 2.82 | 3.30 | 2.82 | 3.23 | 2.62 | 3.02 |
| Texas | 1.61 | 2.49 | 2.02 | 1.68 | 2.29 | 1.75 | 2.08 | 2.15 | 2.01 |
| Wyoming | 1.82 | 1.75 | 1.88 | 2.56 | 2.15 | 2.29 | 1.68 | 1.48 | 1.95 |
| Regional Average | 2.33 | 2.70 | 2.70 | 2.69 | 3.03 | 2.74 | 2.90 | 2.60 | 2.71 |

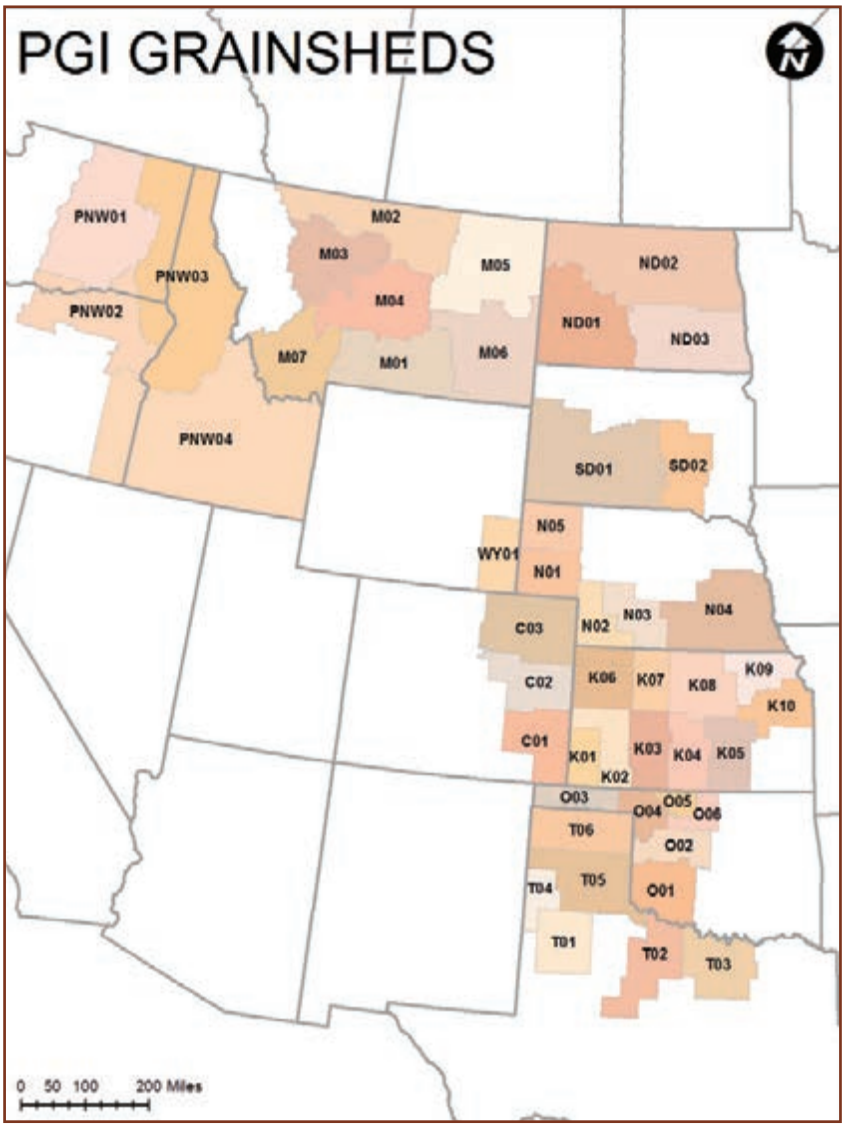
*** Some data derived from Crop Production report issued by USDA NASS updated September 30, 2013.*

# 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, Kan., 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 |
| Foregin 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 |
| Unkown Foregin 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 obkectionable foregin odor (except smut or garlic); or

(c) Is heating or of distinctly low quality.

*Includes damaged kernels (total), foregin materials, and shurken 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 forgin 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.

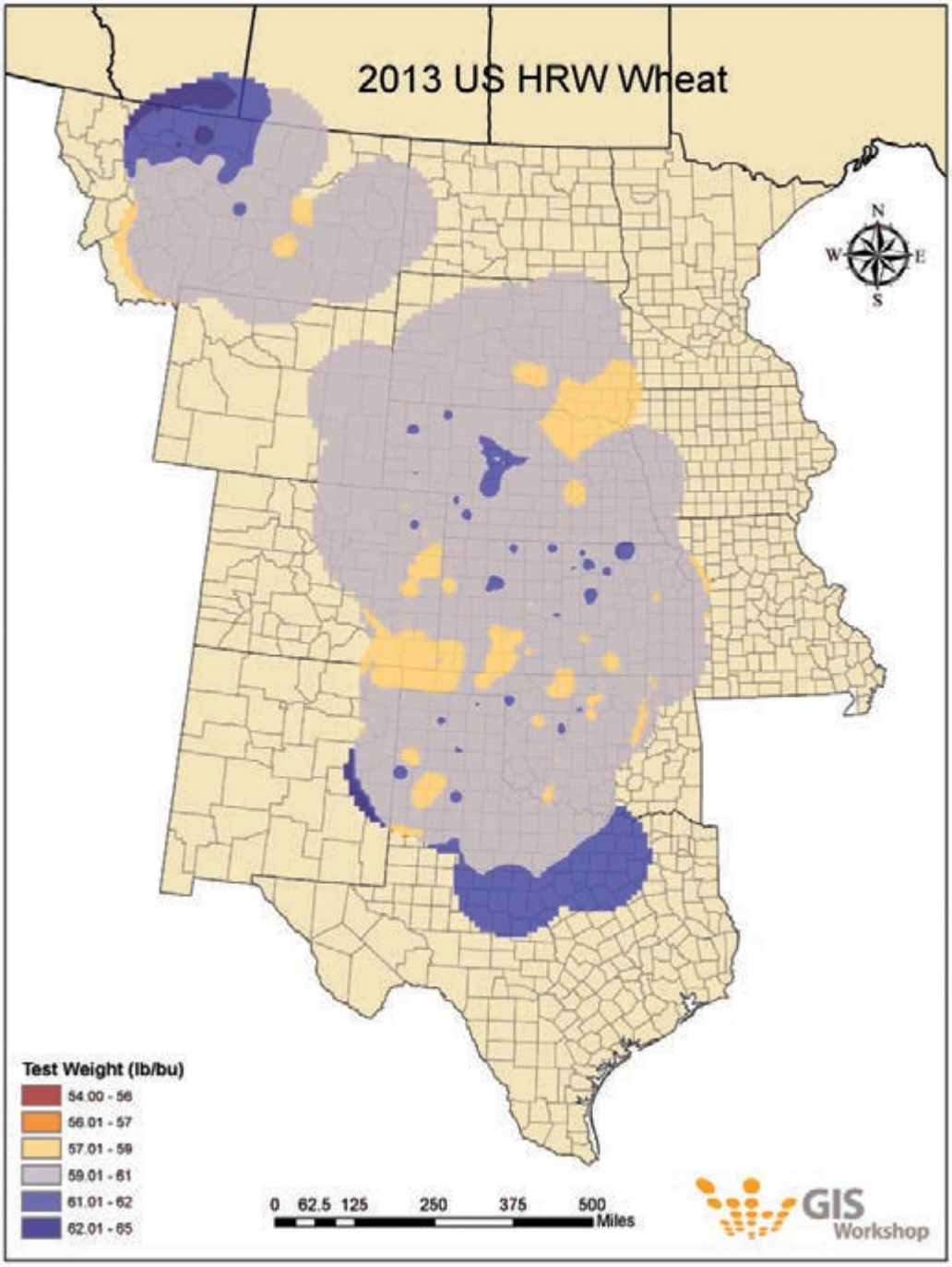
**Foreign material** is all matter other than wheat that remains in the sample after the removal of dockage and shrunken and broken kernels.

**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.

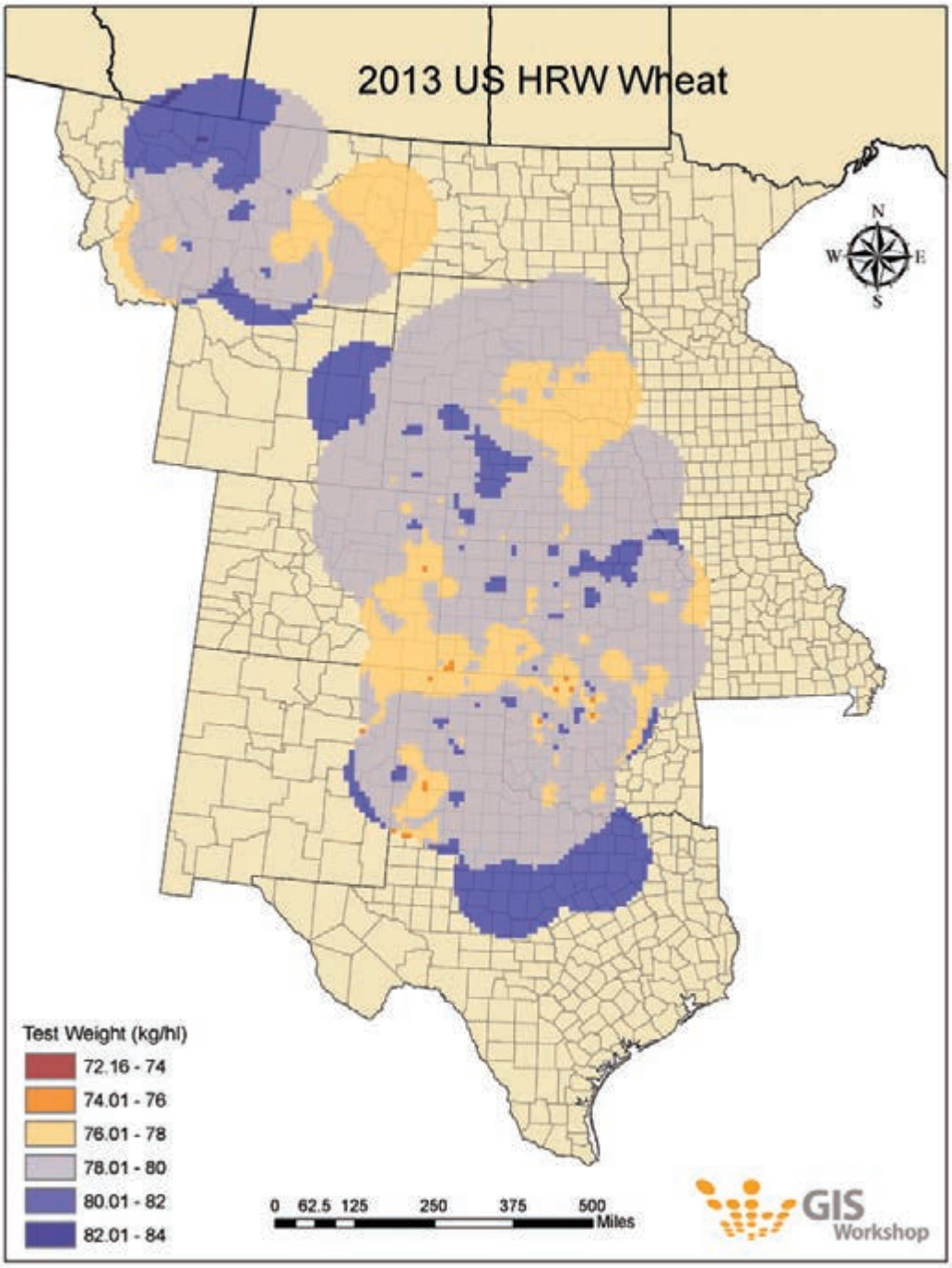
**Damaged kernels** are kernels, pieces of wheat kernels, and other grains that are badly ground-damaged, badly weatherdamaged, diseased, frost-damaged, germdamaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged, or otherwise materially damaged.

**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.) | Test Wt (lb/bu) | Test Wt (kg/hl) | Dockage (%) | Damage Kernels Total (%) | Shrunken & Broken Kernels (%) | Total Defects (%) |
|---|---|---|---|---|---|---|---|---|
| Colorado | C01 | 2 | 59.2 | 77.9 | 0.4 | 0.0 | 1.2 | 1.3 |
| | C02 | 2 | 59.3 | 78.0 | 0.6 | 0.1 | 1.7 | 1.9 |
| | C03 | 2 | 59.9 | 78.8 | 0.5 | 0.1 | 1.6 | 1.9 |
| Kansas | K01 | 2 | 59.7 | 78.6 | 1.0 | 0.2 | 2.6 | 2.9 |
| | K02 | 2 | 59.3 | 78.1 | 0.4 | 0.2 | 1.8 | 2.0 |
| | K03 | 2 | 59.5 | 78.3 | 0.4 | 0.1 | 2.1 | 2.3 |
| | K04 | 1 | 60.1 | 79.0 | 0.4 | 0.1 | 1.9 | 2.3 |
| | K05 | 2 | 59.4 | 78.2 | 0.9 | 0.2 | 2.1 | 2.5 |
| | K06 | 1 | 60.3 | 79.3 | 0.5 | 0.2 | 1.6 | 1.9 |
| | K07 | 1 | 60.3 | 79.4 | 0.3 | 0.3 | 1.6 | 2.0 |
| | K08 | 1 | 60.8 | 80.0 | 0.5 | 0.2 | 1.4 | 1.7 |
| | K09 | 1 | 61.3 | 80.6 | 0.1 | 0.1 | 1.1 | 1.2 |
| | K10 | 1 | 60.0 | 79.0 | 1.0 | 0.7 | 1.2 | 2.0 |
| Montana | M01 | 2 | 59.8 | 78.6 | 0.9 | 0.0 | 1.4 | 1.5 |
| | M02 | 1 | 61.6 | 81.0 | 0.6 | 0.1 | 1.0 | 1.2 |
| | M03 | 1 | 60.9 | 80.2 | 0.7 | 0.1 | 1.4 | 1.6 |
| | M04 | 1 | 60.6 | 79.8 | 0.6 | 0.0 | 1.2 | 1.2 |
| | M05 | 2 | 59.1 | 77.8 | 0.4 | 0.2 | 2.4 | 2.7 |
| | M06 | 2 | 59.4 | 78.2 | 1.4 | 0.2 | 0.5 | 0.9 |
| | M07 | 1 | 60.0 | 78.9 | 1.0 | 0.4 | 2.4 | 2.9 |
| Nebraska | N01 | 1 | 60.2 | 79.3 | 0.5 | 0.2 | 1.1 | 1.7 |
| | N02 | 1 | 60.6 | 79.7 | 0.4 | 0.1 | 1.5 | 1.7 |
| | N03 | 2 | 59.9 | 78.8 | 0.4 | 0.1 | 1.1 | 1.4 |
| | N04 | 2 | 59.7 | 78.6 | 0.7 | 0.3 | 1.4 | 1.8 |
| | N05 | 1 | 60.9 | 80.1 | 0.7 | 0.2 | 1.1 | 1.5 |
| North Dakota | ND01 | 2 | 58.9 | 77.5 | 1.0 | 1.0 | 1.0 | 2.2 |
| | ND02 | 1 | 60.5 | 79.5 | 0.9 | 1.4 | 1.0 | 2.6 |
| | ND03 | 1 | 60.0 | 78.9 | 0.7 | 0.7 | 1.1 | 1.9 |
| Oklahoma | O01 | 2 | 59.8 | 78.7 | 0.8 | 0.2 | 1.7 | 2.1 |
| | O02 | 2 | 60.5 | 79.6 | 0.6 | 0.2 | 1.7 | 2.4 |
| | O03 | 2 | 58.3 | 76.8 | 0.8 | 0.2 | 2.0 | 2.4 |
| | O04 | 2 | 59.9 | 78.8 | 0.8 | 0.5 | 0.9 | 1.1 |
| | O05 | 2 | 58.7 | 77.3 | 0.9 | 0.1 | 2.3 | 2.7 |
| | O06 | 1 | 60.1 | 79.0 | 0.8 | 0.2 | 1.9 | 2.4 |
| | O07 | 2 | 58.3 | 76.7 | 0.2 | 0.1 | 2.0 | 2.3 |
| Pacific Northwest | PNW01 | 1 | 61.2 | 80.4 | 0.3 | 0.0 | 0.7 | 0.8 |
| | PNW02 | 1 | 62.4 | 82.1 | 0.4 | 0.0 | 0.8 | 0.9 |
| | PNW03 | 1 | 61.9 | 81.4 | 0.5 | 0.1 | 0.6 | 0.7 |
| | PNW04 | 1 | 61.5 | 80.9 | 0.4 | 0.0 | 1.2 | 1.2 |
| South Dakota | SD01 | 2 | 59.3 | 78.0 | 0.8 | 0.6 | 1.2 | 2.0 |
| | SD02 | 2 | 59.1 | 77.8 | 0.5 | 0.6 | 1.2 | 2.0 |
| Texas | T01 | 2 | 58.9 | 77.5 | 0.7 | 0.2 | 2.8 | 3.3 |
| | T02 | 1 | 60.1 | 79.0 | 0.5 | 0.0 | 2.1 | 2.2 |
| | T03 | 2 | 61.9 | 81.4 | 0.6 | 0.3 | 3.1 | 3.5 |
| | T04 | 2 | 59.8 | 78.6 | 0.6 | 0.1 | 2.2 | 2.4 |
| | T05 | 2 | 59.7 | 78.6 | 0.8 | 0.3 | 2.0 | 2.5 |
| | T06 | 1 | 60.3 | 79.4 | 0.4 | 0.2 | 1.7 | 2.0 |
| Wyoming | W01 | 2 | 60.1 | 79.1 | 0.5 | 0.1 | 1.1 | 1.8 |

# Kernel Quality Data

| Location | | Foreign Material (%) | Kernel Size Large (%) | Kernel Size Med (%) | Kernel Size Small (%) | Thousand Kernel Wt (g) | SKCS Avg Diam (mm) |
|---|---|---|---|---|---|---|---|
| Colorado | C01 | 0.1 | 30 | 67 | 3 | 24.3 | 2.38 |
| | C02 | 0.1 | 40 | 58 | 2 | 24.7 | 2.42 |
| | C03 | 0.2 | 46 | 51 | 3 | 25.7 | 2.45 |
| Kansas | K01 | 0.1 | 33 | 63 | 5 | 23.4 | 2.41 |
| | K02 | 0.1 | 33 | 64 | 3 | 23.4 | 2.41 |
| | K03 | 0.1 | 34 | 63 | 3 | 23.9 | 2.43 |
| | K04 | 0.3 | 39 | 59 | 2 | 24.6 | 2.47 |
| | K05 | 0.2 | 47 | 51 | 3 | 24.8 | 2.49 |
| | K06 | 0.1 | 42 | 56 | 2 | 25.5 | 2.49 |
| | K07 | 0.1 | 41 | 57 | 2 | 24.7 | 2.47 |
| | K08 | 0.2 | 43 | 54 | 2 | 25.0 | 2.47 |
| | K09 | 0.0 | 51 | 47 | 1 | 26.0 | 2.52 |
| | K10 | 0.2 | 54 | 44 | 2 | 26.0 | 2.56 |
| Montana | M01 | 0.1 | 58 | 41 | 1 | 28.0 | 2.59 |
| | M02 | 0.1 | 62 | 37 | 1 | 28.8 | 2.57 |
| | M03 | 0.1 | 57 | 41 | 2 | 27.5 | 2.55 |
| | M04 | 0.0 | 46 | 51 | 2 | 25.6 | 2.49 |
| | M05 | 0.1 | 44 | 53 | 3 | 24.7 | 2.44 |
| | M06 | 0.2 | 69 | 30 | 1 | 29.9 | 2.58 |
| | M07 | 0.1 | 35 | 59 | 6 | 24.0 | 2.41 |
| Nebraska | N01 | 0.4 | 60 | 39 | 1 | 28.0 | 2.54 |
| | N02 | 0.1 | 54 | 44 | 1 | 27.1 | 2.52 |
| | N03 | 0.1 | 53 | 45 | 1 | 26.6 | 2.51 |
| | N04 | 0.1 | 48 | 50 | 2 | 25.9 | 2.48 |
| | N05 | 0.2 | 68 | 31 | 1 | 30.1 | 2.63 |
| North Dakota | ND01 | 0.2 | 59 | 40 | 1 | 29.3 | 2.59 |
| | ND02 | 0.2 | 68 | 31 | 1 | 31.2 | 2.68 |
| | ND03 | 0.1 | 57 | 41 | 2 | 28.6 | 2.58 |
| Oklahoma | O01 | 0.2 | 36 | 61 | 3 | 24.1 | 2.44 |
| | O02 | 0.5 | 46 | 52 | 2 | 25.1 | 2.52 |
| | O03 | 0.1 | 32 | 64 | 4 | 23.1 | 2.39 |
| | O04 | 0.1 | 35 | 62 | 3 | 23.8 | 2.42 |
| | O05 | 0.3 | 37 | 60 | 3 | 23.4 | 2.44 |
| | O06 | 0.2 | 46 | 51 | 3 | 25.3 | 2.51 |
| | O07 | 0.2 | 40 | 57 | 3 | 24.6 | 2.47 |
| Pacific Northwest | PNW01 | 0.0 | 77 | 22 | 1 | 33.7 | 2.79 |
| | PNW02 | 0.1 | 73 | 27 | 0 | 33.1 | 2.79 |
| | PNW03 | 0.0 | 83 | 17 | 0 | 36.0 | 2.84 |
| | PNW04 | 0.1 | 69 | 28 | 1 | 31.3 | 2.74 |
| South Dakota | SD01 | 0.2 | 56 | 42 | 2 | 28.5 | 2.58 |
| | SD02 | 0.2 | 57 | 42 | 1 | 28.1 | 2.58 |
| Texas | T01 | 0.2 | 33 | 62 | 5 | 22.8 | 2.40 |
| | T02 | 0.1 | 31 | 65 | 4 | 24.0 | 2.43 |
| | T03 | 0.1 | 36 | 61 | 4 | 24.9 | 2.49 |
| | T04 | 0.1 | 39 | 58 | 3 | 23.0 | 2.43 |
| | T05 | 0.3 | 40 | 57 | 3 | 23.9 | 2.45 |
| | T06 | 0.1 | 43 | 54 | 3 | 24.4 | 2.47 |
| Wyoming | W01 | 0.7 | 53 | 45 | 2 | 26.7 | 2.50 |

# 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 allpurpose 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.

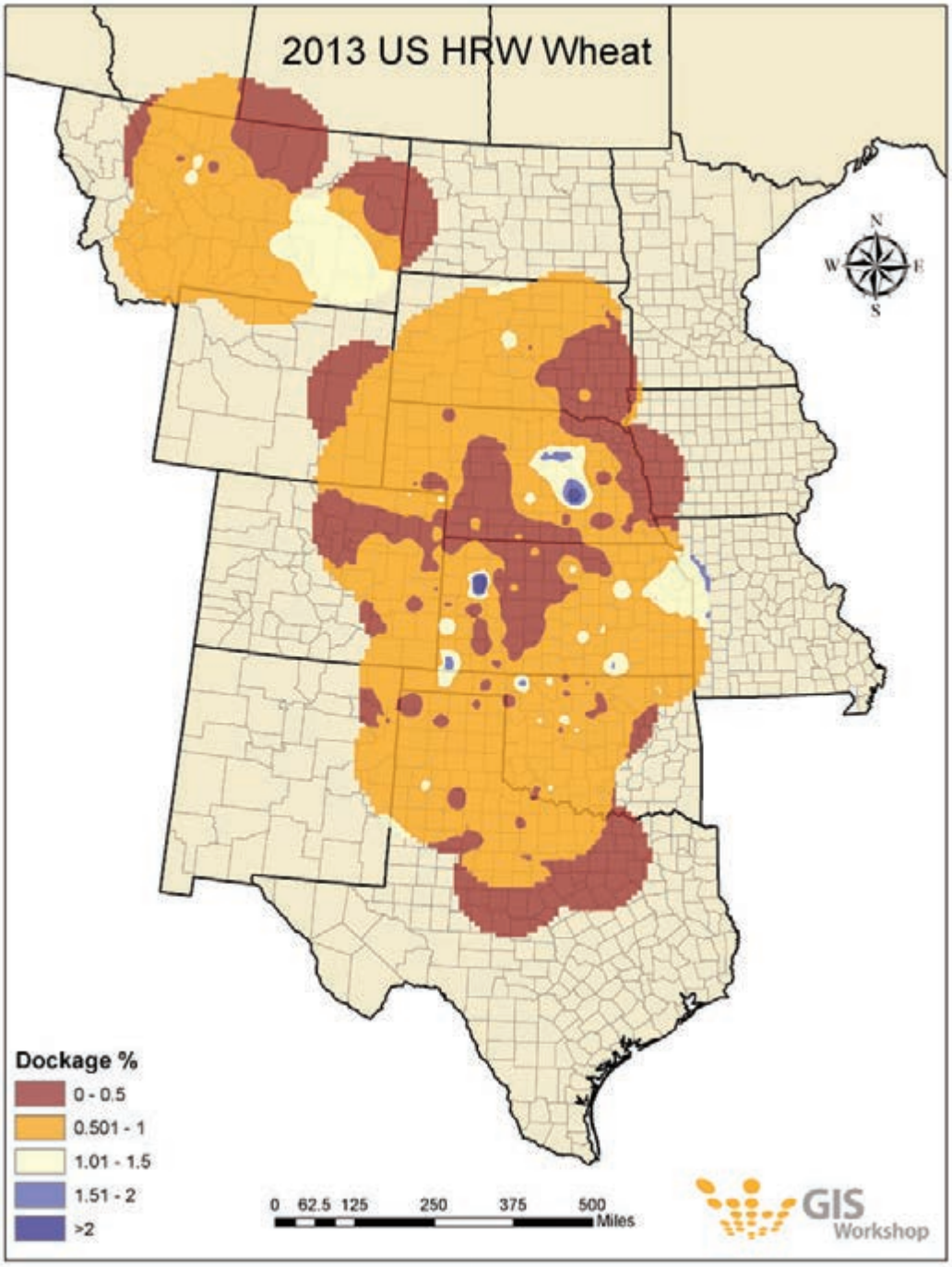
**Falling number** is an index of enzyme activity in wheat or flour and is expressed in seconds. Falling numbers above 300 are desirable, as they indicate little enzyme activity and a sound quality product. Falling numbers below 300 are indicative of more substantial enzyme activity and sprout damage.

**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.

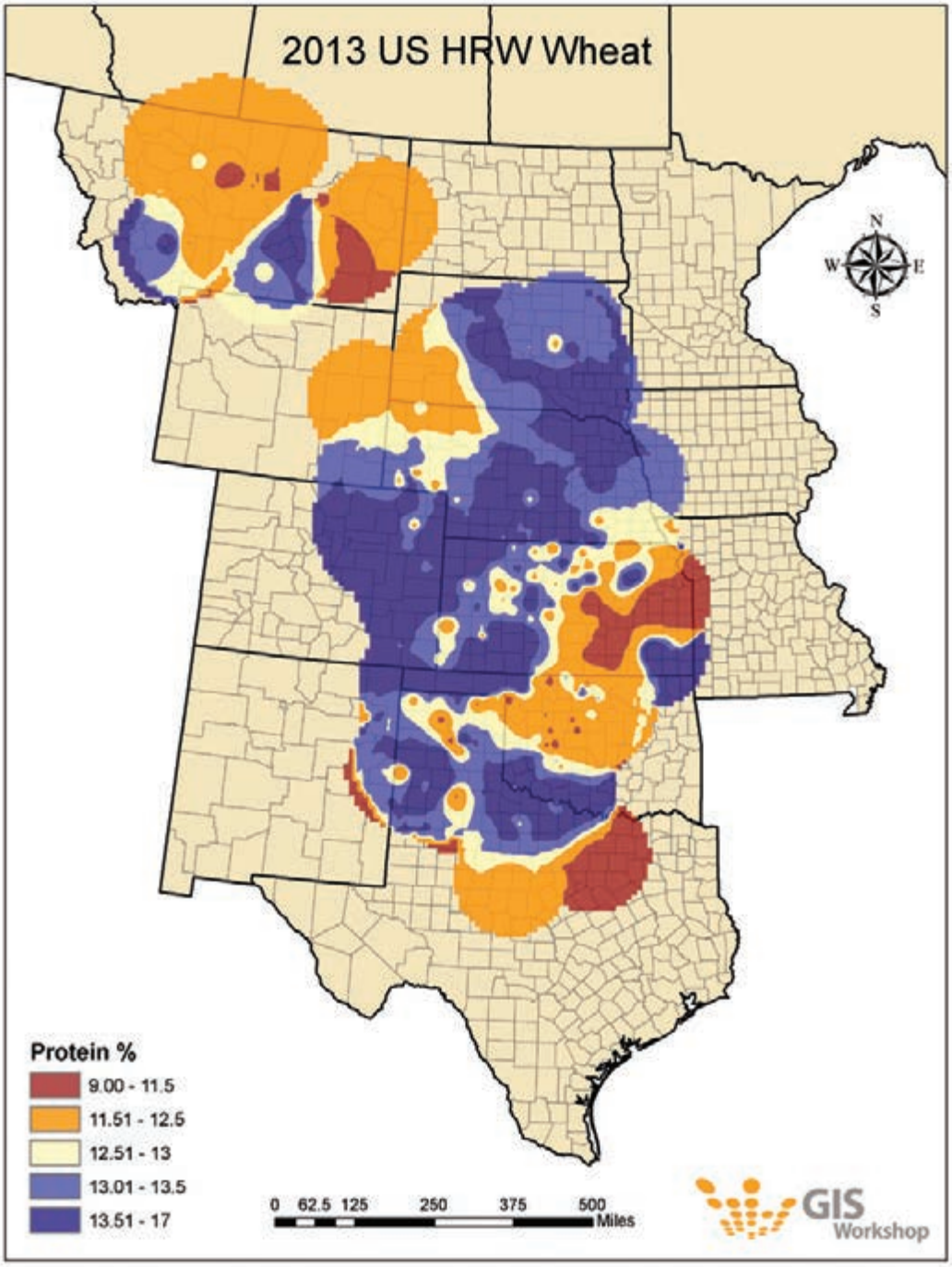
**Kernel Size** is a measure of the percentage by weight of large, medium and small kernels in a sample. Large kernels or more uniform kernel size may help improve milling yield.

**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.

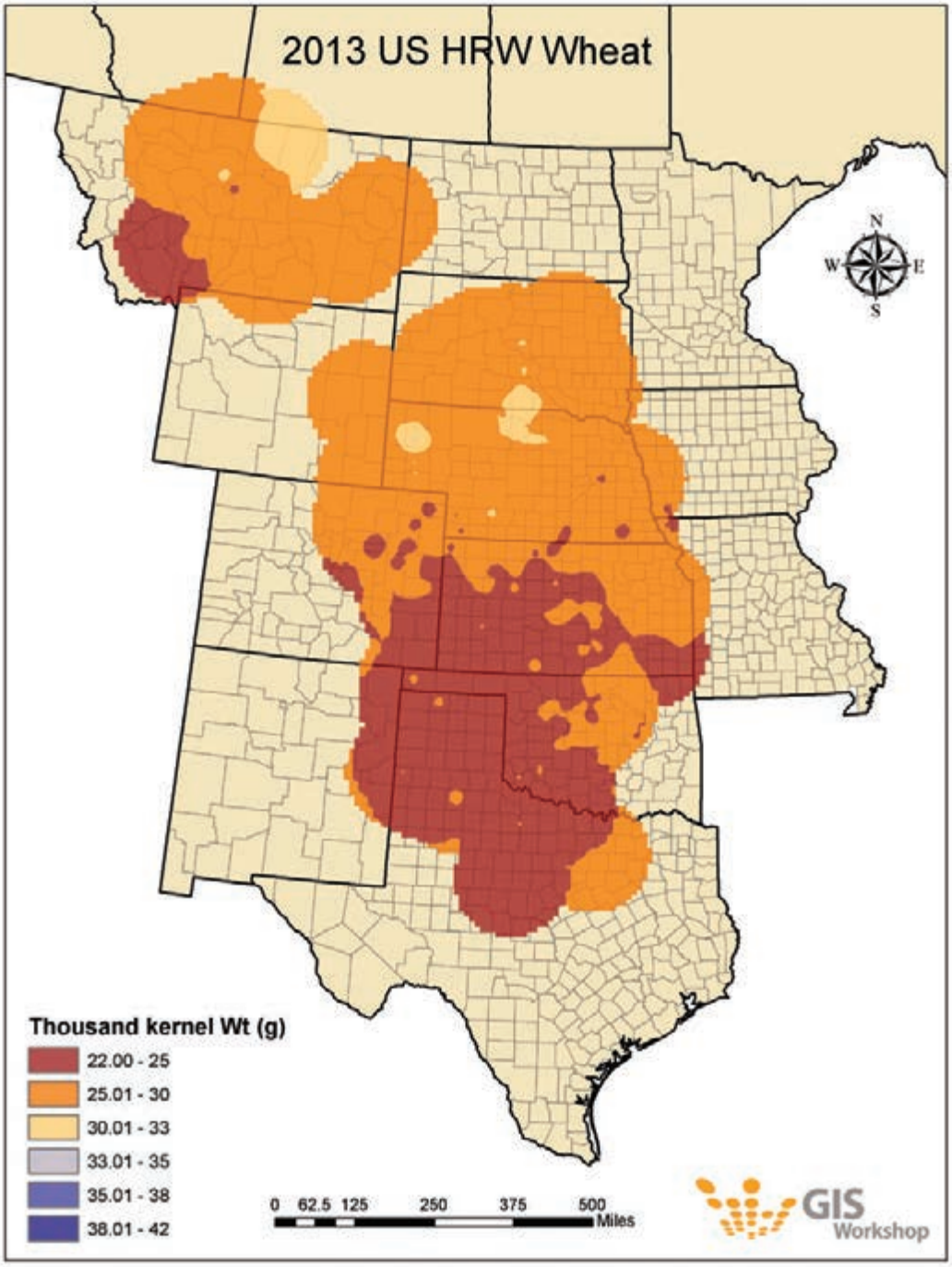
# Dockage (%)


2013 US HRW Wheat
N
W
E
S
Dockage %
0 - 0.5
0.501 - 1
1.01 - 1.5
1.51 - 2
>2
0 62.5 125 250 375 500
Miles
GIS
Workshop

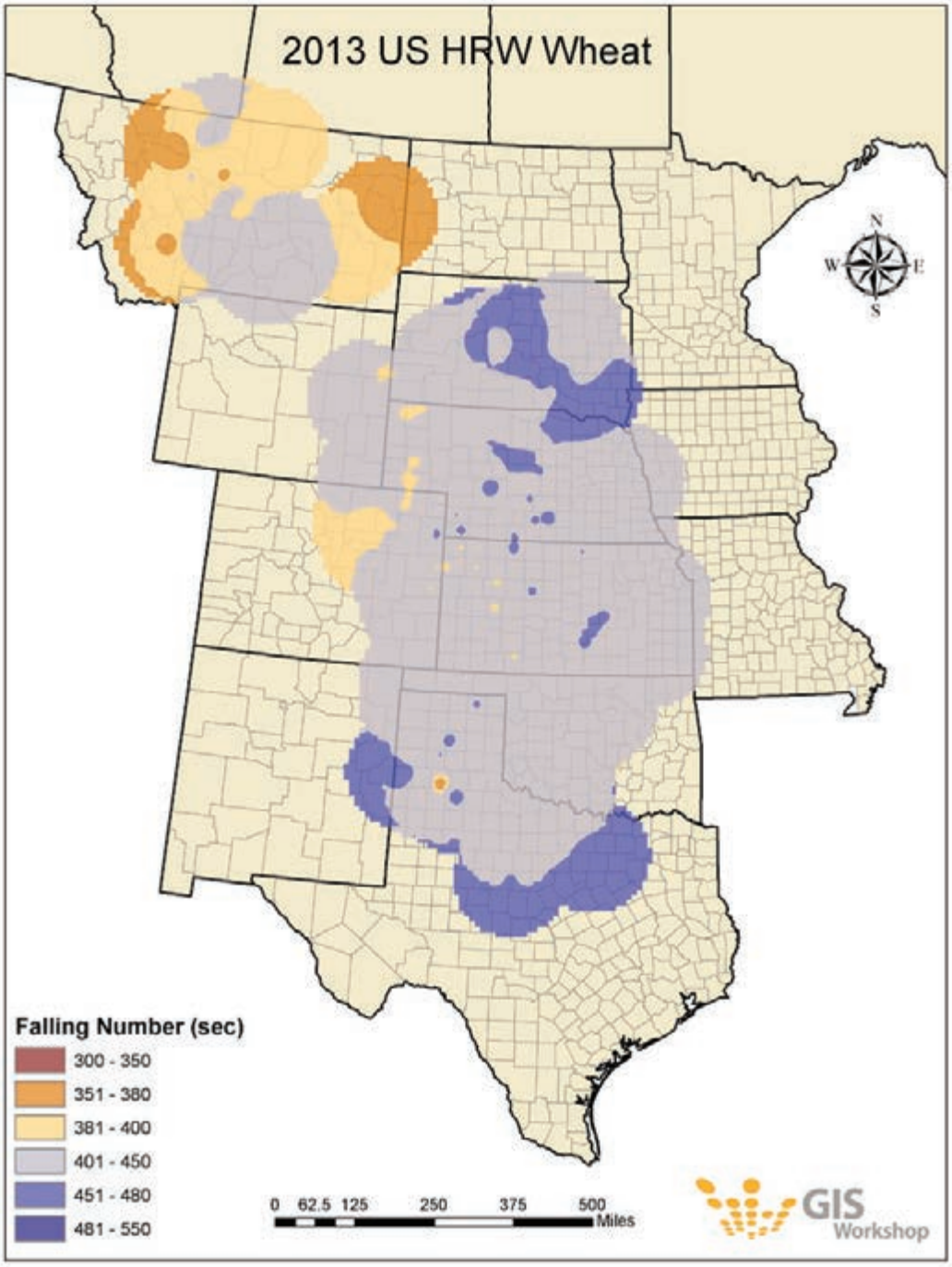
# Protein (%)


2013 US HRW Wheat
N
W
E
S
Protein %
9.00 - 11.5
11.51 - 12.5
12.51 - 13
13.01 - 13.5
13.51 - 17
0 62.5 125 250 375 500
Miles
GIS
Workshop

# Thousand Kernel Weight (g)



# Falling Number (seconds)



# Other Wheat Characteristics (non-grade data)

PGI

| Location | | NIR Wheat Protein (12% mb) | Indv Wheat Ash (12% mb) | Falling Number (sec) | Moisture (%) | SKCS Ave Hard |
|---|---|---|---|---|---|---|
| Colorado | C01 | 14.0 | 1.58 | 420 | 11.2 | 66 |
| | C02 | 14.0 | 1.67 | 417 | 11.3 | 68 |
| | C03 | 14.0 | 1.56 | 412 | 11.3 | 65 |
| Kansas | K01 | 13.3 | 1.77 | 434 | 11.1 | 72 |
| | K02 | 14.3 | 1.66 | 416 | 9.9 | 73 |
| | K03 | 14.3 | 1.62 | 417 | 10.2 | 69 |
| | K04 | 13.3 | 1.58 | 432 | 10.6 | 68 |
| | K05 | 11.6 | 1.67 | 448 | 11.1 | 65 |
| | K06 | 14.5 | 1.65 | 405 | 10.1 | 73 |
| | K07 | 13.1 | 1.60 | 430 | 10.0 | 70 |
| | K08 | 13.6 | 1.66 | 424 | 10.5 | 71 |
| | K09 | 12.2 | 1.64 | 443 | 10.9 | 68 |
| | K10 | 12.3 | 1.64 | 418 | 10.6 | 65 |
| Montana | M01 | 12.8 | 1.51 | 431 | 11.9 | 72 |
| | M02 | 11.8 | 1.41 | 401 | 12.5 | 69 |
| | M03 | 12.3 | 1.46 | 386 | 12.1 | 70 |
| | M04 | 11.9 | 1.45 | 404 | 12.9 | 72 |
| | M05 | 13.9 | 1.54 | 409 | 12.5 | 71 |
| | M06 | 11.5 | 1.31 | 399 | 12.8 | 55 |
| | M07 | 14.2 | 1.52 | 395 | 11.4 | 73 |
| Nebraska | N01 | 12.9 | 1.52 | 405 | 12.3 | 59 |
| | N02 | 14.1 | 1.57 | 441 | 11.2 | 64 |
| | N03 | 14.0 | 1.64 | 436 | 11.6 | 63 |
| | N04 | 14.1 | 1.71 | 434 | 11.5 | 66 |
| | N05 | 12.4 | 1.53 | 418 | 12.8 | 59 |
| North Dakota | ND01 | 14.7 | 1.57 | 417 | 12.7 | 57 |
| | ND02 | 13.7 | 1.61 | 399 | 13.4 | 64 |
| | ND03 | 14.3 | 1.66 | 443 | 13.5 | 66 |
| Oklahoma | O01 | 13.9 | 1.65 | 423 | 11.6 | 73 |
| | O02 | 11.7 | 1.62 | 428 | 10.9 | 72 |
| | O03 | 15.3 | 1.79 | 420 | 10.3 | 73 |
| | O04 | 15.1 | 1.72 | 432 | 10.1 | 66 |
| | O05 | 12.4 | 1.60 | 420 | 11.3 | 70 |
| | O06 | 12.6 | 1.56 | 421 | 11.6 | 73 |
| | O07 | 13.3 | 1.57 | 440 | 11.2 | 68 |
| Pacific Northwest | PNW01 | 12.7 | 1.52 | 375 | 8.7 | 71 |
| | PNW02 | 13.9 | 1.38 | 362 | 8.0 | 70 |
| | PNW03 | 11.5 | 1.28 | 384 | 9.0 | 62 |
| | PNW04 | 13.1 | 1.62 | 393 | 8.2 | 74 |
| South Dakota | SD01 | 13.8 | 1.76 | 450 | 13.4 | 64 |
| | SD02 | 13.8 | 1.80 | 452 | 13.6 | 63 |
| Texas | T01 | 13.8 | 1.80 | 426 | 10.5 | 70 |
| | T02 | 13.8 | 1.67 | 422 | 10.6 | 75 |
| | T03 | 11.7 | 1.63 | 484 | 10.3 | 74 |
| | T04 | 13.8 | 1.74 | 454 | 10.3 | 72 |
| | T05 | 14.5 | 1.79 | 438 | 9.9 | 73 |
| | T06 | 12.7 | 1.73 | 429 | 10.4 | 70 |
| Wyoming | W01 | 13.3 | 1.46 | 423 | 13.6 | 59 |

# 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 | 69.4 | 54.5 | 13.2 | 0.57 | 94.3 | 90.9 | -1.6 | 10.0 |
| | C02 | 77.5 | 57.6 | 12.7 | 0.60 | 93.3 | 91.1 | -1.9 | 10.1 |
| | C03 | 75.4 | 58.6 | 13.1 | 0.63 | 87.3 | 90.7 | -1.7 | 10.2 |
| Kansas | K01 | 74.7 | 51.6 | 12.5 | 0.69 | 94.9 | 90.4 | -1.2 | 10.5 |
| | K02 | 76.2 | 51.4 | 13.1 | 0.67 | 94.8 | 90.8 | -2.0 | 10.8 |
| | K03 | 76.7 | 51.7 | 13.0 | 0.63 | 94.1 | 90.5 | -1.9 | 10.7 |
| | K04 | 75.9 | 48.4 | 12.9 | 0.61 | 83.9 | 90.7 | -1.9 | 10.8 |
| | K05 | 78.8 | 36.4 | 10.5 | 0.67 | 93.9 | 90.0 | -1.8 | 11.2 |
| | K06 | 76.9 | 54.3 | 13.2 | 0.61 | 91.6 | 90.6 | -2.0 | 10.9 |
| | K07 | 75.6 | 46.0 | 11.8 | 0.63 | 93.8 | 91.1 | -2.1 | 10.9 |
| | K08 | 77.2 | 50.9 | 12.6 | 0.66 | 93.7 | 90.4 | -1.8 | 10.8 |
| | K09 | 78.1 | 40.6 | 10.8 | 0.64 | 76.7 | 90.4 | -1.8 | 10.9 |
| | K10 | 77.7 | 41.4 | 11.2 | 0.62 | 94.7 | 90.9 | -2.1 | 10.7 |
| Montana | M01 | 75.2 | 65.7 | 11.6 | 0.51 | 95.5 | 91.2 | -1.8 | 9.8 |
| | M02 | 75.1 | 59.9 | 10.6 | 0.44 | 97.3 | 91.7 | -2.2 | 9.7 |
| | M03 | 75.5 | 58.0 | 11.2 | 0.52 | 97.0 | 91.4 | -2.1 | 10.0 |
| | M04 | 74.8 | 57.8 | 10.7 | 0.51 | 98.9 | 91.6 | -2.0 | 10.2 |
| | M05 | 75.7 | 62.4 | 11.1 | 0.48 | 97.2 | 91.1 | -1.9 | 10.0 |
| | M06 | 77.6 | 57.7 | 10.5 | 0.45 | 98.5 | 91.5 | -2.1 | 10.4 |
| | M07 | 76.8 | 66.6 | 12.9 | 0.53 | 97.2 | 90.7 | -1.9 | 10.9 |
| Nebraska | N01 | 78.5 | 49.2 | 11.7 | 0.64 | 98.1 | 90.6 | -1.7 | 9.8 |
| | N02 | 77.9 | 55.9 | 13.0 | 0.58 | 94.2 | 90.7 | -1.7 | 10.2 |
| | N03 | 76.6 | 52.0 | 13.0 | 0.61 | 94.6 | 90.8 | -1.7 | 10.1 |
| | N04 | 76.5 | 50.4 | 12.7 | 0.60 | 93.1 | 90.9 | -1.8 | 10.3 |
| | N05 | 75.4 | 47.8 | 11.1 | 0.49 | 91.7 | 91.4 | -2.0 | 9.8 |
| North Dakota | ND01 | 74.2 | 63.5 | 12.3 | 0.51 | 96.6 | 90.9 | -1.8 | 9.4 |
| | ND02 | 75.4 | 64.6 | 12.3 | 0.56 | 95.5 | 91.0 | -1.8 | 9.3 |
| | ND03 | 77.0 | 51.8 | 12.5 | 0.58 | 96.2 | 90.2 | -1.8 | 9.9 |
| Oklahoma | O01 | 76.5 | 52.5 | 13.0 | 0.66 | 87.8 | 90.8 | -1.9 | 10.8 |
| | O02 | 76.9 | 39.3 | 10.1 | 0.57 | 95.5 | 91.1 | -2.2 | 11.2 |
| | O03 | 75.5 | 56.3 | 14.0 | 0.71 | 82.7 | 90.6 | -1.9 | 10.8 |
| | O04 | 75.6 | 65.5 | 15.1 | 0.60 | 84.3 | 90.4 | -1.8 | 10.7 |
| | O05 | 75.6 | 47.1 | 11.9 | 0.60 | 97.8 | 91.0 | -2.2 | 11.2 |
| | O06 | 77.1 | 44.8 | 11.4 | 0.57 | 98.0 | 90.8 | -2.1 | 11.2 |
| | O07 | 76.8 | 47.2 | 12.0 | 0.58 | 97.2 | 90.9 | -2.0 | 11.0 |
| Pacific Northwest | PNW01 | 78.4 | 50.5 | 11.9 | 0.56 | 98.0 | 90.2 | -1.6 | 10.1 |
| | PNW02 | 78.5 | 65.9 | 13.0 | 0.51 | 96.7 | 90.6 | -1.6 | 10.0 |
| | PNW03 | 76.7 | 43.1 | 10.0 | 0.46 | 96.6 | 91.1 | -1.7 | 9.6 |
| | PNW04 | 77.1 | 46.3 | 12.2 | 0.53 | 91.6 | 90.7 | -1.6 | 10.0 |
| South Dakota | SD01 | 77.1 | 51.7 | 12.3 | 0.59 | 97.0 | 90.5 | -1.8 | 10.2 |
| | SD02 | 75.2 | 51.3 | 12.3 | 0.57 | 90.7 | 90.4 | -1.8 | 9.9 |
| Texas | T01 | 73.6 | 62.8 | 13.8 | 0.69 | 87.8 | 90.6 | -1.8 | 10.3 |
| | T02 | 78.8 | 47.6 | 12.5 | 0.64 | 95.8 | 91.2 | -1.9 | 10.5 |
| | T03 | 77.2 | 32.4 | 10.6 | 0.61 | 96.7 | 90.9 | -1.9 | 10.2 |
| | T04 | 76.0 | 61.3 | 13.8 | 0.69 | 96.0 | 90.3 | -1.8 | 10.7 |
| | T05 | 77.4 | 59.7 | 13.6 | 0.67 | 92.8 | 90.5 | -1.8 | 10.6 |
| | T06 | 76.6 | 44.1 | 12.2 | 0.68 | 87.8 | 90.5 | -1.9 | 10.8 |
| Wyoming | W01 | 74.9 | 63.6 | 12.1 | 0.52 | 96.1 | 91.4 | -2.0 | 9.7 |

# 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" elates 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

| Location | | ALVEOGRAPH | | | | FARINOGRAPH | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | P (mm) | L (mm) | W (10-4 J) | P/L Ratio | Abs (14%mb) | Devlopmt Time (min) | Stability (min) | MTI (BU) |
| Colorado | C01 | 81 | 90 | 236 | 0.90 | 60.7 | 5.5 | 13.8 | 30 |
| | C02 | 81 | 99 | 267 | 0.82 | 59.8 | 6.0 | 16.9 | 19 |
| | C03 | 85 | 88 | 244 | 0.97 | 62.2 | 7.0 | 13.2 | 24 |
| Kansas | K01 | 90 | 96 | 269 | 0.94 | 60.1 | 5.3 | 14.1 | 28 |
| | K02 | 85 | 90 | 242 | 0.94 | 61.4 | 6.0 | 10.6 | 33 |
| | K03 | 91 | 89 | 265 | 1.02 | 61.0 | 6.1 | 11.8 | 31 |
| | K04 | 94 | 98 | 289 | 0.96 | 60.9 | 6.7 | 12.7 | 30 |
| | K05 | 79 | 73 | 175 | 1.08 | 58.7 | 4.7 | 7.7 | 42 |
| | K06 | 80 | 85 | 218 | 0.94 | 60.8 | 6.0 | 10.9 | 31 |
| | K07 | 93 | 88 | 257 | 1.06 | 60.8 | 5.2 | 9.8 | 37 |
| | K08 | 88 | 92 | 248 | 0.96 | 60.5 | 5.7 | 10.1 | 33 |
| | K09 | 68 | 87 | 182 | 0.78 | 57.7 | 4.0 | 7.6 | 40 |
| | K10 | 74 | 95 | 222 | 0.78 | 57.4 | 5.7 | 12.0 | 30 |
| Montana | M01 | 94 | 92 | 325 | 1.02 | 59.8 | 5.2 | 14.8 | 27 |
| | M02 | 78 | 99 | 269 | 0.79 | 58.1 | 5.4 | 11.8 | 34 |
| | M03 | 76 | 109 | 286 | 0.72 | 58.3 | 5.4 | 10.5 | 33 |
| | M04 | 86 | 89 | 284 | 0.97 | 57.8 | 5.2 | 12.1 | 27 |
| | M05 | 75 | 98 | 255 | 0.77 | 57.5 | 5.5 | 11.8 | 34 |
| | M06 | 68 | 125 | 268 | 0.54 | 59.2 | 4.9 | 9.6 | 41 |
| | M07 | 84 | 94 | 296 | 0.89 | 59.6 | 5.7 | 14.5 | 24 |
| Nebraska | N01 | 70 | 101 | 221 | 0.69 | 57.8 | 5.5 | 12.8 | 24 |
| | N02 | 73 | 87 | 198 | 0.84 | 60.1 | 6.8 | 10.7 | 36 |
| | N03 | 84 | 76 | 219 | 1.11 | 60.5 | 7.7 | 12.9 | 28 |
| | N04 | 91 | 74 | 229 | 1.23 | 60.3 | 5.8 | 10.7 | 35 |
| | N05 | 65 | 94 | 204 | 0.69 | 57.7 | 5.3 | 10.2 | 32 |
| North Dakota | ND01 | 65 | 128 | 270 | 0.51 | 57.8 | 5.5 | 14.8 | 21 |
| | ND02 | 71 | 135 | 285 | 0.53 | 60.2 | 5.4 | 10.9 | 34 |
| | ND03 | 54 | 128 | 195 | 0.42 | 58.3 | 5.7 | 11.4 | 30 |
| Oklahoma | O01 | 83 | 104 | 285 | 0.80 | 60.8 | 5.0 | 15.9 | 17 |
| | O02 | 65 | 102 | 191 | 0.64 | 55.8 | 4.3 | 7.4 | 46 |
| | O03 | 76 | 111 | 236 | 0.68 | 62.4 | 5.7 | 11.3 | 27 |
| | O04 | 84 | 111 | 286 | 0.76 | 63.8 | 7.5 | 16.9 | 19 |
| | O05 | 72 | 104 | 222 | 0.69 | 56.3 | 4.3 | 12.5 | 22 |
| | O06 | 75 | 108 | 236 | 0.69 | 56.9 | 4.7 | 9.1 | 35 |
| | O07 | 68 | 113 | 227 | 0.60 | 58.7 | 5.5 | 12.6 | 24 |
| Pacific Northwest | PNW01 | 93 | 95 | 291 | 1.02 | 61.8 | 4.3 | 9.9 | 28 |
| | PNW02 | 94 | 120 | 349 | 0.78 | 63.5 | 7.2 | 15.7 | 19 |
| | PNW03 | 104 | 63 | 244 | 1.65 | 61.5 | 4.0 | 7.9 | 36 |
| | PNW04 | 96 | 78 | 258 | 1.22 | 63.1 | 7.2 | 17.2 | 13 |
| South Dakota | SD01 | 71 | 99 | 241 | 0.72 | 59.9 | 6.8 | 12.0 | 36 |
| | SD02 | 70 | 91 | 216 | 0.77 | 58.5 | 5.3 | 13.0 | 24 |
| Texas | T01 | 92 | 110 | 330 | 0.84 | 61.1 | 7.5 | 17.9 | 22 |
| | T02 | 81 | 115 | 298 | 0.70 | 60.2 | 4.8 | 12.5 | 24 |
| | T03 | 85 | 78 | 229 | 1.09 | 57.4 | 5.2 | 10.0 | 39 |
| | T04 | 79 | 129 | 297 | 0.61 | 60.8 | 6.2 | 16.7 | 23 |
| | T05 | 79 | 127 | 289 | 0.62 | 61.5 | 5.2 | 11.3 | 32 |
| | T06 | 73 | 99 | 211 | 0.74 | 59.1 | 5.7 | 8.2 | 42 |
| Wyoming | W01 | 84 | 103 | 282 | 0.82 | 59.8 | 7.2 | 16.9 | 17 |

# 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 | 4.3 | 63.0 | 885 | 7.0 | 7.0 | Dull |
| | C02 | 4.3 | 64.1 | 865 | 5.5 | 7.0 | Dull |
| | C03 | 4.4 | 62.5 | 880 | 5.5 | 7.0 | Dull |
| Kansas | K01 | 4.5 | 63.4 | 895 | 5.5 | 7.0 | Dull |
| | K02 | 3.8 | 64.5 | 830 | 5.5 | 7.0 | Dull |
| | K03 | 4.0 | 63.1 | 910 | 6.3 | 7.0 | Dull |
| | K04 | 4.3 | 63.4 | 920 | 7.8 | 7.0 | Dull |
| | K05 | 5.0 | 59.6 | 790 | 5.5 | 7.0 | Dull |
| | K06 | 4.3 | 63.6 | 900 | 7.8 | 7.0 | Creamy |
| | K07 | 4.0 | 61.7 | 850 | 7.0 | 7.0 | Dull |
| | K08 | 4.0 | 63.2 | 875 | 7.0 | 7.0 | Dull |
| | K09 | 4.5 | 60.4 | 810 | 7.0 | 7.0 | Dull |
| | K10 | 5.1 | 60.3 | 850 | 7.0 | 7.0 | Dull |
| Montana | M01 | 6.3 | 62.2 | 900 | 7.0 | 7.0 | Dull |
| | M02 | 6.5 | 60.9 | 795 | 7.8 | 7.0 | Dull |
| | M03 | 6.0 | 60.9 | 835 | 7.0 | 7.0 | Dull |
| | M04 | 6.8 | 63.3 | 845 | 7.0 | 7.0 | Dull |
| | M05 | 6.8 | 61.2 | 810 | 7.0 | 7.0 | Dull |
| | M06 | 6.4 | 61.7 | 835 | 7.0 | 7.0 | Dull |
| | M07 | 6.6 | 64.4 | 885 | 6.3 | 7.0 | Dull |
| Nebraska | N01 | 5.4 | 60.1 | 800 | 7.0 | 7.0 | Dull |
| | N02 | 4.5 | 63.6 | 910 | 7.8 | 7.0 | Dull |
| | N03 | 3.3 | 62.7 | 925 | 7.8 | 7.0 | Dull |
| | N04 | 4.5 | 63.0 | 840 | 5.5 | 7.0 | Dull |
| | N05 | 4.4 | 61.3 | 860 | 7.8 | 7.0 | Dull |
| North Dakota | ND01 | 5.8 | 63.4 | 850 | 7.0 | 7.0 | Dull |
| | ND02 | 5.1 | 63.6 | 870 | 7.0 | 7.0 | Dull |
| | ND03 | 5.0 | 62.4 | 850 | 7.0 | 7.0 | Dull |
| Oklahoma | O01 | 4.6 | 65.8 | 865 | 7.8 | 8.5 | Dull |
| | O02 | 4.8 | 58.9 | 775 | 6.3 | 7.0 | Dull |
| | O03 | 3.5 | 62.6 | 885 | 6.3 | 7.0 | Dull |
| | O04 | 3.5 | 66.9 | 930 | 7.8 | 7.0 | Dull |
| | O05 | 4.5 | 62.8 | 860 | 7.0 | 7.0 | Dull |
| | O06 | 4.6 | 62.2 | 835 | 7.0 | 7.0 | Dull |
| | O07 | 4.5 | 60.7 | 890 | 7.0 | 7.0 | Dull |
| Pacific Northwest | PNW01 | 5.3 | 63.7 | 805 | 5.5 | 7.0 | Dull |
| | PNW02 | 4.8 | 62.8 | 870 | 7.8 | 7.0 | Dull |
| | PNW03 | 3.3 | 60.7 | 740 | 4.8 | 7.0 | Dull |
| | PNW04 | 3.5 | 63.2 | 850 | 4.8 | 7.0 | Dull |
| South Dakota | SD01 | 5.3 | 62.2 | 850 | 7.0 | 7.0 | Dull |
| | SD02 | 4.8 | 63.2 | 905 | 7.0 | 7.0 | Dull |
| Texas | T01 | 5.0 | 66.4 | 965 | 7.0 | 8.5 | Dull |
| | T02 | 4.8 | 61.9 | 910 | 7.0 | 8.5 | Dull |
| | T03 | 5.0 | 62.0 | 810 | 7.8 | 7.0 | Dull |
| | T04 | 4.8 | 65.8 | 900 | 7.0 | 8.5 | Dull |
| | T05 | 4.1 | 65.0 | 880 | 7.0 | 8.5 | Dull |
| | T06 | 3.8 | 62.8 | 840 | 7.0 | 8.5 | Dull |
| Wyoming | W01 | 4.5 | 62.1 | 885 | 5.5 | 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 38-12Farinograph: 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.