2012 Hard Red Winter Wheat Regional Quality Survey

PGI

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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.

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 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 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.

Crop Production Review and Analysis

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Weather and Harvest

Planting dates and conditions for the 2012 HRW crop were variable across the production region with generally later planting and emergence (2 weeks average) prevailing in the southern areas (Texas and Oklahoma) and near normal planting and emergence from Kansas and Colorado northward to Montana. Planting and emergence in the Pacific Northwest were near the 3-year normal. Late emergence in the southern areas was due to the severe drought of 2011 extending into November when uncharacteristic precipitation began. Timely moisture continued throughout the central and southern plains until early spring when untimely high temperatures and drought conditions expanded northward into the northern plains and Montana. Abnormally warm conditions over the winter coupled with the lack of adequate precipitation in the spring pushed heading and harvest dates forward from Texas to Montana some 10 days to 14 days on the average. Many areas were completed with harvest before their normal starting date. The timely moisture and warm temperatures over the winter also allowed much more extensive root and tiller development during a time when the plants would normally have been dormant. As a result, early spring indications were (by tiller/head counts) that the 2012 production would be well above average. However, while there were more heads than normal, the combination of hot and dry weather caused fewer kernels per head resulting in lower yields. There were not only fewer kernels, the adverse conditions in the central and southern Plains happened during a very vunerable stage of physiological development, meaning protein accumulation was affected. There were many locations throughout that area that reported a wide range of protein being delivered to terminals unrelated to production practices historically favorable to high protein. The positive result of a very dry spring with early maturity of the crop was limited disease/insect pressure and good falling numbers.

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. 538 samples were collected from grain elevators when at least 30% of the local harvest was completed in 12 states from Texas to the Pacific Northwest. Official grade and non-grade parameters were determined on each sample. 102 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 of Texas, Oklahoma, Colorado, Kansas, Nebraska, South Dakota, North Dakota, Wyoming, Montana, Washington, Oregon and Idaho. 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 2012 HRW crop official grade averaged 78% Grade #1 (Gulf tributary averaging 72% and PNW tributary averaging 88%) when considering all protein levels. This was a very clean crop with the overall average dockage level of 0.5%, which was equal to last year's average of 0.5%, and below the 5-year average of 0.6%. Total defects of 1.4% in 2012 are also below the 5-year average of 1.6% and last year's average of 1.5%. Foreign material, shrunken and broken, and wheat ash contents are consistent with the 5-year average. Test weight was 61.1 lbs/bu (80.4 kg/hl), significantly above the 5-year average of 60.5 lbs/bu (79.5 kg/hl) and above the 2011 crop of 60.8 lbs/bu (80.0 kg/hl). The overall average thousand kernel weight of 29.0 g, is slightly lower than the 2011 crop (30.3 g) and the 5-year average (29.5 g). Kernel diameter was equal to the 2011 crop and significantly higher than the 5-year average of 2.45 mm, averaging 2.60 mm. The kernel characteristics were uniform across the production region, but more pronounced in PNW region and less pronounced in the southern part of the testing area. The crop protein averaged more than a half percent above the 5-year average across the testing area and higher than the overall average of the 2011 crop. Protein content splits across the testing region and tributaries were very consistent with approximately 20% of samples being in the < 11.5% protein content category, 35% in the 11.5% – 12.5% category and 45% in the < 12.5% category. Average falling number for this crop was 409 sec, comparable to the 5-year average and indicative of sound wheat.

Flour and Baking Data

The Buhler flour yield overall averaged (75.2%) and while is significantly above 2011 and 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 and a regression analysis was done to insure the increased extraction and resulting ash contents were not affecting other test results. Protein loss during flour conversion averaged 1.1% (when wheat is converted to 14% mb). This was below the 2011 crop and the 5-year average of 1.3%. Gluten index values averaged 93.9% and were lower within the southern parts of the sampling areas versus the northern parts. The W value, 254 (10-4 J) was above the 2011 crop (246 10-4 J) and above the 5-year average of 231 (10-4 J). Overall average water absorption (WA) was 58.9%, compared to 57.1% in 2011 and a 5-year average of 57.6%. Farinograph development time and stability, 5.3 min and 11.1 min respectively, and were comparable to 2011 and the 5-year average for development time, but significantly lower than 2011 for stability (14.7 min). Overall loaf volume averaged 789 cc.; this was lower than the 2011 crop of 804, but significantly lower than the 5 year average of 817 cc. Wheat protein had to exceed 12.5% before a significant number of samples exceeded 800 cc. When evaluating gluten index, W value, water absorption, development time, stability and loaf volume, it would appear there is protein quantity present while protein quality performance may be below long term averages.

Summary

This year's crop can be characterized as one in which we saw above average kernel sizes and weights. However, while overall protein quantity was above 2011 and the 5-year average, protein quality was diverse and was reflected in dough functionality and bake test.

Hard Red Winter Wheat Production Charts

English Units

Hard Winter Wheat Production (1,000 bu.)

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Colorado	52,800	39,900	94,000	57,000	98,000	105,750	78,000	83,250	76,088
Kansas	380,000	291,200	283,800	356,000	369,600	360,000	276,500	387,000	338,013
Montana	92,250	82,560	83,220	94,380	89,540	93,600	89,790	81,320	88,333
North Dakota	11,115	7,920	22,250	22,550	26,160	17,600	13,875	38,500	19,996
Nebraska	68,640	61,200	84,280	73,480	76,800	64,070	65,250	55,440	68,645
Oklahoma	128,000	81,600	98,000	166,500	77,000	120,900	70,400	155,400	112,225
Pacific NW	19,993	19,368	17,841	16,246	16,194	19,869	22,004	37,990	21,188
South Dakota	63,360	41,400	95,040	103,950	64,260	63,700	66,780	62,400	70,111
Texas	96,000	33,600	140,600	99,000	61,250	127,500	49,400	91,450	87,350
Wyoming	4,350	3,645	3,250	3,780	5,016	4,640	4,420	3,000	4,013
Regional Total	916,508	662,393	922,281	992,886	883,820	977,629	736,419	995,750	885,961

Hard Winter Wheat Harvested Acres (1,000 Acres)

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Colorado	2,200	1,900	2,350	1,900	2,450	2,350	2,000	2,250	2,175
Kansas	9,500	9,100	8,600	8,900	8,800	8,000	7,900	9,000	8,725
Montana	2,050	1,920	2,190	2,420	2,420	1,950	2,190	2,140	2,160
North Dakota	285	180	445	550	545	320	375	700	425
Nebraska	1,760	1,700	1,960	1,670	1,600	1,490	1,450	1,320	1,619
Oklahoma	4,000	3,400	3,500	4,500	3,500	3,900	3,200	4,200	3,775
Pacific NW	283	299	294	258	276	289	293	535	316
South Dakota	1,440	1,150	1,980	1,890	1,530	1,300	1,590	1,300	1,523
Texas	3,000	1,400	3,800	3,300	2,450	3,750	1,900	2,950	2,819
Wyoming	135	135	125	135	132	145	130	120	132
Regional Total	24,653	21,184	25,244	25,523	23,703	23,494	21,028	24,515	20,910

Hard Winter Wheat Yield (bu/ac)

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Colorado	24	21	40	30	40	45	39	37	35
Kansas	40	32	33	40	42	45	45	43	40
Montana	45	43	38	39	37	48	41	38	41
North Dakota	39	44	50	41	48	55	37	55	46
Nebraska	39	36	43	44	48	43	45	42	43
Oklahoma	32	24	28	37	22	31	22	37	29
Pacific NW	64	60	59	57	58	68	76	75	65
South Dakota	44	36	48	55	42	49	42	48	46
Texas	32	24	37	30	25	34	26	31	30
Wyoming	30	27	26	28	38	32	34	25	30
Regional Total	39	35	40	40	40	45	41	43	40

*** Some data derived from Crop Production report issued by USDA NASS updated September 30, 2012.*

Hard Red Winter Wheat Production Charts

Metric Units

Hard Winter Wheat Production (MMT)

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Colorado	1.44	1.09	2.56	1.55	2.67	2.88	2.12	2.27	2.07
Kansas	10.34	7.93	7.72	9.69	10.06	9.80	7.53	10.53	9.20
Montana	2.51	2.25	2.27	2.57	2.44	2.55	2.44	2.21	2.40
North Dakota	0.30	0.22	0.61	0.61	0.71	0.48	0.38	1.05	0.54
Nebraska	1.87	1.67	2.29	2.00	2.09	1.74	1.78	1.51	1.87
Oklahoma	3.48	2.22	2.67	4.53	2.10	3.29	1.92	4.23	3.05
Pacific NW	0.54	0.53	0.49	0.44	0.44	0.54	0.60	1.03	0.58
South Dakota	1.72	1.13	2.59	2.83	1.75	1.73	1.82	1.70	1.91
Texas	2.61	0.91	3.83	2.69	1.67	3.47	1.34	2.49	2.38
Wyoming	0.12	0.10	0.09	0.10	0.14	0.13	0.12	0.08	0.11
Regional Total	24.95	18.03	25.10	27.02	24.06	26.61	20.04	27.10	24.11

Hard Winter Wheat Harvested Acres (1,000 ha)

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Colorado	890	769	951	769	992	951	809	911	880
Kansas	3,845	3,683	3,480	3,602	3,561	3,238	3,197	3,642	3,531
Montana	830	777	886	979	979	789	886	866	874
North Dakota	115	73	180	223	221	130	152	283	172
Nebraska	712	688	793	676	648	603	587	534	655
Oklahoma	1,619	1,376	1,416	1,821	1,416	1,578	1,295	1,700	1,528
Pacific NW	115	121	119	104	112	117	119	217	128
South Dakota	583	465	801	765	619	526	643	526	616
Texas	1,214	567	1,538	1,335	992	1,518	769	1,194	1,141
Wyoming	55	55	51	55	53	59	53	49	53
Regional Total	9,977	8,573	10,216	10,329	9,592	9,508	8,510	9,921	9,578

Hard Winter Wheat Yield (tons/ha)

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Colorado	1.63	1.43	2.72	2.04	2.72	3.06	2.65	2.52	2.35
Kansas	2.72	2.18	2.24	2.72	2.86	3.06	3.06	2.92	2.72
Montana	3.06	2.92	2.58	2.65	2.52	3.26	2.79	2.58	2.80
North Dakota	2.65	2.99	3.40	2.79	3.26	3.74	2.52	3.74	3.14
Nebraska	2.65	2.45	2.92	2.99	3.26	2.92	3.06	2.86	2.89
Oklahoma	2.18	1.63	1.90	2.52	1.50	2.11	1.50	2.52	1.98
Pacific NW	4.35	4.08	4.01	3.88	3.94	4.62	5.17	5.10	4.39
South Dakota	2.99	2.45	3.26	3.74	2.86	3.33	2.86	3.26	3.09
Texas	2.18	1.63	2.52	2.04	1.70	2.31	1.77	2.11	2.03
Wyoming	2.04	1.84	1.77	1.90	2.58	2.18	2.31	1.70	2.04
Regional Total	26.45	23.60	27.34	27.27	27.20	30.60	27.68	29.31	27.43

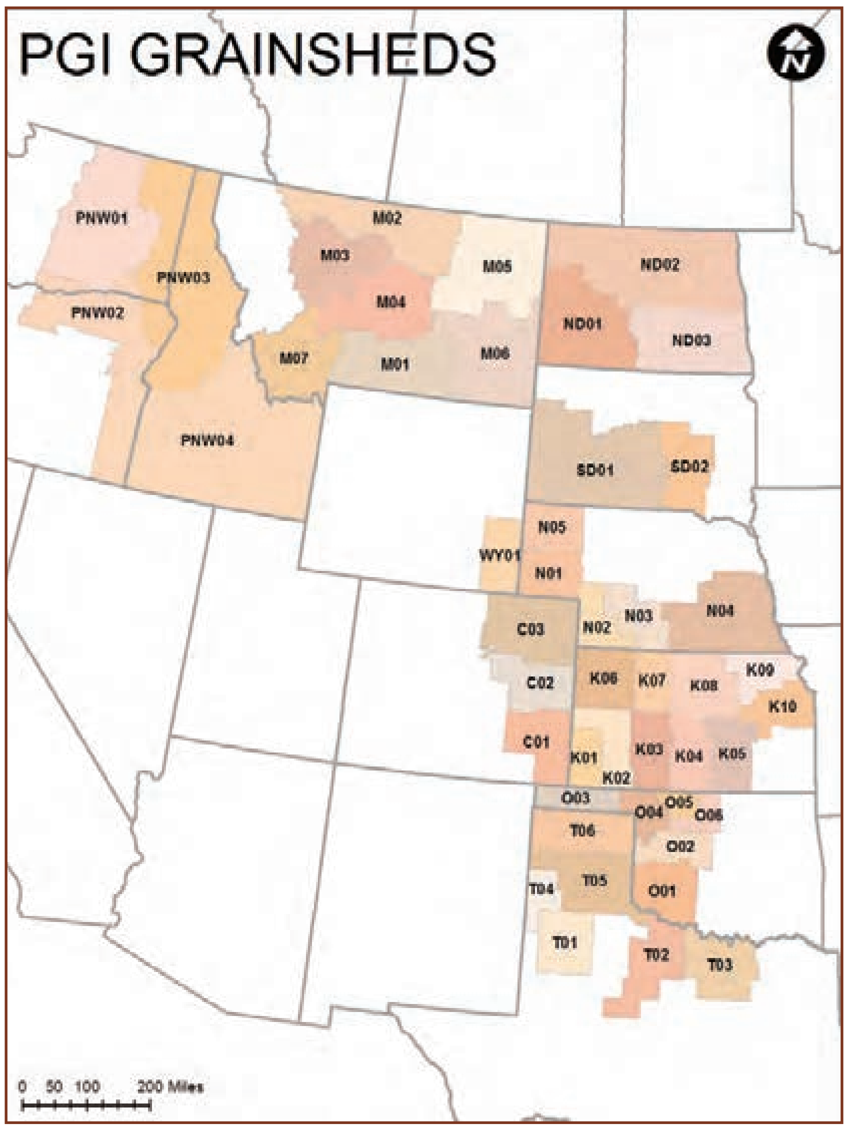
*** Some data derived from Crop Production report issued by USDA NASS updated September 30, 2012.*

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 Topeka, Kan.



Wheat Grading Characteristics

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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.

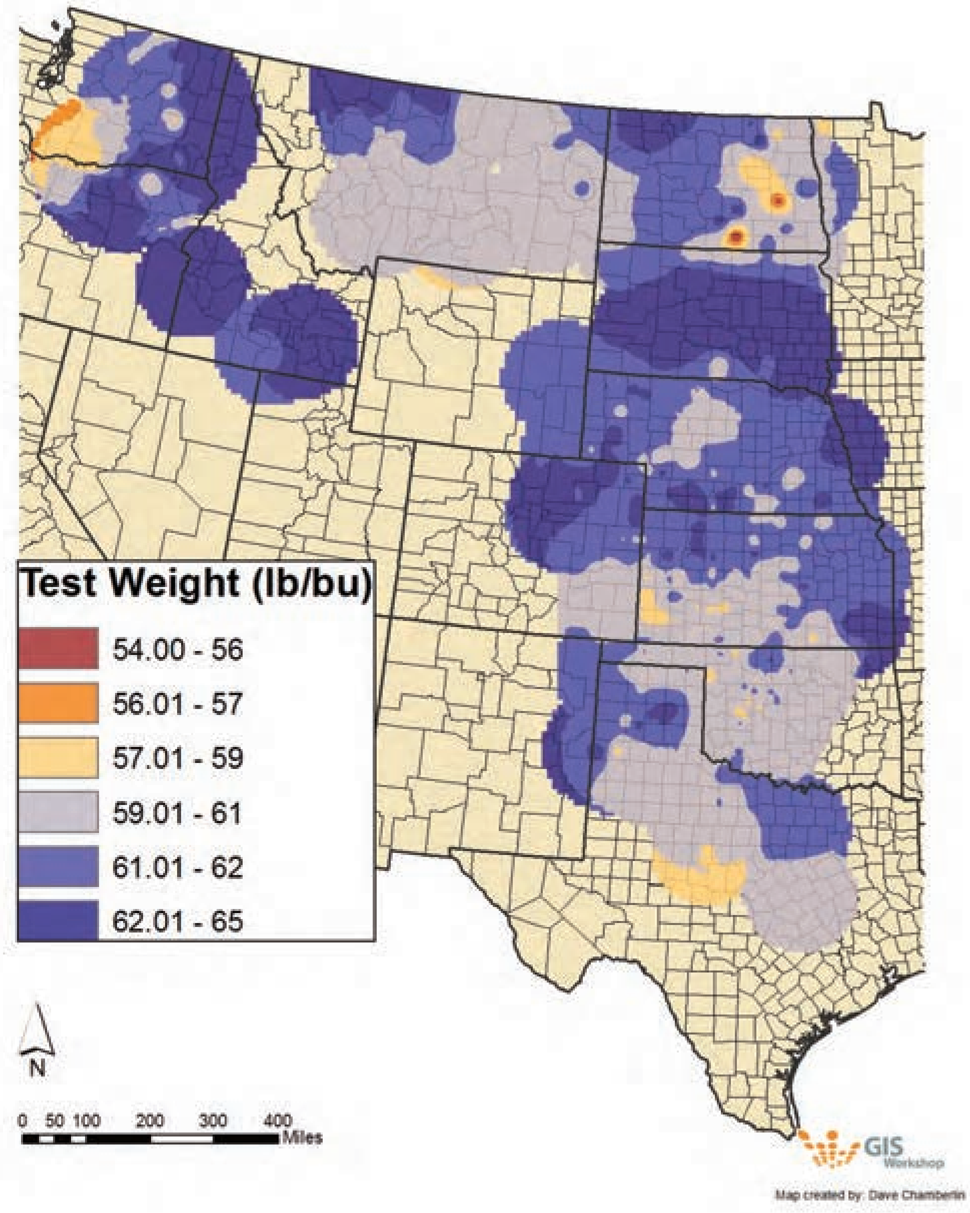
Foreign material is all matter other than wheat that remains in the sample after the removal of dockage and shrunken and broken kernels.

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.

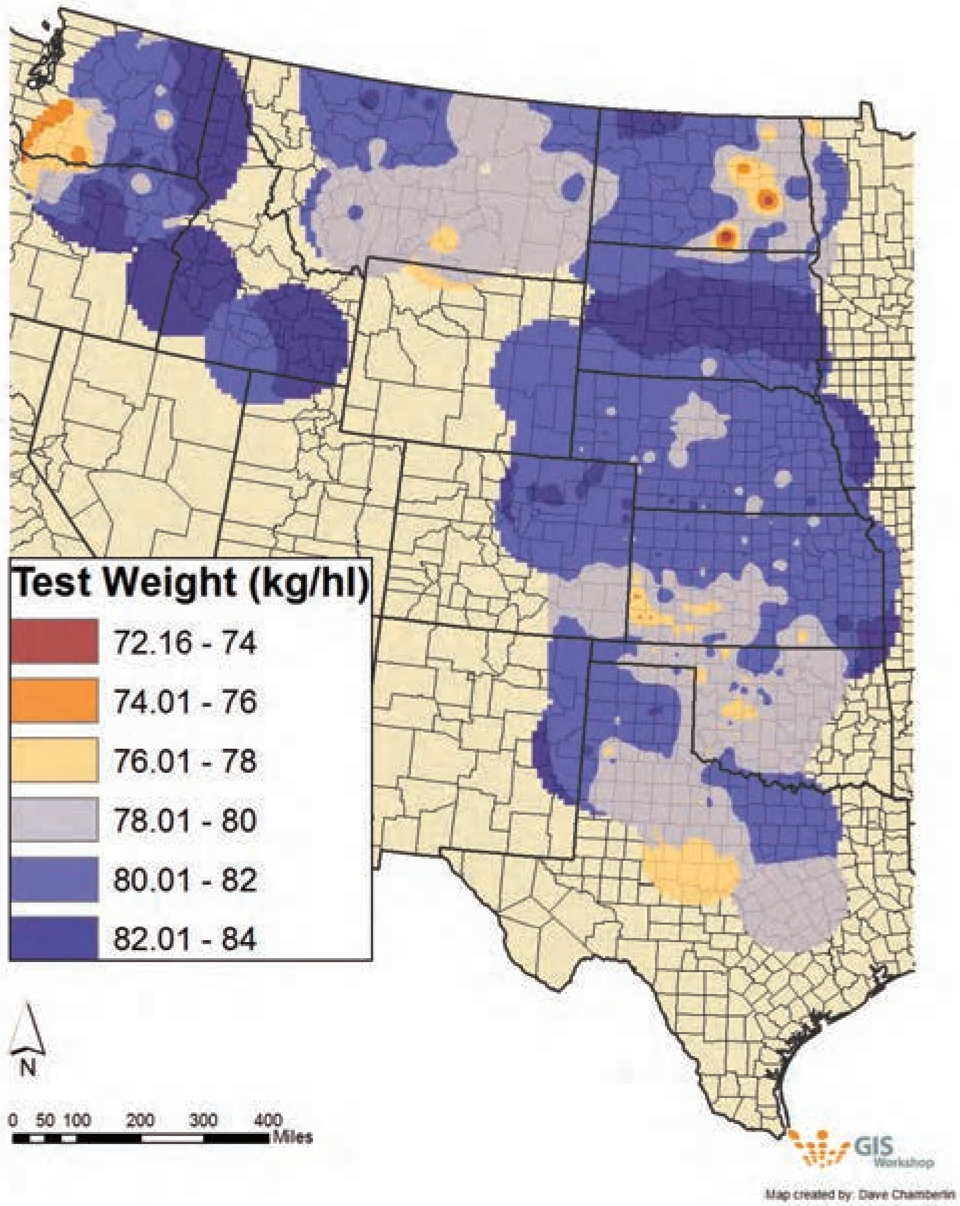
Damaged kernels are kernels, pieces of wheat kernels, and other grains that are badly ground-damaged, badly weatherdamaged, diseased, frost-damaged, germdamaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged, or otherwise materially damaged.

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

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Location		Official Grade (U.S. NO.)	Test Wt (lb/bu)	Test Wt (kg/hl)	Moisture (%)	Damage Kernels Total (%)	Shrunken & Broken Kernels (%)	Total Defects (%)
Colorado	C01	1	60.5	79.6	11.5	0.1	0.9	1.0
	C02	1	61.7	81.2	8.3	0.1	1.5	1.6
	C03	1	62.0	81.6	9.1	0.1	1.2	1.4
Kansas	K01	2	58.6	77.1	9.1	0.1	1.2	1.4
	K02	1	60.1	79.1	11.8	0.0	1.2	1.3
	K03	1	60.1	79.1	11.6	0.2	1.5	1.6
	K04	1	60.6	79.7	11.6	0.0	1.4	1.6
	K05	1	60.7	79.8	11.5	0.0	1.3	1.4
	K06	1	61.6	81.0	10.0	0.1	1.1	1.3
	K07	1	61.6	81.1	11.2	0.0	1.1	1.2
	K08	1	60.9	80.1	10.7	0.1	1.4	1.6
	K09	1	61.1	80.4	10.5	0.1	1.4	1.7
	K10	1	61.7	81.2	9.9	0.0	1.3	1.4
Montana	M01	2	59.5	78.3	9.1	0.0	2.2	2.3
	M02	1	61.7	81.1	10.6	0.0	1.3	1.3
	M03	1	61.1	80.4	9.8	0.0	1.7	1.7
	M04	1	60.7	79.8	9.6	0.0	1.3	1.6
	M05	1	60.9	80.1	10.8	0.0	0.8	0.9
	M06	2	59.4	78.2	9.6	0.0	1.4	1.6
	M07	1	60.6	79.6	9.5	0.1	1.8	1.9
Nebraska	N01	1	61.7	81.1	10.6	0.0	1.1	1.3
	N02	1	61.7	81.1	10.8	0.2	0.9	1.1
	N03	1	61.8	81.2	11.0	0.1	0.9	1.2
	N04	1	61.5	80.9	10.7	0.3	1.3	1.5
	N05	1	61.6	81.0	11.0	0.1	1.3	1.5
North Dakota	ND01	1	61.3	80.7	11.3	0.3	1.2	1.5
	ND02	1	61.2	80.4	13.1	0.2	0.7	1.0
	ND03	1	60.2	79.2	12.1	0.2	1.3	1.7
Oklahoma	O01	2	59.7	78.5	11.3	0.1	1.4	1.6
	O02	1	60.3	79.3	11.8	0.1	1.7	1.9
	O03	1	60.1	79.1	11.0	0.1	1.4	1.5
	O04	1	60.1	79.0	12.7	0.0	1.4	2.0
	O05	1	61.0	80.2	11.3	0.1	1.4	1.8
	O06	1	60.7	79.9	11.8	0.2	1.7	2.4
	O07	2	59.9	78.9	11.8	0.4	1.9	2.8
Pacific Northwest	PNW01	1	61.7	81.1	8.6	0.0	0.7	0.8
	PNW02	1	61.9	81.4	10.0	0.0	1.0	1.1
	PNW03	1	63.2	83.1	8.5	0.1	0.5	0.6
	PNW04	1	61.9	81.4	8.6	0.0	0.6	0.7
South Dakota	SD01	1	62.6	82.3	10.8	0.1	0.9	1.1
	SD02	1	62.6	82.2	11.5	0.1	0.8	0.9
Texas	T01	1	60.3	79.3	10.6	1.6	1.3	3.0
	T02	1	60.8	79.9	10.7	0.1	1.7	1.9
	T03	1	61.6	81.0	11.8	0.3	1.0	1.3
	T04	1	60.3	79.3	13.6	0.5	0.9	1.5
	T05	1	62.0	81.5	11.7	0.0	0.8	0.9
	T06	1	60.3	79.4	10.9	0.0	1.7	1.8
Wyoming	W01	1	61.5	80.9	9.7	0.0	1.3	1.5

Kernel Quality Data

Location		Foreign Material (%)	Kernel Size Large (%)	Kernel Size Med (%)	Kernel Size Small (%)	SKCS Wt (mg)	SKCS Diam (mm)
Colorado	C01	0.0	54	45	1	28.1	2.57
	C02	0.1	50	49	1	28.4	2.60
	C03	0.2	46	52	1	27.7	2.56
Kansas	K01	0.1	41	59	1	26.7	2.53
	K02	0.1	39	59	2	26.7	2.52
	K03	0.1	42	56	2	26.8	2.53
	K04	0.2	46	52	2	27.5	2.57
	K05	0.1	51	47	1	28.0	2.59
	K06	0.1	53	46	1	29.0	2.60
	K07	0.1	53	46	1	28.6	2.60
	K08	0.1	52	46	2	27.8	2.60
	K09	0.4	50	49	1	27.0	2.56
	K10	0.0	61	38	1	29.5	2.64
Montana	M01	0.1	48	50	2	27.3	2.55
	M02	0.1	51	47	2	28.5	2.57
	M03	0.0	47	50	3	27.3	2.55
	M04	0.3	50	48	2	27.4	2.55
	M05	0.1	63	37	1	29.9	2.59
	M06	0.2	48	51	1	28.7	2.59
	M07	0.1	51	46	3	28.3	2.56
Nebraska	N01	0.1	50	49	1	28.7	2.58
	N02	0.0	55	44	1	28.9	2.60
	N03	0.1	60	39	1	29.1	2.62
	N04	0.0	57	42	1	28.3	2.59
	N05	0.1	47	51	1	28.4	2.58
North Dakota	ND01	0.1	65	34	1	30.6	2.69
	ND02	0.1	73	26	1	31.6	2.67
	ND03	0.1	60	39	2	29.4	2.61
Oklahoma	O01	0.1	51	49	2	27.7	2.53
	O02	0.1	42	57	1	26.4	2.55
	O03	0.1	44	55	1	27.4	2.55
	O04	0.6	48	52	1	26.8	2.55
	O05	0.3	49	50	1	28.4	2.56
	O06	0.4	52	46	2	28.7	2.55
	O07	0.4	46	52	2	29.4	2.58
Pacific Northwest	PNW01	0.0	81	18	0	34.5	2.82
	PNW02	0.0	84	15	1	35.3	2.80
	PNW03	0.0	83	17	0	34.7	2.84
	PNW04	0.1	70	29	1	31.7	2.73
South Dakota	SD01	0.1	65	34	1	31.2	2.69
	SD02	0.1	71	28	1	32.7	2.73
Texas	T01	0.2	47	52	1	27.8	2.56
	T02	0.1	50	48	2	28.4	2.55
	T03	0.1	62	37	1	30.0	2.60
	T04	0.1	49	50	1	28.1	2.57
	T05	0.1	53	47	1	29.4	2.62
	T06	0.1	45	53	2	28.3	2.57
Wyoming	W01	0.1	39	59	2	26.7	2.54

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.

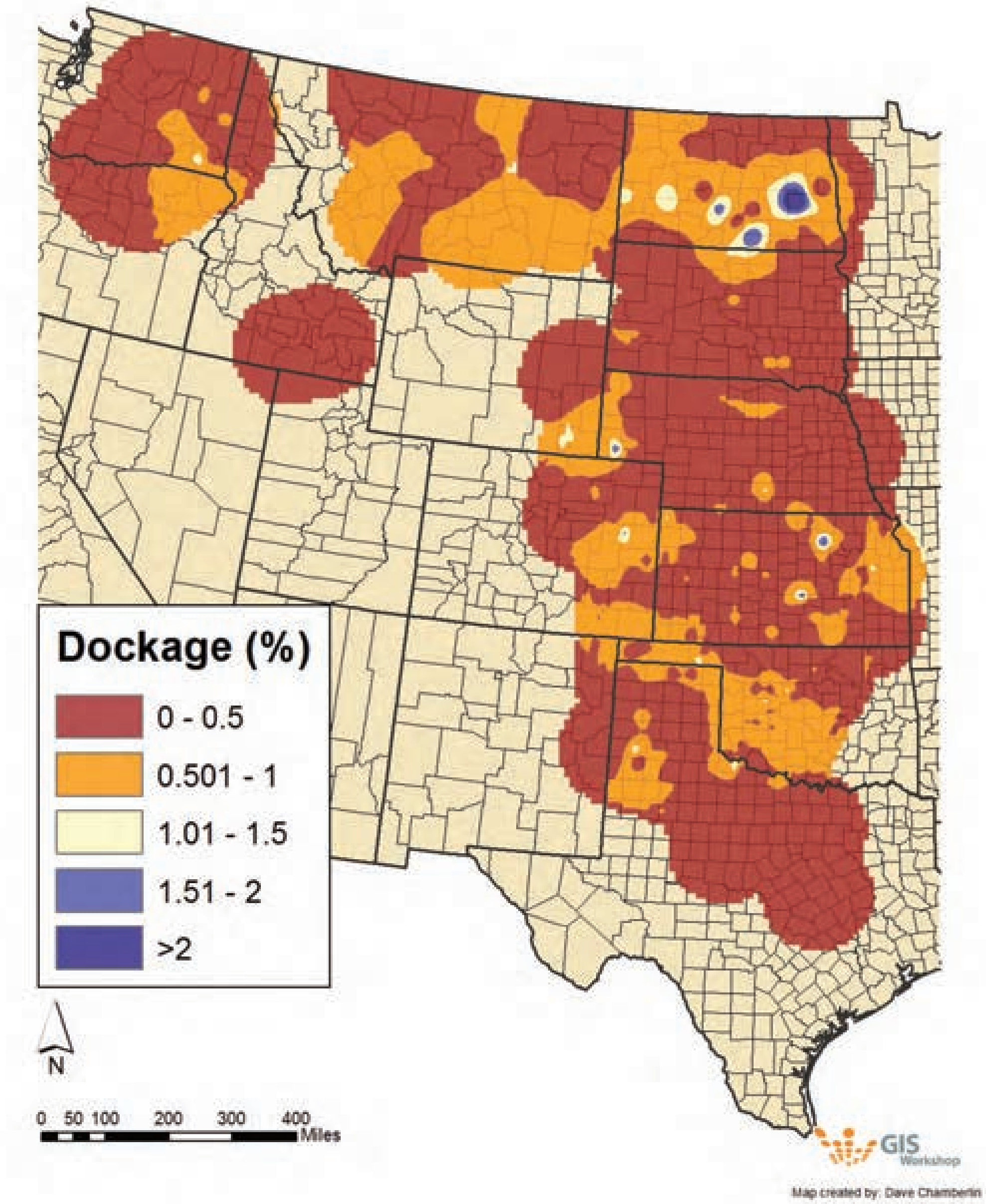
Falling number is an index of enzyme activity in wheat or flour and is expressed in seconds. Falling numbers above 300 are desirable, as they indicate little enzyme activity and a sound quality product. Falling numbers below 300 are indicative of more substantial enzyme activity and sprout damage.

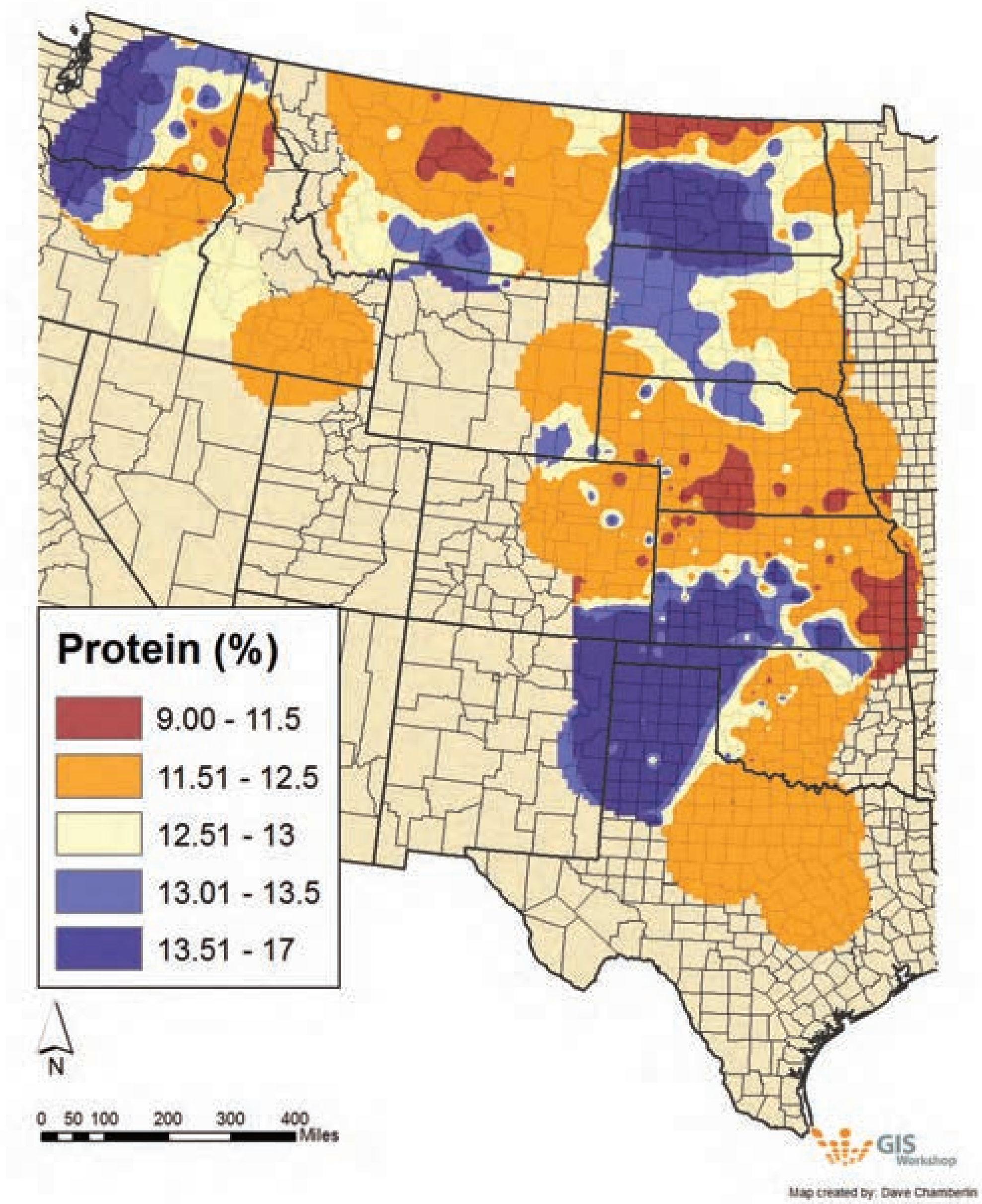
Dockage is all matter other than wheat that can be removed from the original sample by use of an approved device according to procedures prescribed in FGIS instructions.

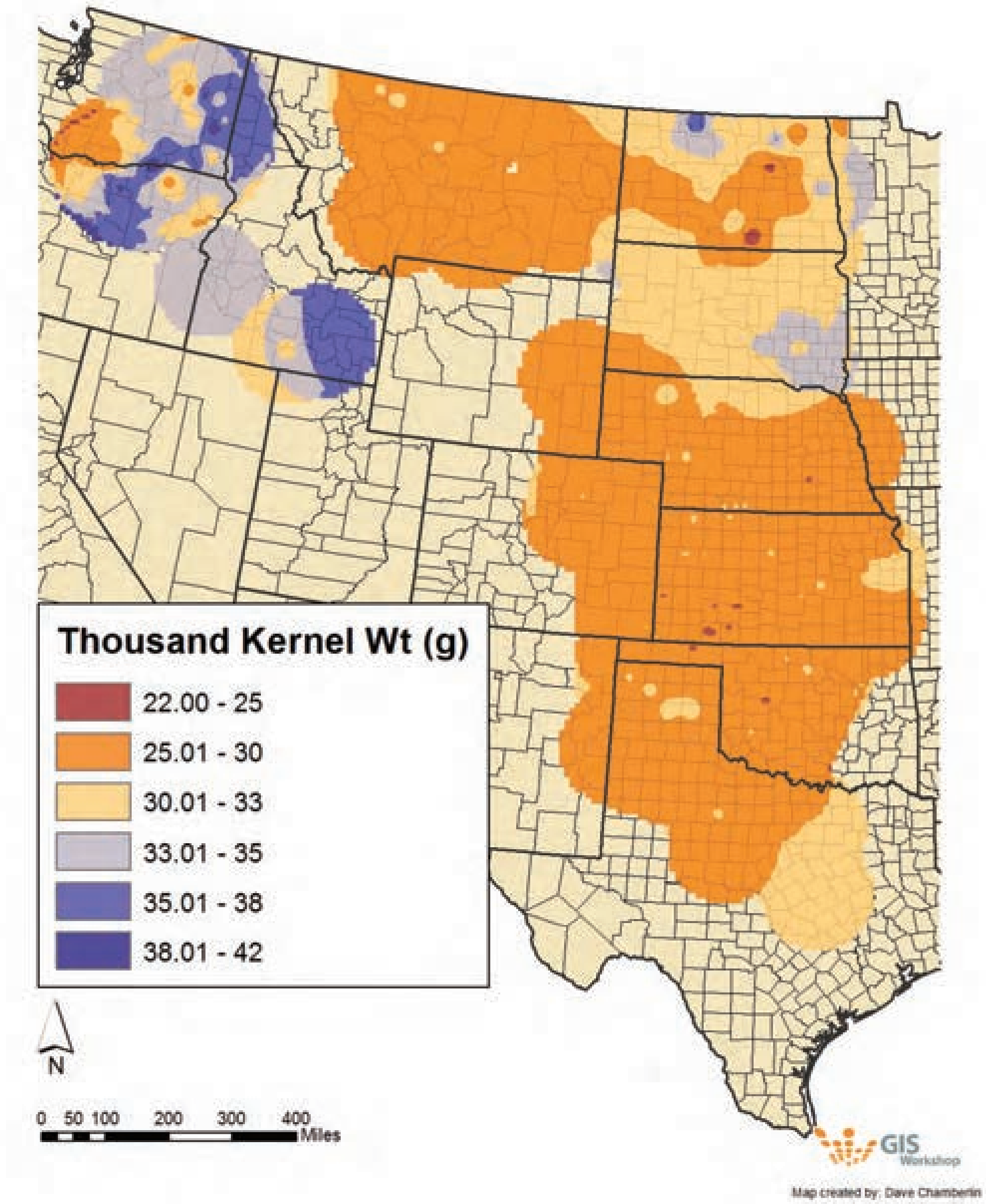
Kernel Size is a measure of the percentage by weight of large, medium and small kernels in a sample. Large kernels or more uniform kernel size may help improve milling yield.

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 (%)

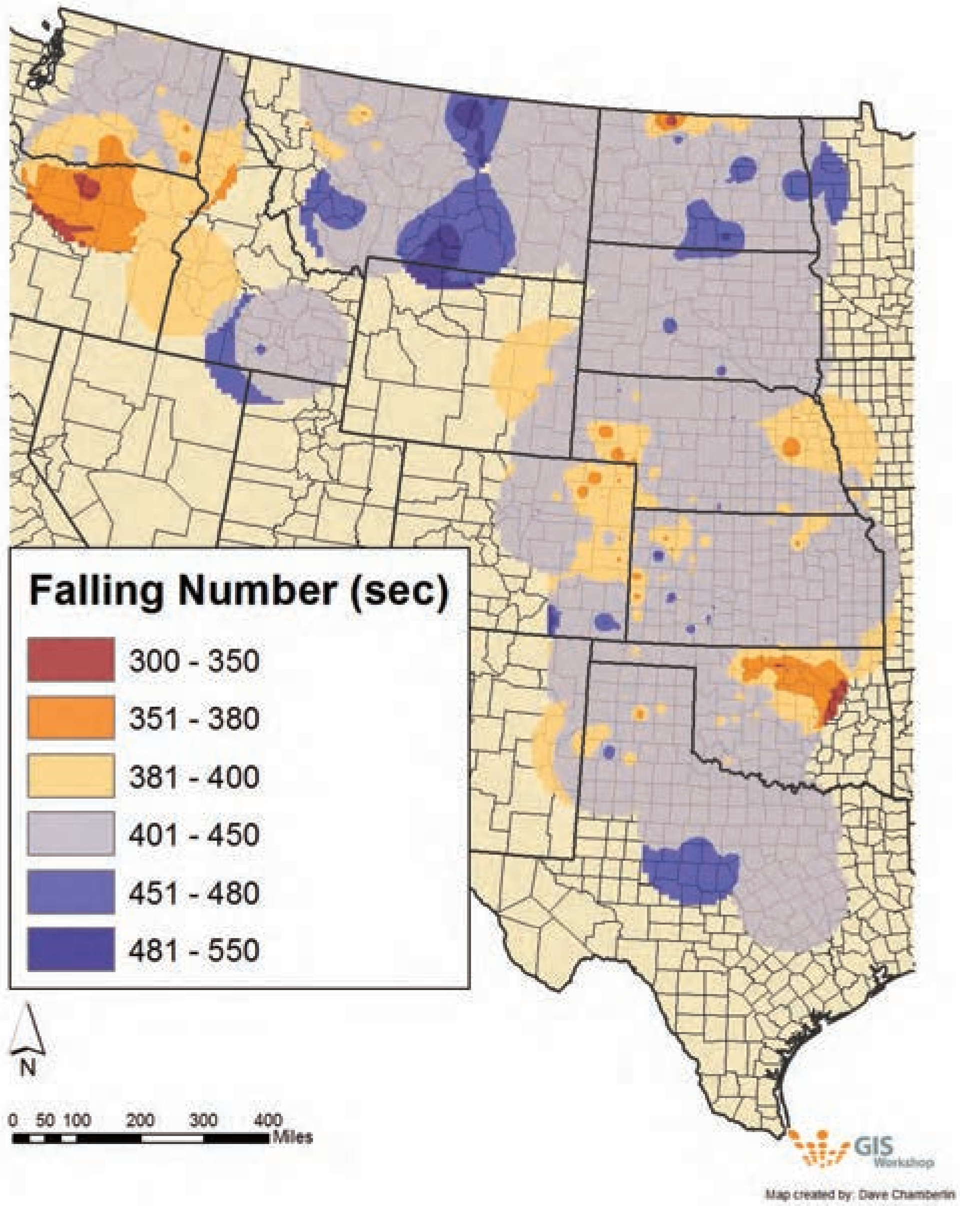

Dockage (%)
0 - 0.5
0.501 - 1
1.01 - 1.5
1.51 - 2
>2
N
0 50 100 200 300 400
Miles
GIS
Workshop
Map created by: Dave Chamberlin


Protein (%)
9.00 - 11.5
11.51 - 12.5
12.51 - 13
13.01 - 13.5
13.51 - 17
N
0 50 100 200 300 400
Miles
GIS Workshop
Map created by: Dave Chamberlin



Thousand Kernel Wt (g)
22.00 - 25
25.01 - 30
30.01 - 33
33.01 - 35
35.01 - 38
38.01 - 42
N
0 50 100 200 300 400
Miles
GIS
Workshop
Map created by: Dave Chamberlin

Falling Number (seconds)



Other Wheat Characteristics (Non-Grade Data)

PGI

Location		NIR Wheat Protein (12% mb)	Wheat Ash (12% mb)	Falling Number (sec)	Moisture (%)	SKCS Ave Hard
Colorado	C01	13.0	1.59	433	11.5	64
	C02	12.1	1.50	402	8.3	74
	C03	12.1	1.42	395	9.1	73
Kansas	K01	13.4	1.60	401	9.1	71
	K02	13.9	1.62	420	11.8	77
	K03	14.1	1.61	433	11.6	76
	K04	13.4	1.53	429	11.6	73
	K05	13.1	1.57	424	11.5	73
	K06	11.9	1.49	408	10.0	73
	K07	12.2	1.53	409	11.2	75
	K08	12.5	1.55	418	10.7	70
	K09	12.3	1.56	398	10.5	70
	K10	11.7	1.43	417	9.9	69
Montana	M01	12.8	1.41	478	9.1	69
	M02	11.6	1.41	425	10.6	72
	M03	11.7	1.42	404	9.8	73
	M04	11.5	1.41	438	9.6	72
	M05	12.5	1.32	441	10.8	69
	M06	12.3	1.20	445	9.6	64
	M07	12.9	1.39	446	9.5	75
Nebraska	N01	12.0	1.42	388	10.6	71
	N02	11.6	1.47	409	10.8	68
	N03	11.3	1.55	414	11.0	68
	N04	11.6	1.53	410	10.7	70
	N05	12.4	1.51	428	11.0	73
North Dakota	ND01	14.2	1.40	438	11.3	68
	ND02	11.6	1.43	417	13.1	61
	ND03	13.3	1.46	447	12.1	65
Oklahoma	O01	12.5	1.53	416	11.3	75
	O02	12.2	1.56	415	11.8	81
	O03	14.1	1.54	418	11.0	77
	O04	15.4	1.62	398	12.7	78
	O05	12.8	1.61	392	11.3	82
	O06	12.1	1.54	381	11.8	79
	O07	12.4	1.56	345	11.8	82
Pacific Northwest	PNW01	12.9	1.38	397	8.6	68
	PNW02	12.6	1.34	359	10.0	67
	PNW03	12.3	1.38	394	8.5	69
	PNW04	12.3	1.64	417	8.6	76
South Dakota	SD01	12.9	1.55	430	10.8	72
	SD02	12.4	1.58	426	11.5	70
Texas	T01	13.6	1.55	284	10.6	74
	T02	11.9	1.54	419	10.7	76
	T03	12.2	1.54	417	11.8	66
	T04	14.8	1.54	387	13.6	74
	T05	14.3	1.57	409	11.7	80
	T06	14.2	1.54	437	10.9	76
Wyoming	W01	13.0	1.42	403	9.7	75

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	73.4	46.8	11.2	0.49	96.1	92.1	-1.1	10.5
	C02	74.3	43.1	10.8	0.50	95.7	91.5	-1.2	10.8
	C03	73.0	45.5	10.7	0.45	95.4	91.9	-1.3	10.7
Kansas	K01	71.0	52.7	12.1	0.50	84.9	92.2	-1.3	10.9
	K02	71.0	62.2	12.6	0.49	93.9	91.9	-1.2	11.2
	K03	75.1	59.0	14.6	0.53	92.2	91.6	-1.2	11.2
	K04	74.0	56.4	12.3	0.47	91.0	91.9	-1.2	11.2
	K05	75.3	49.1	11.9	0.54	90.5	91.5	-1.2	11.3
	K06	73.6	46.2	10.4	0.47	94.1	92.0	-1.2	10.5
	K07	73.8	50.8	10.9	0.48	96.7	92.0	-1.3	10.9
	K08	74.3	47.3	11.0	0.48	94.5	92.1	-1.3	11.0
	K09	73.9	44.6	10.9	0.48	95.8	92.1	-1.4	10.9
	K10	74.5	45.7	10.3	0.46	95.1	92.2	-1.3	10.7
Montana	M01	72.7	44.7	11.6	0.48	96.6	92.3	-1.3	10.7
	M02	74.0	40.0	10.6	0.46	98.9	92.1	-1.2	10.2
	M03	74.2	41.5	10.7	0.49	96.4	92.1	-1.2	10.4
	M04	78.3	43.6	10.6	0.60	94.1	91.0	-0.9	11.1
	M05	77.3	45.9	11.3	0.58	96.9	91.3	-1.1	11.1
	M06	71.1	57.9	10.9	0.47	93.2	91.8	-1.1	11.0
	M07	78.7	57.0	12.0	0.66	83.4	91.1	-0.7	10.9
Nebraska	N01	77.7	41.2	10.7	0.66	96.5	91.0	-0.6	10.8
	N02	79.5	40.3	10.1	0.58	94.9	91.1	-0.9	11.0
	N03	79.9	41.2	9.8	0.63	92.5	90.0	-0.5	10.9
	N04	76.9	48.3	10.1	0.58	93.6	91.2	-0.8	10.3
	N05	78.5	39.6	11.0	0.61	97.6	91.2	-0.9	10.9
North Dakota	ND01	77.9	37.5	12.8	0.54	89.5	91.7	-1.0	10.4
	ND02	74.5	63.9	10.2	0.50	90.8	91.3	-0.9	10.6
	ND03	76.6	58.6	12.0	0.52	88.2	91.6	-0.9	10.6
Oklahoma	O01	79.8	53.9	11.3	0.59	87.6	91.1	-0.8	10.9
	O02	73.1	54.5	11.0	0.45	96.5	91.8	-1.0	10.1
	O03	74.1	53.3	12.6	0.45	96.9	92.0	-1.2	10.2
	O04	74.0	51.1	14.1	0.45	99.0	92.1	-1.3	10.9
	O05	71.5	50.1	11.1	0.48	98.0	91.9	-1.1	10.2
	O06	75.4	54.1	10.7	0.45	95.2	91.5	-1.1	10.5
	O07	74.4	53.0	11.3	0.41	99.7	91.7	-1.0	10.0
Pacific Northwest	PNW01	73.6	63.3	12.0	0.46	98.6	91.5	-1.1	10.5
	PNW02	74.3	61.5	11.4	0.46	95.3	91.7	-1.0	10.2
	PNW03	75.4	51.8	11.0	0.46	97.9	91.8	-1.3	10.3
	PNW04	73.8	53.8	11.3	0.47	94.5	91.3	-1.1	10.0
South Dakota	SD01	74.7	46.1	11.6	0.48	97.1	91.8	-1.2	10.5
	SD02	75.9	45.2	11.0	0.47	93.7	91.8	-1.1	10.6
Texas	T01	77.5	47.6	12.5	0.48	91.0	91.2	-1.1	10.7
	T02	76.4	52.2	10.7	0.44	97.7	91.4	-0.8	9.2
	T03	76.4	50.2	11.1	0.43	96.9	91.4	-1.0	10.2
	T04	74.5	45.2	13.2	0.53	85.2	91.4	-1.5	11.9
	T05	76.4	51.5	12.8	0.48	96.4	91.6	-1.0	10.0
	T06	76.3	44.3	13.0	0.45	94.8	91.9	-1.1	10.2
Wyoming	W01	74.4	52.0	11.7	0.48	90.4	91.6	-1.2	11.1

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	75	110	264	0.68	58.3	5.5	12.0	31
	C02	77	94	233	0.82	58.8	4.5	9.2	33
	C03	78	94	245	0.83	58.4	5.5	10.6	35
Kansas	K01	80	108	284	0.74	59.3	7.8	14.9	26
	K02	96	101	334	0.95	60.4	6.0	17.0	23
	K03	80	117	297	0.68	60.5	7.2	17.0	16
	K04	81	113	304	0.72	59.2	4.7	14.5	11
	K05	72	111	245	0.65	60.3	7.0	12.6	32
	K06	80	103	266	0.78	58.0	4.7	9.4	36
	K07	81	92	253	0.88	58.7	5.3	10.9	34
	K08	74	106	255	0.70	57.9	5.5	12.4	27
	K09	65	136	266	0.48	56.7	4.0	9.4	34
	K10	72	91	217	0.79	57.0	4.4	9.1	35
Montana	M01	76	87	227	0.87	57.7	5.8	11.9	32
	M02	69	91	210	0.76	55.7	4.7	9.8	33
	M03	66	97	203	0.68	57.1	5.0	8.9	45
	M04	67	95	190	0.71	58.0	5.9	10.4	34
	M05	65	122	210	0.53	57.8	4.3	6.5	52
	M06	95	98	310	0.97	60.5	6.7	15.5	22
	M07	75	97	224	0.77	62.7	6.4	9.2	29
Nebraska	N01	77	79	184	0.97	59.4	4.2	7.3	48
	N02	65	92	166	0.71	58.4	3.3	5.9	52
	N03	61	98	157	0.62	58.8	4.5	6.5	44
	N04	74	101	215	0.73	60.5	4.2	7.0	43
	N05	76	95	212	0.80	58.4	4.4	7.9	40
North Dakota	ND01	65	85	157	0.76	58.8	5.2	8.4	34
	ND02	98	93	304	1.05	62.4	6.7	16.6	23
	ND03	93	93	263	1.00	63.7	5.4	11.7	21
Oklahoma	O01	86	101	263	0.85	62.1	5.0	9.0	32
	O02	84	99	327	0.85	57.7	5.9	17.4	23
	O03	78	99	280	0.79	56.9	6.0	12.2	33
	O04	72	111	283	0.65	57.0	5.5	12.0	28
	O05	89	92	313	0.97	57.2	2.4	11.6	25
	O06	73	125	299	0.58	58.4	4.8	9.7	32
	O07	83	80	270	1.04	57.5	5.0	16.2	16
Pacific Northwest	PNW01	80	113	342	0.71	58.4	5.7	15.9	25
	PNW02	91	135	400	0.67	58.9	6.7	17.0	11
	PNW03	79	107	286	0.74	55.2	5.5	10.5	37
	PNW04	70	139	243	0.50	56.6	4.2	11.9	23
South Dakota	SD01	69	99	234	0.70	56.9	5.2	11.9	27
	SD02	71	83	201	0.86	58.1	5.0	7.4	50
Texas	T01	91	125	348	0.72	59.5	5.7	9.4	41
	T02	91	111	352	0.82	58.5	5.8	13.1	27
	T03	101	99	345	1.02	58.6	5.2	8.9	45
	T04	96	99	283	0.97	62.1	5.5	8.2	40
	T05	66	126	259	0.52	59.1	4.8	13.1	22
	T06	69	92	216	0.75	57.5	5.8	11.7	20
Wyoming	W01	74	111	267	0.67	59.1	5.2	10.2	29

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

PGI

Location		Bake Mix (min)	Bake Abs (14% mb)	Loaf Volume (cc)	Crumb Grain (1-10)	Crumb Texture (1-10)	Crumb Color
Colorado	C01	4.0	62.2	790	5.5	5.5	Yellow
	C02	4.0	61.6	755	4.8	5.5	Yellow
	C03	4.4	60.7	800	7.0	7.0	Dull
Kansas	K01	4.0	62.2	770	4.0	5.5	Yellow
	K02	4.3	64.0	775	5.3	4.0	Yellow
	K03	4.5	64.0	800	2.5	5.5	Yellow
	K04	5.0	62.7	820	4.0	5.5	Yellow
	K05	4.3	62.9	780	4.0	5.5	Dull
	K06	4.6	61.1	735	3.3	5.5	Yellow
	K07	5.0	61.3	790	7.0	7.0	Dull
	K08	4.5	61.2	820	7.8	7.0	Creamy
	K09	5.0	60.8	750	7.0	5.5	Creamy
	K10	5.3	61.0	755	6.8	5.5	Dull
Montana	M01	4.8	60.1	780	6.3	5.5	Yellow
	M02	5.0	59.2	745	4.0	5.5	Dull
	M03	4.6	60.4	690	4.8	5.5	Yellow
	M04	4.4	62.2	770	4.0	5.5	Yellow
	M05	5.3	62.5	760	7.0	4.0	Yellow
	M06	4.0	63.5	865	4.8	5.5	Yellow
	M07	3.5	63.4	820	2.5	5.5	Yellow
Nebraska	N01	4.5	61.4	805	4.0	5.5	Yellow
	N02	4.3	62.6	815	4.8	5.5	Yellow
	N03	4.3	60.6	740	3.3	5.5	Yellow
	N04	3.5	63.3	835	3.3	5.5	Yellow
	N05	4.5	61.7	755	4.8	7.0	Yellow
North Dakota	ND01	3.5	60.4	775	4.0	4.0	Yellow
	ND02	4.1	64.6	875	5.3	5.5	Yellow
	ND03	3.4	64.0	820	4.8	5.5	Yellow
Oklahoma	O01	4.0	63.8	800	4.8	5.5	Yellow
	O02	6.5	60.8	865	7.8	7.0	Creamy
	O03	6.0	61.3	775	7.4	7.0	Dull
	O04	6.0	61.0	820	7.0	7.0	Dull
	O05	6.3	59.9	725	4.0	5.5	Dull
	O06	4.5	60.9	735	3.3	5.5	Dull
	O07	6.3	61.2	830	6.8	7.0	Creamy
Pacific Northwest	PNW01	6.5	62.6	915	6.3	7.0	Creamy
	PNW02	4.8	64.6	945	7.8	7.0	Dull
	PNW03	6.3	59.4	750	7.8	5.5	Creamy
	PNW04	5.5	62.1	805	4.8	7.0	Dull
South Dakota	SD01	5.0	61.8	750	6.3	5.5	Dull
	SD02	4.8	58.4	695	4.0	5.5	Dull
Texas	T01	4.0	61.3	775	5.5	7.0	Dull
	T02	6.4	61.3	810	7.0	7.0	Dull
	T03	5.5	61.2	780	6.3	5.5	Dull
	T04	4.0	60.0	775	5.5	7.0	Yellow
	T05	4.8	61.7	770	6.3	7.0	Dull
	T06	4.4	61.1	800	5.5	5.5	Dull
Wyoming	W01	4.5	62.7	850	4.0	5.5	Yellow

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.