

Wheat Quality Evaluations from the 2016 CSU Dryland and Irrigated Variety Trials

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Introduction

End-use quality maintenance and improvement is an important objective of virtually all wheat breeding programs. Grain milling and product manufacturing industries have become increasingly sophisticated in both domestic and export markets and, while wheat producers are seldom rewarded for improved functional quality, technological advancements promise to increase the ability of the trade to identify and source good quality and discount poor quality in the market place.

Breeding for wheat end-use quality is relatively complex in comparison to many breeding objectives. Quality is a function of variety interacting with climate and agronomic practices and Colorado's harsh and variable climatic conditions often negatively impact quality. Quality assessment is commonly done through evaluation of multiple traits with many underlying genetic factors controlling their expression. Most experimental quality tests only approximate average quality needs of product manufacturers and don't exactly match specific requirements of different wheat product types and processes. For hard winter wheat, high grain protein content is an important criterion for improved quality but is generally associated with lower yield (and vice versa). Finally, wheat quality testing must accommodate the reality of large sample numbers and small sample sizes that are typical of all wheat breeding programs. Despite these challenges, standard testing methodologies have been developed that are consistent, repeatable, and can be done on large numbers of relatively small samples. These analyses provide reliable assessments of functional quality characteristics for a broad array of potential product types and processes.

Our objective with providing quality data and summaries for entries in the CSU Dryland and Irrigated Variety Trials is to characterize the quality of public and private trial entries that are currently or have the potential to be marketed in Colorado. We hope that the data and resulting ratings will be included among the criteria by which wheat producers choose their varieties. At the very least, we encourage producers to carefully consider avoiding varieties that have lower wheat quality when other agronomically acceptable varieties with better quality are available.

Testing Methodology

In 2016, grain samples were collected from six dryland (UVPT) variety trial locations (Arapahoe, Julesburg, Orchard, Roggen, Yuma, Walsh) and two irrigated (IVPT) variety trial locations (Fort Collins, Haxtun). Preliminary small-scale quality analyses were carried out to determine sample suitability for full-scale analyses, with criteria including grain protein not too far below or above 12% grain protein content, sound grain free of visual defects, and good discrimination among samples at a given location for experimental dough mixing properties. In this process of sample selection, the Julesburg, Orchard, and Roggen dryland locations were excluded from analyses beyond protein content due to average protein values being well below the level required for meaningful dough mixing and baking quality evaluations. During sample processing we also realized that the Haxtun location was infected by *Fusarium* head blight, though much less than observed in 2016.

Using standard protocols, analyses were done in the CSU Wheat Quality Laboratory on samples from the remaining locations. These tests, reported in the attached tables, include the following:

Milling-Related Traits

- Test weight: obtained by standard methodology on a cleaned sample of the harvested grain.
- Grain protein and protein recovery: obtained using near-infrared reflectance spectroscopy (NIRs) with a Foss NIRS™ DA1650 Feed and Forage analyzer. Grain protein is reported on a

standard 12% moisture basis. High grain protein content is associated with higher water absorption of flours and higher loaf volumes in the bakery. Protein recovery represents the numerical difference between grain and flour protein content and a lower value is most desirable by the milling industry.

- Single kernel characterization system (SKCS): the Perten SKCS 4100 provides data on kernel weight and hardness of a grain sample. From 100-300 kernels are analyzed to provide an average value and a measure of variability for each trait. Millers prefer a uniform sample with heavier (>30 grams per 1000 kernels, or >15,133 seeds per pound) kernels for improved milling performance. Hardness should be representative of the hard winter wheat class (60-80 hardness units).
- Flour yield: obtained using a modified Brabender Quadrumat Milling System. Flour yield represents the percentage of straight grade flour obtained from milling a grain sample (approximately one pound). In general, millers prefer high flour extraction values. Due to variation among different milling systems, valid comparison of values from different mills and establishment of a single target value is not possible.

Baking-Related Traits

- Mixograph mixing time and tolerance: obtained using a National Manufacturing Computerized Mixograph. The Mixograph measures the resistance of dough during the mixing process. Bakers generally prefer flours with moderate mixing time requirements (between 3 and 6 minutes) and good tolerance to breakdown of the dough with over-mixing (subjective score >3). Some varieties with exceptionally long mixing times (i.e., Snowmass, Sunshine) may not compare favorably with other varieties in conventional evaluations but have unique characteristics that merit handling in an identity-preserved program such as with the CWRF Ardent Mills UltraGrain® Premium Program.
- Pup loaf bake test: using a 100-gram straight-dough test, data on bake water absorption, mixing time, loaf volume, and crumb characteristics are obtained. In general, bakers prefer higher water absorption (> 62%), high loaf volume (> 850 cubic centimeters), and higher crumb grain and crumb color scores (score > 3). The crumb grain and color scores are subjective assessments of the color and size, shape, and structure of the small holes in a slice of bread.

Composite Scores

Because none of the traits measured can be used alone to represent overall milling or baking quality, development of a composite score has proven useful as a means to differentiate and characterize overall quality of different samples. The development of a composite score also has the advantage of "smoothing" out differences in environmental conditions from year to year and utilizing all of the data generated on the samples from year to year.

Composite scores are generated through a two-step process. First, each trait is ranked from high to low (or "good" to "bad") at individual locations and a score from 1=good to 9=bad is assigned to each variety for each trait depending on the optimal orientation of the trait. Second, these individual-trait scores are used to generate a composite score that weights the trait scores by the relative importance of that trait to overall milling or baking quality. The weights that we have used are similar to those developed by the USDA-ARS Hard Winter Wheat Quality Laboratory for the Wheat Quality Council evaluations. These weights are as follows:

Milling – test weight 30%, grain protein content 10%, protein recovery 10%, kernel weight 20%, grain hardness 10%, flour yield 20% (100% total)

Baking – bake absorption 20%, Mixograph mixing time 20%, Mixograph tolerance 20%, loaf volume 20%, crumb color 10%, crumb grain 10% (100% total)

Wheat Milling and Baking Quality Data - 2016 Arapahoe

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Akron	54.1	11.9	28.0	<u>44.9</u>	65.7	-0.9	61.1	3.91	4	1000	5	5	4	2
Antero	55.4	<u>10.0</u>	31.9	<u>29.3</u>	68.4	-0.9	<u>57.0</u>	5.11	3	<u>715</u>	3	3	4	7
Avery	53.0	12.4	25.6	<u>45.3</u>	66.3	<u>-1.2</u>	61.0	5.21	5	1020	4	4	5	1
Brawl CL Plus	55.8	11.8	28.2	<u>48.8</u>	68.7	-0.9	60.7	5.08	4	955	5	4	3	2
Byrd	53.6	11.5	25.6	<u>38.8</u>	69.2	-0.5	61.2	5.35	5	965	5	5	4	1
CO11D1539	52.7	<u>10.6</u>	31.1	<u>35.9</u>	67.1	<u>-1.4</u>	<u>58.2</u>	4.39	4	775	4	3	6	5
CO12D2011	57.5	11.5	28.6	<u>48.6</u>	69.1	-1.0	62.2	4.53	4	885	5	4	1	3
CO14A058	<u>50.5</u>	11.9	<u>25.3</u>	<u>51.3</u>	<u>64.8</u>	<u>-1.3</u>	61.0	3.61	3	785	3	<u>2</u>	<u>9</u>	6
CO14A065	<u>50.3</u>	11.2	<u>21.5</u>	<u>51.2</u>	<u>64.9</u>	-0.6	60.2	5.36	5	870	4	3	<u>9</u>	3
Cowboy	52.7	13.7	25.7	<u>51.7</u>	<u>65.5</u>	-0.8	65.0	3.49	3	835	<u>2</u>	<u>2</u>	5	4
Denali	55.2	11.4	29.2	<u>38.1</u>	65.7	-0.4	61.2	3.33	3	795	3	3	5	5
Doublestop CL	57.8	12.2	32.7	<u>55.1</u>	67.1	-0.6	63.1	3.50	3	920	5	4	1	3
Hatcher	<u>52.1</u>	11.5	27.6	<u>41.7</u>	<u>64.8</u>	<u>-1.2</u>	60.2	4.36	4	825	4	3	<u>7</u>	4
Joe	<u>52.6</u>	11.9	<u>25.3</u>	<u>42.5</u>	67.3	-0.5	61.3	3.67	<u>2</u>	765	3	<u>2</u>	6	6
KanMark	55.7	<u>10.5</u>	26.8	<u>48.8</u>	67.9	-0.7	59.1	6.20	4	900	4	5	3	2
Langin	52.8	11.1	26.1	<u>37.9</u>	68.0	<u>-1.2</u>	59.1	6.15	5	920	4	4	6	2
LCH13-032	56.5	11.9	33.0	<u>47.3</u>	67.2	-1.1	61.2	3.31	3	770	3	3	2	5
LCH13NEDH-14	55.7	11.6	32.5	<u>39.4</u>	68.5	-1.2	59.0	3.55	<u>2</u>	<u>755</u>	4	3	3	6
LCS Chrome	53.0	12.2	<u>24.0</u>	<u>50.0</u>	67.6	-0.4	62.3	3.57	3	840	4	4	5	4
LCS Mint	55.6	12.6	28.6	<u>41.8</u>	67.7	-0.8	63.2	4.49	4	905	3	3	3	3
MTS1024	53.8	11.6	27.5	<u>54.9</u>	<u>65.3</u>	-0.8	64.1	4.53	5	865	4	3	6	2
Oakley CL	54.5	13.0	27.7	<u>57.1</u>	66.3	<u>-1.3</u>	63.0	4.15	4	825	3	3	6	3
Prairie Red	55.3	12.1	30.4	<u>52.7</u>	<u>63.5</u>	-0.6	60.2	<u>2.76</u>	<u>2</u>	860	4	4	5	5
Ripper	<u>52.3</u>	13.5	28.9	<u>43.7</u>	69.3	<u>-1.3</u>	60.2	3.87	<u>2</u>	785	<u>2</u>	<u>2</u>	4	6
Ruth	55.1	11.7	26.0	<u>50.1</u>	67.9	-0.7	60.0	<u>2.86</u>	<u>2</u>	775	<u>2</u>	<u>1</u>	4	<u>7</u>
Settler CL	54.8	<u>9.8</u>	29.7	<u>39.2</u>	69.1	-0.9	<u>57.3</u>	6.20	5	775	4	4	4	4
Snowmass	54.7	<u>9.9</u>	30.6	<u>56.4</u>	67.1	-0.6	<u>58.3</u>	8.63	5	875	5	5	5	2
Sunshine	55.4	<u>10.3</u>	33.7	<u>37.2</u>	67.1	-0.8	61.1	5.09	5	860	5	4	3	2
SY Monument	52.8	12.2	26.3	<u>52.1</u>	67.1	-1.0	64.1	5.86	5	985	5	5	6	1
SY Sunrise	54.7	12.7	29.5	<u>43.9</u>	66.2	-0.8	63.1	<u>2.79</u>	3	770	3	3	4	5
SY Wolf	54.5	11.9	26.4	<u>50.4</u>	66.9	-1.1	59.4	3.85	<u>2</u>	795	4	4	5	5
TAM 114	56.8	12.0	27.7	<u>46.9</u>	68.3	-0.5	62.1	5.64	4	1005	4	5	2	1
TAM 204	<u>52.3</u>	13.2	<u>23.9</u>	<u>55.7</u>	<u>65.5</u>	-0.9	61.1	<u>2.63</u>	<u>1</u>	765	<u>2</u>	<u>1</u>	<u>8</u>	<u>8</u>
WB-Grainfield	55.3	<u>10.3</u>	28.0	<u>48.8</u>	68.5	-0.9	<u>57.2</u>	3.89	<u>2</u>	<u>690</u>	<u>2</u>	<u>2</u>	4	<u>8</u>
WB4721	56.6	12.1	29.2	<u>50.0</u>	68.6	-0.7	61.2	<u>3.02</u>	<u>2</u>	855	4	4	2	5
Winterhawk	55.3	12.1	28.2	<u>47.3</u>	68.8	<u>-1.3</u>	62.4	4.48	3	825	<u>2</u>	3	3	4

Average	54.4	11.7	28.1	46.5	67.1	-0.9	60.9	4.40	3.5	848	3.7	3.4		
Minimum	50.3	9.8	21.5	29.3	63.5	-1.4	57.0	2.63	1	690	2	1		
Maximum	57.8	13.7	33.7	57.1	69.3	-0.4	65.0	8.63	5	1020	5	5		

Wheat Milling and Baking Quality Data - 2016 Walsh

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Akron	55.4	12.8	24.9	63.8	66.7	-0.3	64.2	5.98	5	925	4	4	4	3
Antero	56.1	<u>12.2</u>	24.4	<u>58.5</u>	68.8	-0.5	<u>62.1</u>	4.82	4	<u>800</u>	3	3	4	6
Avery	54.0	13.1	<u>21.8</u>	68.5	66.9	-0.3	64.0	6.37	5	1035	5	4	6	2
Brawl CL Plus	56.5	14.6	25.0	68.4	68.6	-0.8	65.7	3.98	4	1020	4	5	3	3
Byrd	55.0	<u>12.0</u>	23.3	<u>57.6</u>	69.9	-0.3	<u>62.2</u>	7.61	6	965	4	4	4	2
CO11D1539	53.9	14.4	26.5	<u>58.0</u>	67.7	<u>-1.0</u>	67.1	4.80	5	910	3	3	5	3
CO12D2011	56.9	14.7	25.3	66.8	68.6	-0.1	70.2	5.13	5	1000	5	4	2	1
CO14A058	<u>51.2</u>	14.6	<u>22.1</u>	66.4	<u>62.4</u>	-0.3	66.8	3.21	3	<u>815</u>	<u>2</u>	<u>2</u>	<u>8</u>	6
CO14A065	<u>52.2</u>	14.8	<u>22.3</u>	69.5	<u>64.2</u>	0.2	67.9	4.73	4	910	3	3	<u>7</u>	3
Cowboy	<u>53.0</u>	15.6	23.9	62.2	65.4	-0.4	68.8	3.87	4	850	<u>1</u>	<u>1</u>	5	5
Denali	56.6	<u>12.4</u>	23.5	66.4	67.0	-0.9	<u>62.2</u>	3.82	3	<u>745</u>	<u>2</u>	<u>2</u>	4	<u>7</u>
Doublestop CL	57.9	14.4	26.1	73.2	67.2	-0.9	66.0	3.92	4	920	5	4	3	4
Hatcher	56.1	<u>11.8</u>	25.3	61.6	67.1	-0.6	<u>62.3</u>	5.47	4	820	4	3	5	5
Joe	57.7	13.9	26.2	<u>59.6</u>	67.9	-0.3	66.3	4.04	<u>2</u>	<u>810</u>	4	<u>2</u>	2	6
KanMark	54.7	14.0	23.6	71.4	67.0	-0.4	65.3	5.38	5	1105	4	4	4	1
Langin	54.1	14.4	<u>22.2</u>	61.5	67.5	<u>-1.2</u>	65.3	9.84	6	1160	4	4	6	1
LCH13-032	56.0	14.4	26.7	64.0	<u>64.7</u>	-0.7	66.1	3.44	3	<u>815</u>	4	3	4	5
LCH13NEDH-14	54.3	16.0	25.6	60.2	68.9	-0.4	65.2	3.54	<u>1</u>	905	3	4	3	6
LCS Chrome	54.7	13.7	<u>22.5</u>	64.9	67.9	-0.5	<u>62.2</u>	3.76	<u>2</u>	940	4	3	4	6
LCS Mint	57.3	13.0	25.1	62.3	67.8	-0.7	64.1	4.56	4	955	3	3	3	4
MTS1024	<u>51.7</u>	14.5	<u>22.6</u>	74.9	<u>63.2</u>	<u>-1.2</u>	65.1	5.92	5	975	4	3	<u>9</u>	2
Oakley CL	57.0	15.8	25.4	79.6	65.8	<u>-1.0</u>	70.1	4.39	5	830	4	3	4	2
Prairie Red	55.2	13.2	26.0	73.9	<u>64.5</u>	-0.9	63.2	3.92	3	835	4	3	6	5
Ripper	<u>50.9</u>	16.2	24.6	61.5	65.7	-0.7	71.1	3.97	4	900	<u>2</u>	<u>2</u>	6	3
Ruth	56.1	15.0	23.2	64.5	67.3	-0.7	65.3	<u>2.98</u>	<u>1</u>	825	3	<u>1</u>	4	<u>7</u>
Settler CL	54.1	14.9	24.3	62.1	67.8	-0.6	67.2	6.22	5	920	3	3	4	3
Snowmass	56.0	<u>12.5</u>	24.7	73.5	<u>65.3</u>	-0.2	65.1	9.20	6	975	5	5	6	1
Sunshine	56.2	13.7	26.7	<u>59.7</u>	68.4	-0.5	67.2	6.66	6	955	4	5	3	1
SY Monument	54.4	13.2	24.4	67.7	68.4	-0.9	67.1	6.95	5	1040	5	4	4	1
SY Sunrise	57.0	14.1	27.0	61.4	67.7	-0.8	64.3	<u>3.17</u>	<u>2</u>	870	<u>2</u>	<u>2</u>	3	6
SY Wolf	56.8	13.8	25.5	62.4	67.5	-0.5	63.2	3.71	<u>0</u>	905	3	3	3	<u>7</u>
TAM 114	56.2	<u>12.3</u>	<u>21.8</u>	72.9	67.6	0.1	66.1	7.75	6	1050	4	5	5	1
TAM 204	53.8	15.0	<u>20.7</u>	71.3	66.1	-0.8	64.2	<u>2.49</u>	<u>0</u>	<u>785</u>	<u>1</u>	<u>0</u>	<u>7</u>	<u>9</u>
WB-Grainfield	57.0	<u>11.1</u>	25.3	64.7	67.9	0.2	64.2	4.02	3	<u>790</u>	3	<u>2</u>	3	6
WB4721	56.0	14.4	25.3	61.4	68.7	<u>-1.2</u>	<u>62.7</u>	3.32	<u>1</u>	895	4	3	4	<u>7</u>
Winterhawk	57.2	<u>11.2</u>	27.8	63.2	68.2	-0.0	63.4	3.89	4	870	4	4	2	4

Average	55.3	13.8	24.5	65.5	67.0	-0.6	65.4	4.91	3.8	912	3.5	3.1		
Minimum	50.9	11.1	20.7	57.6	62.4	-1.2	62.1	2.49	0	745	1	0		
Maximum	57.9	16.2	27.8	79.6	69.9	0.2	71.1	9.84	6	1160	5	5		

Wheat Milling and Baking Quality Data - 2016 Yuma

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Akron	55.1	12.1	23.0	61.7	67.1	-1.8	62.3	4.75	5	820	4	3	5	4
Antero	54.6	12.8	23.6	<u>59.6</u>	68.0	-1.0	63.2	5.91	4	740	<u>2</u>	3	5	5
Avery	55.1	<u>11.0</u>	22.9	64.5	68.8	-0.6	<u>60.9</u>	5.24	5	875	5	3	4	4
Brawl CL Plus	55.1	13.5	22.5	70.0	68.8	-0.7	65.1	4.61	4	880	3	3	3	3
Byrd	56.5	<u>11.4</u>	23.4	61.2	71.1	-0.9	<u>61.3</u>	6.46	5	950	5	4	3	2
CO11D1539	54.4	<u>12.1</u>	26.3	<u>53.9</u>	68.9	-1.0	63.2	4.33	4	830	<u>2</u>	<u>2</u>	5	5
CO12D2011	59.0	12.4	24.8	66.5	69.7	-1.1	63.8	3.85	4	825	5	4	1	4
CO14A058	<u>52.1</u>	12.6	<u>21.3</u>	66.6	<u>64.3</u>	-1.4	62.9	<u>3.01</u>	3	<u>705</u>	<u>1</u>	<u>1</u>	<u>8</u>	<u>7</u>
CO14A065	<u>53.4</u>	12.8	<u>21.8</u>	73.3	<u>65.7</u>	<u>-1.5</u>	62.8	4.84	5	810	<u>2</u>	<u>2</u>	<u>8</u>	4
Cowboy	53.9	12.7	<u>21.8</u>	66.3	66.4	-1.2	63.9	4.65	4	<u>725</u>	4	<u>2</u>	6	5
Denali	57.3	<u>11.8</u>	24.9	62.8	68.6	<u>-1.5</u>	62.3	3.63	3	<u>710</u>	<u>2</u>	<u>1</u>	3	<u>7</u>
Doublestop CL	57.6	13.9	25.7	75.2	66.9	-1.4	65.0	3.42	3	875	4	3	3	3
Hatcher	56.6	<u>11.7</u>	25.5	63.1	68.1	-1.3	<u>62.2</u>	5.12	5	825	4	3	4	4
Joe	<u>52.8</u>	13.7	<u>21.9</u>	63.4	66.9	-1.3	<u>61.7</u>	5.69	4	795	3	<u>2</u>	6	5
KanMark	56.7	12.3	22.3	74.2	67.7	-1.1	63.1	5.35	5	1025	4	4	5	1
Langin	54.5	12.9	22.9	60.8	67.3	<u>-1.6</u>	63.8	9.01	6	915	3	3	6	1
LCH13-032	57.8	12.6	28.0	62.0	67.9	-1.2	<u>62.0</u>	3.62	4	760	3	<u>2</u>	2	6
LCH13NEDH-14	55.2	12.8	25.6	62.2	67.7	-1.0	<u>62.2</u>	4.48	4	785	3	<u>2</u>	4	5
LCS Chrome	54.1	14.1	<u>21.8</u>	79.0	66.7	-1.3	63.9	3.74	3	<u>725</u>	3	<u>2</u>	6	6
LCS Mint	57.3	12.8	25.2	64.4	67.7	-0.9	64.1	6.02	4	875	3	3	2	3
MTS1024	<u>52.1</u>	13.8	<u>21.6</u>	<u>84.5</u>	<u>64.1</u>	-1.2	65.9	7.98	5	975	4	4	<u>9</u>	1
Oakley CL	55.8	13.1	25.3	70.7	<u>66.0</u>	-1.4	64.1	5.23	5	785	3	<u>2</u>	5	3
Prairie Red	55.1	<u>12.0</u>	25.9	72.5	66.7	-0.7	63.2	4.47	4	820	4	3	4	4
Ripper	<u>53.1</u>	13.1	24.6	60.6	68.5	-1.3	64.1	3.50	4	825	<u>1</u>	<u>1</u>	5	5
Ruth	56.8	13.2	23.8	67.4	67.8	-1.1	64.0	3.81	4	770	3	<u>1</u>	3	5
Settler CL	55.2	12.8	24.4	73.1	67.8	-1.3	63.4	5.62	5	845	4	4	4	3
Snowmass	53.8	12.8	24.6	75.5	<u>64.5</u>	-1.2	65.0	?	6	935	5	5	<u>7</u>	1
Sunshine	56.5	12.4	27.2	62.0	68.8	-1.2	63.4	6.08	5	805	4	3	2	3
SY Monument	55.1	12.8	22.9	79.6	68.1	-1.2	64.3	9.53	6	855	4	4	6	1
SY Sunrise	57.7	13.5	27.9	61.1	68.3	-1.3	63.1	<u>3.15</u>	3	<u>720</u>	3	<u>2</u>	1	6
SY Wolf	56.5	13.8	<u>22.0</u>	74.1	67.6	-1.1	<u>61.9</u>	5.36	3	790	<u>1</u>	<u>1</u>	4	6
TAM 114	58.6	12.7	23.6	68.0	69.4	-1.0	65.1	7.94	6	970	4	4	1	1
TAM 204	<u>53.2</u>	13.6	<u>20.5</u>	70.6	66.1	-1.1	64.1	3.94	3	<u>650</u>	<u>2</u>	<u>2</u>	<u>7</u>	<u>7</u>
WB-Grainfield	54.0	14.1	22.7	68.1	67.6	-1.4	64.1	4.21	4	755	<u>1</u>	<u>1</u>	4	5
WB4721	58.2	14.1	25.3	67.6	68.0	-1.0	64.2	4.10	3	805	3	<u>2</u>	1	5
Winterhawk	55.3	12.8	23.9	73.0	68.0	-1.3	<u>61.9</u>	4.46	4	790	<u>2</u>	<u>2</u>	4	5

Average	55.4	12.8	23.9	67.8	67.5	-1.2	63.4	5.27	4.3	821	3.1	2.6		
Minimum	52.1	11.0	20.5	53.9	64.1	-1.8	60.9	3.01	3	650	1	1		
Maximum	59.0	14.1	28.0	84.5	71.1	-0.6	65.9	?	6	1025	5	5		

Wheat Milling and Baking Quality Data - 2016 Fort Collins

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Antero	<u>54.1</u>	16.9	23.0	74.2	<u>62.8</u>	<u>-1.7</u>	66.5	3.37	<u>0</u>	940	<u>2</u>	<u>2</u>	<u>7</u>	<u>7</u>
Avery	56.2	15.6	23.4	76.1	65.5	-0.7	67.3	4.38	3	1190	4	4	4	2
Brawl CL Plus	57.0	16.9	21.6	<u>82.6</u>	65.2	-0.6	70.5	4.27	3	1070	4	4	4	3
Byrd	55.7	15.5	23.1	<u>78.1</u>	68.3	-1.0	67.5	5.50	5	1140	5	4	3	1
CO11D1539	55.1	16.9	25.2	70.5	65.7	<u>-2.2</u>	66.7	3.33	<u>2</u>	1020	3	3	5	6
CO12D2011	59.9	15.5	23.3	<u>80.4</u>	68.3	-0.7	67.4	4.41	4	1100	5	4	1	2
Cowboy	56.8	16.5	22.7	<u>75.5</u>	65.3	<u>-1.7</u>	66.2	3.38	<u>1</u>	935	3	3	4	6
Denali	58.1	15.5	23.6	75.4	65.4	-0.8	<u>65.3</u>	<u>2.70</u>	<u>1</u>	<u>875</u>	3	3	3	<u>8</u>
Hatcher	55.8	<u>14.7</u>	23.0	74.5	64.4	-0.7	66.4	3.44	3	980	5	3	5	4
Joe	<u>54.5</u>	17.1	<u>20.6</u>	79.8	64.9	-0.3	69.2	2.92	<u>1</u>	975	3	<u>2</u>	6	6
KanMark	56.1	16.8	<u>21.2</u>	<u>84.0</u>	65.4	-0.9	69.3	4.32	4	1125	4	3	5	3
Langin	55.8	<u>14.7</u>	22.0	<u>75.5</u>	65.9	-0.7	70.4	5.99	5	1205	4	4	5	1
LCH13NEDH-14	54.7	16.0	23.7	73.8	65.7	-0.2	67.2	3.52	<u>0</u>	1020	5	3	4	6
Oakley CL	55.6	16.7	26.6	<u>89.0</u>	<u>63.4</u>	<u>-1.5</u>	66.3	3.56	<u>1</u>	950	4	3	5	6
Sunshine	56.0	16.4	22.7	<u>77.6</u>	66.8	-0.7	71.3	6.09	5	1100	5	4	3	1
SY Sunrise	59.9	15.6	27.1	67.9	67.5	-1.1	<u>65.4</u>	<u>2.34</u>	<u>1</u>	<u>825</u>	<u>2</u>	<u>2</u>	1	<u>9</u>
SY Wolf	57.8	16.9	24.6	79.0	64.7	-1.0	67.3	3.56	<u>0</u>	1075	5	4	3	5
Thunder CL	56.9	<u>14.6</u>	22.0	<u>80.4</u>	67.0	-1.1	67.5	4.45	4	1035	5	3	4	3
WB-Cedar	56.6	16.2	25.2	<u>76.9</u>	64.6	-0.7	66.4	<u>2.47</u>	<u>0</u>	<u>845</u>	3	3	3	<u>9</u>
WB4303	<u>53.2</u>	18.0	<u>20.5</u>	<u>80.2</u>	65.4	-1.1	70.4	4.50	<u>2</u>	1215	4	3	6	2
WB4458	59.1	<u>15.1</u>	24.4	<u>77.8</u>	65.0	-0.4	<u>65.7</u>	2.99	<u>0</u>	965	3	3	1	<u>8</u>
Yuma	<u>54.5</u>	15.8	22.1	79.0	<u>61.5</u>	-0.6	67.5	3.39	<u>2</u>	990	3	3	<u>7</u>	<u>5</u>

Average	56.3	16.1	23.3	77.6	65.4	-0.9	67.6	3.86	2.1	1026	3.8	3.2		
Minimum	53.2	14.6	20.5	67.9	61.5	-2.2	65.3	2.34	0	825	2	2		
Maximum	59.9	18.0	27.1	89.0	68.3	-0.2	71.3	6.09	5	1215	5	4		

Wheat Milling and Baking Quality Data - 2016 Haxtun

* **Bold** indicates superior value, underlined indicates inferior value.

Entry	Test Weight	Grain Protein	SKCS Weight	SKCS Hardness	Flour Yield	Protein Recovery	Bake Absorption	Mixograph Mix Time	Mixograph Tolerance	Loaf Volume	Crumb Color	Crumb Grain	Milling Score	Baking Score
Antero	58.1	12.9	29.6	65.1	68.4	<u>-1.7</u>	60.4	3.73	<u>2</u>	885	3	<u>2</u>	4	6
Avery	57.2	13.5	<u>26.7</u>	70.5	68.4	-1.2	63.3	3.95	3	965	4	3	4	3
Brawl CL Plus	57.4	14.0	27.8	70.9	67.5	-0.3	65.4	3.27	3	925	4	3	3	3
Byrd	<u>55.5</u>	13.9	<u>24.0</u>	68.9	69.6	-1.5	63.3	5.05	4	990	<u>2</u>	3	6	2
CO11D1539	<u>56.3</u>	<u>12.2</u>	30.7	64.0	67.4	-1.2	62.3	4.02	3	950	<u>2</u>	<u>2</u>	6	4
CO12D2011	59.4	13.8	29.3	69.4	67.9	<u>-1.8</u>	61.1	3.49	<u>1</u>	955	4	3	2	5
Cowboy	57.5	12.5	30.3	64.2	67.5	-1.3	<u>60.1</u>	3.33	<u>2</u>	<u>835</u>	<u>2</u>	<u>2</u>	4	<u>7</u>
Denali	57.9	13.6	27.9	67.4	67.4	-1.2	61.4	3.25	<u>1</u>	860	3	3	4	6
Hatcher	<u>56.2</u>	13.0	<u>26.4</u>	64.5	67.1	-1.1	61.5	3.38	<u>2</u>	875	3	<u>2</u>	6	6
Joe	58.0	13.1	28.7	70.4	68.0	-1.4	<u>60.0</u>	2.98	<u>1</u>	860	3	3	4	<u>7</u>
KanMark	58.6	13.5	<u>25.1</u>	<u>81.0</u>	68.3	-1.0	64.3	3.83	3	1025	<u>2</u>	3	5	2
Langin	58.1	13.0	27.5	<u>74.4</u>	69.0	<u>-1.5</u>	62.0	5.76	5	975	4	3	3	1
LCH13NEDH-14	<u>56.5</u>	12.6	30.3	72.4	67.3	-0.6	61.1	3.37	<u>2</u>	890	<u>2</u>	<u>1</u>	5	6
Oakley CL	57.4	13.3	31.9	70.9	<u>66.6</u>	-1.1	62.1	3.43	<u>2</u>	930	5	3	4	5
Sunshine	59.8	<u>12.4</u>	33.9	61.0	68.4	-0.7	62.4	4.63	4	990	5	4	1	2
SY Sunrise	57.8	13.0	30.4	67.5	<u>66.0</u>	-1.2	63.0	3.04	3	<u>855</u>	3	3	5	5
SY Wolf	57.3	13.3	31.2	71.8	<u>66.4</u>	-1.4	<u>60.2</u>	3.53	<u>0</u>	895	3	3	5	<u>7</u>
Thunder CL	56.8	<u>11.9</u>	28.8	65.6	67.6	-0.4	62.6	3.28	3	940	3	3	5	4
WB-Cedar	57.8	12.7	31.2	70.8	<u>66.5</u>	-1.1	<u>60.2</u>	3.03	<u>1</u>	<u>825</u>	<u>2</u>	<u>2</u>	4	<u>9</u>
WB4303	56.6	12.5	28.8	72.9	66.9	-0.8	<u>60.1</u>	3.05	<u>1</u>	910	4	3	5	<u>7</u>
WB4458	58.3	13.2	30.6	68.8	<u>66.0</u>	-0.8	61.2	<u>2.60</u>	<u>0</u>	875	3	<u>2</u>	4	<u>8</u>
Yuma	57.0	13.0	28.1	68.0	66.9	-1.3	63.6	<u>2.67</u>	3	865	3	3	5	5

Average	57.5	13.0	29.1	69.1	67.5	-1.1	61.9	3.58	2.2	913	3.1	2.7		
Minimum	55.5	11.9	24.0	61.0	66.0	-1.8	60.0	2.60	0	825	2	1		
Maximum	59.8	14.0	33.9	81.0	69.6	-0.3	65.4	5.76	5	1025	5	4		