

Wheat Quality Evaluations from the 2015 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 yields (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 fully 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 2015, grain samples were collected from four dryland (UVPT) variety trial locations (Akron, Julesburg, Yuma, and Roggen) 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 Roggen dryland location was excluded from analyses beyond protein content with the primary issue being protein values well below the level required for meaningful dough mixing and baking quality evaluations. During sample processing we also realized that the Haxtun location was severely infected by *Fusarium* head blight, though we proceeded to analyze the samples.

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 - 2015 Akron

* **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
Above	53.5	12.7	25.7	66.9	69.8	-0.4	62.5	<u>2.98</u>	3	870	3	3	4	5
Akron	<u>50.6</u>	13.1	<u>21.7</u>	65.2	<u>68.0</u>	<u>-1.6</u>	64.3	3.78	4	875	3	3	<u>8</u>	3
Antero	58.6	<u>11.8</u>	30.3	60.4	73.2	-0.6	<u>61.4</u>	4.26	3	<u>780</u>	3	<u>2</u>	2	6
Avery	<u>51.0</u>	12.8	<u>21.3</u>	63.7	70.5	-1.1	63.2	3.25	4	905	<u>2</u>	<u>2</u>	6	5
Bearpaw	<u>49.7</u>	14.0	<u>23.7</u>	71.3	<u>69.6</u>	-0.9	64.2	4.05	3	905	<u>2</u>	3	<u>7</u>	4
Brawl CL Plus	54.0	14.1	24.9	66.9	71.6	-0.7	65.0	4.35	4	895	<u>2</u>	<u>2</u>	3	3
Byrd	52.6	13.3	<u>23.3</u>	60.4	72.3	-0.8	63.4	4.39	5	890	<u>2</u>	3	5	4
CO11D1236	55.5	<u>11.6</u>	29.0	<u>53.6</u>	75.0	-0.6	<u>60.7</u>	4.83	4	<u>750</u>	<u>2</u>	<u>2</u>	3	<u>7</u>
CO11D1306W	58.7	<u>12.2</u>	27.7	63.6	72.5	-1.1	<u>61.8</u>	3.55	4	<u>765</u>	3	<u>2</u>	3	6
CO11D1397	<u>50.4</u>	12.8	<u>21.3</u>	60.6	<u>67.3</u>	-1.0	62.5	5.98	5	935	3	4	<u>9</u>	2
CO11D1539	57.4	12.9	31.5	61.7	72.0	<u>-1.3</u>	62.6	3.39	3	925	5	4	3	4
CO11D1767	56.2	<u>12.3</u>	27.9	61.8	73.8	-0.9	62.5	3.97	3	<u>790</u>	<u>2</u>	<u>2</u>	3	6
CO11D446	55.6	14.2	26.6	<u>57.3</u>	71.1	-0.8	65.1	5.52	5	880	3	<u>2</u>	4	2
Cowboy	54.3	12.7	27.6	61.3	70.2	-1.2	<u>61.7</u>	3.51	3	795	<u>1</u>	<u>2</u>	4	<u>7</u>
Denali	57.2	<u>12.2</u>	26.2	<u>59.6</u>	71.9	<u>-1.7</u>	<u>61.3</u>	<u>2.53</u>	3	<u>735</u>	<u>1</u>	<u>1</u>	5	<u>9</u>
Gallagher	55.1	13.6	25.4	74.9	70.2	-1.0	63.6	4.51	4	825	<u>2</u>	3	5	5
Hatcher	55.6	12.8	25.4	67.6	71.3	<u>-1.7</u>	<u>61.4</u>	3.80	3	810	3	3	5	6
Iba	54.7	13.1	<u>23.1</u>	69.4	71.1	-1.1	<u>61.7</u>	3.76	<u>2</u>	840	<u>2</u>	3	5	6
Joe	58.5	12.8	28.6	68.8	71.4	-0.1	62.4	3.96	<u>2</u>	855	3	<u>2</u>	2	5
KanMark	56.4	13.6	<u>23.5</u>	72.7	73.0	-0.8	64.4	5.06	5	975	3	4	3	1
LCS Mint	54.5	<u>12.2</u>	23.9	69.1	72.2	-0.5	<u>61.1</u>	4.86	4	860	3	<u>2</u>	4	5
LCS Pistol	57.0	13.6	26.5	<u>59.9</u>	<u>68.8</u>	-0.6	63.0	<u>3.11</u>	<u>1</u>	840	3	<u>2</u>	4	<u>7</u>
MTS1024	<u>51.2</u>	13.2	<u>23.3</u>	69.0	70.5	-0.6	64.0	5.62	5	925	4	3	5	2
Oakley CL	57.9	13.4	30.9	75.1	72.7	-0.8	63.8	4.09	4	950	5	5	2	2
Prairie Red	<u>51.7</u>	13.1	26.1	68.0	<u>68.8</u>	-0.3	64.5	4.13	4	990	4	3	5	2
Ripper	<u>52.0</u>	13.4	25.6	62.2	69.9	-0.7	64.4	3.62	3	845	<u>2</u>	<u>2</u>	5	5
Ruth	57.8	12.8	27.9	66.9	72.8	-1.2	<u>61.6</u>	3.75	3	850	4	3	2	5
Settler CL	54.5	13.5	26.4	61.8	72.0	-1.1	63.3	4.55	4	810	3	<u>2</u>	4	5
Snowmass	<u>51.0</u>	12.9	26.2	68.5	<u>68.9</u>	-0.9	63.2	5.59	5	940	3	3	6	2
Sunshine	57.5	13.8	29.4	61.7	72.4	-0.7	64.3	4.58	5	980	5	4	1	1
SY Monument	57.5	12.8	30.4	73.5	73.5	-0.4	64.4	7.15	6	975	5	5	1	1
SY Wolf	55.7	14.3	27.1	71.1	71.1	<u>-1.4</u>	62.3	5.07	5	860	<u>2</u>	<u>2</u>	4	4
T158	58.5	14.8	32.3	65.7	72.3	<u>-1.6</u>	62.2	3.54	<u>2</u>	860	3	3	1	6
TAM 112	54.5	12.8	27.7	64.3	<u>68.8</u>	-0.4	64.2	3.63	4	965	4	4	4	3
TAM 113	56.5	<u>12.4</u>	26.4	67.9	72.1	-0.5	62.5	3.23	3	875	3	3	3	5
TAM 114	57.5	13.7	28.9	63.8	72.5	-1.0	65.3	6.40	5	1075	4	4	1	1
TAM 204	55.2	13.4	23.8	69.4	71.0	-1.1	<u>61.6</u>	<u>2.34</u>	<u>1</u>	<u>715</u>	<u>2</u>	<u>1</u>	5	<u>9</u>
WB-Grainfield	55.9	13.3	26.8	72.2	71.4	-0.5	64.2	3.59	3	800	<u>2</u>	<u>2</u>	4	5
Winterhawk	55.2	13.5	26.6	67.0	72.2	-1.0	63.4	3.69	3	855	<u>2</u>	<u>2</u>	3	5
Average	55.1	13.1	26.4	65.8	71.3	-0.9	63.1	4.20	3.6	871	2.9	2.7		
Minimum	49.7	11.6	21.3	53.6	67.3	-1.7	60.7	2.34	1	715	1	1		
Maximum	58.7	14.8	32.3	75.1	75.0	-0.1	65.3	7.15	6	1075	5	5		

Wheat Milling and Baking Quality Data - 2015 Julesburg

* **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
Above	57.4	12.0	31.1	<u>59.8</u>	72.7	-0.7	<u>59.6</u>	3.83	<u>2</u>	900	3	3	5	6
Akron	57.0	12.3	29.9	<u>52.5</u>	73.1	-1.0	60.8	4.95	5	955	5	5	4	2
Antero	58.3	<u>11.2</u>	31.0	<u>44.3</u>	75.5	-1.0	<u>58.0</u>	4.10	<u>2</u>	945	<u>2</u>	<u>2</u>	3	<u>7</u>
Avery	57.6	<u>10.9</u>	30.9	<u>44.5</u>	74.8	-0.6	<u>59.7</u>	5.25	5	950	5	4	4	3
Bearpaw	<u>53.6</u>	11.7	<u>25.5</u>	<u>59.1</u>	73.4	-0.5	<u>58.9</u>	4.43	<u>2</u>	855	3	3	<u>8</u>	<u>7</u>
Brawl CL Plus	56.6	12.6	29.5	<u>51.1</u>	73.2	-0.1	62.9	4.66	3	970	3	4	4	3
Byrd	57.5	12.0	30.6	<u>47.2</u>	76.3	<u>-1.2</u>	60.7	4.90	5	945	5	4	3	2
CO11D1236	57.5	12.0	34.4	<u>42.2</u>	75.4	-1.2	<u>59.8</u>	4.56	4	840	3	3	3	5
CO11D1306W	58.7	<u>10.9</u>	29.5	<u>54.3</u>	73.5	-0.5	60.6	3.56	3	<u>760</u>	4	3	4	6
CO11D1397	57.4	11.5	30.5	<u>48.5</u>	72.7	-0.9	61.3	5.31	4	985	4	4	5	3
CO11D1539	57.3	11.6	33.6	<u>43.9</u>	<u>72.1</u>	-1.1	61.8	<u>3.38</u>	4	835	3	3	6	5
CO11D1767	57.1	12.0	30.4	<u>54.6</u>	73.6	<u>-1.3</u>	60.9	3.74	3	<u>790</u>	3	3	4	6
CO11D446	57.5	11.7	33.6	<u>44.9</u>	74.6	<u>-1.3</u>	62.7	5.17	5	945	5	4	4	2
Cowboy	56.9	<u>11.3</u>	31.0	<u>50.0</u>	73.2	-1.0	61.4	5.53	3	<u>775</u>	<u>2</u>	3	4	5
Denali	58.8	<u>11.3</u>	33.8	<u>39.3</u>	73.8	-1.1	<u>58.6</u>	<u>3.34</u>	<u>2</u>	<u>675</u>	3	<u>2</u>	4	<u>9</u>
Gallagher	56.4	12.8	29.9	62.2	73.0	-1.0	62.7	4.27	4	860	<u>2</u>	<u>2</u>	6	4
Hatcher	56.8	12.4	33.3	<u>47.7</u>	73.9	-1.2	61.7	4.58	4	840	4	3	3	4
Iba	57.0	13.1	30.5	<u>53.1</u>	73.8	<u>-1.6</u>	61.7	3.78	3	890	3	3	4	5
Joe	58.5	11.5	32.2	<u>51.1</u>	<u>71.7</u>	-0.4	62.8	4.48	4	875	4	3	4	3
KanMark	58.2	12.3	31.2	<u>57.8</u>	75.0	-0.2	63.6	5.06	5	1090	4	4	2	1
LCS Mint	57.0	12.2	32.1	<u>50.3</u>	73.9	-1.1	61.6	4.07	3	960	3	3	4	4
LCS Pistol	57.4	12.3	<u>27.0</u>	<u>47.7</u>	<u>69.8</u>	-0.7	<u>58.6</u>	<u>2.65</u>	<u>1</u>	<u>800</u>	3	<u>2</u>	<u>7</u>	<u>9</u>
MTS1024	<u>54.0</u>	12.2	<u>28.0</u>	61.2	73.2	-0.9	60.8	5.29	5	955	4	4	<u>8</u>	2
Oakley CL	58.7	12.7	33.1	63.9	72.8	<u>-1.2</u>	61.7	5.11	4	1025	4	4	4	2
Prairie Red	56.9	13.1	33.6	<u>55.8</u>	<u>72.2</u>	-0.8	62.7	3.59	3	1050	5	4	4	3
Ripper	<u>55.3</u>	13.1	<u>29.0</u>	<u>54.9</u>	72.9	<u>-1.4</u>	62.5	<u>3.27</u>	3	<u>815</u>	<u>2</u>	<u>1</u>	6	6
Ruth	58.3	11.7	32.4	<u>50.2</u>	73.8	-0.5	61.4	3.86	4	820	4	3	3	5
Settler CL	57.4	12.3	32.5	<u>49.1</u>	74.1	-0.8	61.4	4.34	4	895	4	4	4	3
Snowmass	56.9	11.7	37.2	<u>50.6</u>	73.7	-0.7	63.8	7.52	5	1055	4	4	2	1
Sunshine	57.1	12.2	34.7	<u>43.7</u>	73.2	-0.9	63.9	4.32	4	1025	4	4	4	1
SY Monument	57.9	12.2	34.2	<u>57.1</u>	73.2	-1.2	63.8	5.56	5	1010	5	4	4	1
SY Wolf	58.1	12.1	32.7	<u>53.7</u>	73.2	-0.8	<u>58.7</u>	4.88	<u>2</u>	855	3	3	3	<u>7</u>
T158	58.6	12.0	35.7	<u>46.3</u>	73.7	-0.5	59.9	3.47	3	940	4	3	2	5
TAM 112	58.5	12.4	34.6	<u>50.4</u>	72.4	-0.3	63.1	4.16	4	1040	5	4	2	2
TAM 113	57.4	12.4	30.5	<u>56.3</u>	73.3	-0.5	63.0	3.50	3	990	4	4	4	3
TAM 114	58.4	11.9	31.5	<u>48.5</u>	72.8	-0.5	62.9	6.53	5	1040	4	4	3	1
TAM 204	57.7	13.0	<u>28.2</u>	<u>58.3</u>	<u>72.2</u>	-0.7	61.1	<u>2.41</u>	<u>1</u>	825	<u>1</u>	<u>1</u>	6	<u>8</u>
WB-Grainfield	58.7	11.8	34.8	<u>56.5</u>	73.5	-0.7	61.9	3.88	3	865	4	3	2	5
Winterhawk	59.9	<u>11.2</u>	34.5	<u>51.6</u>	73.5	-0.6	60.9	5.05	4	890	5	5	1	3

Average	57.4	12.0	31.8	51.6	73.4	-0.8	61.4	4.42	3.5	911	3.6	3.3		
Minimum	53.6	10.9	25.5	39.3	69.8	-1.6	58.0	2.41	1	675	1	1		
Maximum	59.9	13.1	37.2	63.9	76.3	-0.1	63.9	7.52	5	1090	5	5		

Wheat Milling and Baking Quality Data - 2015 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
Above	54.7	12.3	31.3	<u>52.3</u>	<u>69.7</u>	-0.7	60.9	3.47	3	850	4	3	5	5
Akron	54.3	12.0	27.1	61.1	<u>69.6</u>	-0.8	61.9	4.84	4	975	5	4	<u>8</u>	3
Antero	55.9	<u>11.5</u>	31.3	<u>41.4</u>	<u>72.5</u>	-1.4	60.7	4.55	3	<u>790</u>	4	3	5	5
Avery	54.8	12.1	<u>26.4</u>	<u>49.6</u>	73.6	-0.9	62.7	4.68	5	960	4	4	4	3
Bearpaw	<u>53.6</u>	11.8	<u>26.4</u>	<u>53.6</u>	73.0	-0.5	<u>60.2</u>	4.65	4	<u>820</u>	3	3	5	5
Brawl CL Plus	54.6	13.4	28.7	<u>49.7</u>	72.7	-0.9	<u>60.6</u>	3.56	<u>2</u>	990	5	4	4	5
Byrd	54.1	12.6	<u>26.1</u>	<u>51.6</u>	74.2	-1.2	63.8	5.25	5	1010	4	4	4	1
CO11D1236	56.5	11.8	30.7	<u>41.7</u>	74.6	-1.2	62.2	4.43	5	<u>820</u>	<u>2</u>	<u>2</u>	3	4
CO11D1306W	55.5	12.7	28.7	<u>45.4</u>	<u>70.4</u>	-1.5	62.1	5.10	4	850	4	3	5	4
CO11D1397	56.5	<u>11.5</u>	28.7	<u>45.0</u>	71.5	-1.0	63.1	5.92	5	900	4	5	4	1
CO11D1539	54.5	12.3	33.1	<u>38.5</u>	71.1	-1.5	61.3	4.12	3	905	3	3	6	5
CO11D1767	54.4	12.2	28.7	<u>51.4</u>	71.9	<u>-1.6</u>	61.0	<u>3.19</u>	3	<u>750</u>	<u>2</u>	<u>2</u>	5	<u>7</u>
CO11D446	54.9	12.7	31.9	<u>42.1</u>	73.6	-1.0	64.0	5.35	5	975	4	3	4	2
Cowboy	54.3	12.2	27.5	<u>50.8</u>	70.6	<u>-1.6</u>	62.9	3.69	3	825	<u>2</u>	3	5	5
Denali	56.5	11.9	30.6	<u>47.6</u>	72.2	-1.0	60.7	3.56	<u>2</u>	835	<u>2</u>	<u>2</u>	4	<u>7</u>
Gallagher	54.1	13.1	28.5	63.2	<u>70.0</u>	-1.1	62.9	3.70	3	860	<u>2</u>	<u>2</u>	6	5
Hatcher	54.0	<u>11.5</u>	<u>25.4</u>	<u>59.0</u>	71.2	-0.7	60.9	3.35	3	<u>800</u>	3	3	<u>7</u>	6
Iba	56.5	12.2	28.6	<u>45.4</u>	72.4	-1.0	<u>60.1</u>	4.21	<u>2</u>	840	<u>2</u>	<u>2</u>	4	<u>7</u>
Joe	55.4	12.9	29.1	<u>45.4</u>	71.0	-1.5	62.0	3.82	4	875	4	3	5	4
KanMark	56.4	12.3	30.5	<u>53.9</u>	72.9	-0.6	64.1	4.76	5	1100	5	5	3	1
LCS Mint	56.1	11.8	29.8	<u>47.6</u>	71.8	-0.7	60.9	3.86	4	860	4	3	3	4
LCS Pistol	56.4	12.3	30.1	<u>44.7</u>	<u>68.2</u>	-0.9	<u>59.8</u>	<u>2.60</u>	<u>1</u>	835	4	3	5	<u>8</u>
MTS1024	<u>50.6</u>	13.1	<u>24.9</u>	<u>59.1</u>	70.6	-0.8	64.0	4.87	4	945	4	4	<u>8</u>	3
Oakley CL	55.4	13.6	31.2	<u>58.6</u>	71.9	-0.8	63.8	4.07	4	930	5	4	4	2
Prairie Red	56.1	14.7	32.8	<u>58.0</u>	71.2	<u>-2.2</u>	63.8	<u>3.01</u>	3	1030	5	5	4	3
Ripper	<u>53.0</u>	13.0	29.0	<u>50.7</u>	71.3	-0.7	65.0	3.68	3	900	<u>2</u>	<u>2</u>	5	4
Ruth	55.0	<u>11.5</u>	28.2	<u>52.4</u>	71.4	-0.6	60.9	3.54	3	870	3	3	4	5
Settler CL	57.4	12.9	37.5	<u>43.8</u>	73.0	-1.2	63.1	5.04	5	955	5	4	1	1
Snowmass	56.0	12.0	34.4	<u>55.1</u>	73.2	-0.9	64.7	6.47	6	1015	5	5	3	1
Sunshine	56.2	12.1	31.4	<u>47.8</u>	71.7	-1.0	62.3	5.80	5	1025	5	4	3	1
SY Monument	56.0	12.5	33.0	<u>51.2</u>	73.9	-0.9	64.2	6.62	5	1010	5	4	2	1
SY Wolf	56.6	13.3	30.1	<u>51.1</u>	72.3	<u>-1.7</u>	<u>59.0</u>	4.61	<u>2</u>	875	3	3	3	<u>7</u>
T158	56.8	14.4	37.0	<u>47.1</u>	72.3	<u>-2.2</u>	62.1	<u>3.27</u>	<u>2</u>	<u>815</u>	3	3	1	6
TAM 112	56.4	12.0	29.8	<u>56.1</u>	70.9	-0.4	62.8	3.49	3	1000	6	5	4	2
TAM 113	56.4	12.8	30.4	<u>53.3</u>	72.6	-1.0	63.7	3.31	3	995	5	4	3	3
TAM 114	55.1	12.5	29.1	<u>50.5</u>	72.3	-1.3	62.7	5.60	5	1130	4	4	4	1
TAM 204	54.2	12.7	<u>25.1</u>	<u>53.4</u>	<u>69.6</u>	-1.0	60.9	<u>2.99</u>	<u>1</u>	<u>810</u>	3	<u>2</u>	<u>7</u>	<u>8</u>
WB-Grainfield	57.4	11.9	32.9	<u>51.7</u>	73.5	-0.6	60.8	3.84	3	835	4	3	1	5
Winterhawk	58.0	12.4	35.8	<u>47.1</u>	73.7	-1.3	61.0	3.89	3	940	5	5	1	4

Average	55.4	12.5	30.1	50.5	71.9	-1.1	62.1	4.28	3.5	910	3.8	3.4		
Minimum	50.6	11.5	24.9	38.5	68.2	-2.2	59.0	2.60	1	750	2	2		
Maximum	58.0	14.7	37.5	63.2	74.6	-0.4	65.0	6.62	6	1130	6	5		

Wheat Milling and Baking Quality Data - 2015 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	60.3	11.6	35.3	<u>50.5</u>	73.4	-1.6	<u>59.0</u>	3.10	<u>2</u>	805	4	4	2	5
Avery	57.9	11.3	30.1	<u>53.0</u>	72.3	-0.9	61.0	4.80	4	920	4	4	4	2
Brawl CL Plus	58.8	15.5	28.7	72.5	70.9	<u>-1.9</u>	64.7	3.08	<u>2</u>	950	3	4	5	4
Byrd	58.5	12.7	28.1	62.9	73.5	-0.8	63.0	4.47	4	1065	5	4	4	1
CO11D1236	58.0	10.9	31.5	<u>42.6</u>	74.4	-1.2	<u>59.0</u>	4.21	3	<u>725</u>	<u>2</u>	<u>2</u>	4	6
CO11D1306W	58.8	<u>10.6</u>	35.2	<u>43.8</u>	72.3	-1.5	<u>58.0</u>	3.77	3	<u>685</u>	<u>2</u>	<u>2</u>	5	<u>7</u>
CO11D1397	58.7	11.2	28.2	<u>50.8</u>	72.0	-1.4	60.7	5.88	5	915	3	4	5	2
CO11D1539	59.6	11.6	36.8	<u>52.0</u>	71.6	-0.4	61.9	3.19	3	925	4	4	2	4
CO11D1767	58.4	10.9	36.0	<u>58.4</u>	70.9	-0.7	59.7	3.37	3	<u>745</u>	<u>2</u>	<u>2</u>	3	6
CO11D446	<u>56.4</u>	11.3	<u>25.2</u>	<u>57.7</u>	71.2	-1.1	59.8	5.82	5	915	3	4	6	2
Cowboy	57.3	11.6	30.8	<u>52.6</u>	71.6	-1.0	60.7	4.43	3	905	3	3	5	4
Denali	60.7	<u>10.4</u>	31.6	<u>55.0</u>	72.0	-1.1	<u>58.8</u>	3.35	3	<u>715</u>	4	<u>2</u>	3	6
Hatcher	57.9	12.0	32.4	<u>51.7</u>	71.2	-1.0	61.8	3.46	3	875	3	3	4	5
Iba	59.5	<u>10.8</u>	33.3	<u>43.6</u>	74.2	-1.0	<u>58.9</u>	3.70	3	800	3	3	4	5
KanMark	58.5	12.1	<u>24.7</u>	74.3	72.2	-1.1	62.7	4.16	4	1015	5	5	6	2
LCS Jet	<u>53.8</u>	12.1	30.2	<u>57.4</u>	72.0	-0.8	63.9	4.64	4	860	<u>2</u>	3	6	3
LCS Mint	60.5	11.0	34.3	<u>48.5</u>	73.7	-0.9	59.8	4.84	4	865	5	5	2	3
LCS Pistol	58.1	15.0	28.2	<u>57.6</u>	<u>65.5</u>	<u>-2.4</u>	61.4	<u>1.87</u>	<u>0</u>	790	3	3	6	<u>8</u>
Oakley CL	60.0	11.0	39.2	<u>56.1</u>	72.1	-1.1	61.1	3.54	3	845	5	4	2	4
Sunshine	57.7	15.3	30.2	61.4	70.1	<u>-2.2</u>	67.7	4.81	5	1045	4	4	6	1
SY Sunrise	60.1	13.1	37.8	<u>46.8</u>	71.3	-1.5	60.1	<u>2.12</u>	<u>1</u>	<u>685</u>	3	<u>2</u>	2	<u>7</u>
SY Wolf	59.4	12.8	36.0	<u>56.5</u>	72.8	-1.3	59.8	2.92	<u>0</u>	915	3	4	2	<u>7</u>
T158	59.0	14.2	36.0	62.6	70.4	-1.4	60.8	<u>2.11</u>	<u>0</u>	<u>725</u>	3	3	4	<u>8</u>
TAM 114	59.1	13.7	<u>25.3</u>	72.7	69.9	-1.3	65.8	4.19	4	1075	3	5	<u>7</u>	1
Thunder CL	59.2	14.6	35.1	<u>56.4</u>	71.8	<u>-1.8</u>	63.8	3.24	<u>1</u>	1025	4	4	3	3
WB-Cedar	57.4	13.9	31.1	64.1	69.8	-0.6	62.8	<u>2.58</u>	<u>1</u>	855	4	4	5	5
Yuma	<u>55.8</u>	12.6	<u>26.8</u>	60.2	<u>68.8</u>	-1.5	63.8	2.67	3	890	3	3	<u>8</u>	4

Average	58.5	12.4	31.8	56.4	71.6	-1.2	61.5	3.72	2.8	872	3.4	3.5		
Minimum	53.8	10.4	24.7	42.6	65.5	-2.4	58.0	1.87	0	685	2	2		
Maximum	60.7	15.5	39.2	74.3	74.4	-0.4	67.7	5.88	5	1075	5	5		

Wheat Milling and Baking Quality Data - 2015 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	53.8	12.6	29.9	<u>51.1</u>	71.0	-1.3	61.6	3.77	3	840	<u>1</u>	<u>1</u>	3	6
Avery	53.1	<u>12.2</u>	25.3	60.4	71.3	-0.6	61.9	4.89	3	870	4	3	4	3
Brawl CL Plus	53.1	14.3	28.0	<u>56.3</u>	70.2	-1.2	64.6	<u>2.91</u>	3	935	<u>1</u>	<u>1</u>	3	4
Byrd	53.2	12.8	<u>25.0</u>	<u>57.4</u>	72.7	-1.1	62.6	4.96	5	975	4	3	3	1
CO11D1236	<u>50.5</u>	12.6	25.6	<u>57.3</u>	70.2	-0.9	62.9	4.52	5	855	<u>1</u>	<u>1</u>	6	4
CO11D1306W	52.3	12.4	<u>23.9</u>	66.1	69.3	-1.1	60.9	4.72	4	840	3	3	6	4
CO11D1397	51.9	<u>12.2</u>	<u>24.5</u>	<u>53.3</u>	<u>68.4</u>	-1.4	60.7	5.45	3	890	4	4	<u>7</u>	3
CO11D1539	52.0	13.3	28.2	<u>57.7</u>	70.7	-1.5	60.8	4.02	3	820	<u>1</u>	<u>1</u>	4	6
CO11D1767	54.4	12.6	27.2	69.4	71.9	-1.3	60.8	3.56	<u>2</u>	820	<u>1</u>	<u>0</u>	3	<u>7</u>
CO11D446	53.3	12.8	26.2	63.2	71.7	-0.5	63.8	5.63	5	935	3	<u>1</u>	2	1
Cowboy	51.4	<u>12.0</u>	<u>25.1</u>	61.0	69.2	-0.9	61.7	3.89	3	855	<u>1</u>	<u>1</u>	5	6
Denali	54.8	<u>11.9</u>	26.8	<u>59.8</u>	70.3	-1.0	60.6	3.19	3	855	<u>1</u>	<u>1</u>	3	6
Hatcher	52.5	13.4	26.5	60.8	70.1	<u>-1.8</u>	60.6	3.31	<u>2</u>	800	<u>2</u>	<u>1</u>	4	<u>7</u>
Iba	53.2	13.2	27.3	61.1	71.1	-1.5	<u>59.8</u>	3.06	<u>2</u>	<u>780</u>	<u>1</u>	<u>0</u>	3	<u>8</u>
KanMark	54.5	14.4	26.9	66.1	72.3	-1.6	63.5	3.57	<u>2</u>	965	3	3	2	3
LCS Jet	<u>47.8</u>	14.8	26.0	67.4	<u>68.6</u>	-1.6	64.6	3.92	3	865	3	<u>2</u>	<u>7</u>	4
LCS Mint	<u>50.6</u>	13.2	26.8	<u>58.7</u>	69.3	-1.4	61.9	3.68	<u>2</u>	810	<u>2</u>	3	6	6
LCS Pistol	52.7	14.0	26.9	<u>50.2</u>	<u>67.1</u>	<u>-1.7</u>	61.7	<u>2.62</u>	<u>1</u>	<u>760</u>	<u>2</u>	<u>1</u>	<u>7</u>	<u>8</u>
Oakley CL	52.7	14.4	26.0	71.7	70.5	-1.4	62.9	4.05	3	905	4	3	5	3
Sunshine	55.2	13.7	29.4	<u>46.1</u>	72.0	<u>-1.9</u>	64.7	3.98	4	980	<u>2</u>	<u>2</u>	2	2
SY Sunrise	53.2	12.5	29.0	<u>56.1</u>	70.8	-0.9	<u>59.8</u>	<u>2.55</u>	<u>1</u>	<u>700</u>	<u>1</u>	<u>1</u>	3	<u>9</u>
SY Wolf	55.4	14.3	29.7	69.8	71.1	<u>-1.8</u>	60.8	3.46	<u>0</u>	805	<u>2</u>	<u>2</u>	1	<u>7</u>
T158	52.5	13.3	29.0	<u>57.2</u>	70.9	-1.1	61.9	<u>2.85</u>	<u>2</u>	<u>730</u>	<u>2</u>	<u>2</u>	3	<u>8</u>
TAM 114	53.5	<u>11.9</u>	<u>24.9</u>	66.1	70.4	-0.8	61.0	4.81	5	980	5	4	4	1
Thunder CL	<u>50.6</u>	13.3	26.2	61.8	70.2	-1.2	62.5	3.50	<u>2</u>	900	<u>1</u>	<u>1</u>	5	6
WB-Cedar	54.3	14.4	32.0	<u>57.3</u>	71.7	-1.6	60.5	<u>2.59</u>	<u>1</u>	<u>770</u>	<u>1</u>	<u>1</u>	1	<u>9</u>
Yuma	51.4	12.9	26.4	<u>58.7</u>	69.4	-1.2	63.7	<u>2.89</u>	3	865	3	3	5	5

Average	52.7	13.2	27.0	60.1	70.5	-1.3	62.0	3.79	2.8	856	2.2	1.8		
Minimum	47.8	11.9	23.9	46.1	67.1	-1.9	59.8	2.55	0	700	1	0		
Maximum	55.4	14.8	32.0	71.7	72.7	-0.5	64.7	5.63	5	980	5	4		