

Wheat Quality Evaluations from the 2018 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 may not always be 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 other 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 baking quality but may be indicative of varieties with lower yield if yield differences at a given location are not taken into account (through "grain protein deviation"). 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 2018, grain samples were collected from seven dryland (UVPT) variety trial locations (Akron, Arapahoe, Burlington, Julesburg, Orchard, 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 content not too far below or above 11.5%, 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 Yuma dryland locations were excluded from analyses beyond protein content due either to average grain protein values being well below the minimum required for meaningful analysis or a lack of discrimination among the samples at that location.

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 value closer to zero 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) 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 CWRP 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 accounting for differences in environmental conditions from year to year and utilizing all of the data generated on the samples collected at a given trial location.

Composite scores are generated through a two-step process. First, each trait is ranked from high to low (or "very good" to "very poor") at individual locations and a score from 1=very good to 9=very 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 - 2018 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
AM Eastwood	58.3	13.5	24.2	79.0	65.8	-0.9	64.2	4.98	4	775	3	<u>2</u>	4	4
Antero	57.9	12.6	24.5	76.7	65.2	-1.4	<u>60.3</u>	4.46	3	<u>750</u>	3	<u>1</u>	5	7
Avery	57.3	<u>12.1</u>	24.2	79.5	66.9	-0.7	62.2	5.56	4	825	3	3	5	4
Brawl CL Plus	59.6	13.6	26.2	76.3	66.7	-1.3	63.4	4.82	3	850	4	3	2	3
Breck	59.3	13.5	<u>23.3</u>	72.2	66.0	<u>-1.6</u>	63.3	5.11	4	870	4	3	4	3
Byrd	57.7	12.9	<u>23.8</u>	74.1	68.7	-1.0	63.2	7.28	5	875	<u>2</u>	<u>2</u>	4	2
Byrd CL Plus	58.3	<u>11.9</u>	26.0	76.0	68.0	-0.9	<u>61.2</u>	4.78	4	<u>755</u>	<u>2</u>	<u>2</u>	3	6
Canvas	58.4	12.4	24.2	79.4	66.6	-1.2	<u>61.2</u>	6.51	4	760	<u>2</u>	<u>2</u>	5	5
CO13D0787	59.4	13.5	24.8	77.6	66.7	<u>-1.8</u>	64.2	4.77	5	865	4	<u>2</u>	3	2
CO13D1479	59.6	12.7	25.4	78.3	66.8	-1.5	<u>61.2</u>	6.07	5	885	4	4	3	3
CO14A070	57.9	<u>11.9</u>	<u>22.9</u>	78.0	67.8	-0.7	62.3	5.69	5	830	4	<u>2</u>	4	3
CO14A136	58.4	12.2	25.7	74.0	68.1	-1.5	<u>61.2</u>	5.21	4	<u>695</u>	3	<u>2</u>	4	<u>7</u>
CO15A018	58.7	12.2	27.1	73.5	68.5	-0.6	63.3	<u>3.23</u>	3	<u>735</u>	<u>1</u>	<u>1</u>	2	<u>7</u>
CO15D098R	58.5	12.9	25.6	79.4	67.5	<u>-1.5</u>	63.0	4.67	4	855	3	<u>2</u>	4	4
CO15SFD092	56.9	<u>11.4</u>	27.6	66.8	68.2	-1.0	<u>59.3</u>	6.43	4	785	3	<u>2</u>	5	6
CO15SFD107	59.0	12.9	<u>23.2</u>	72.9	71.2	-1.0	64.2	4.11	4	870	3	3	2	3
Crescent AX	58.2	12.8	27.4	67.9	68.1	-1.3	62.1	5.89	4	875	4	3	4	3
Denali	59.6	12.3	27.7	69.6	66.7	-1.2	<u>61.2</u>	4.49	4	<u>735</u>	<u>2</u>	<u>1</u>	3	<u>7</u>
Hatcher	58.2	<u>12.1</u>	25.1	78.0	65.7	-1.3	62.2	4.83	4	<u>750</u>	3	3	4	5
Incline AX	57.5	12.8	24.6	78.7	66.3	-1.2	62.2	4.40	3	775	3	<u>2</u>	4	6
Langin	57.9	<u>12.0</u>	26.0	72.5	67.8	-1.3	62.3	6.38	5	845	3	3	4	3
LCS Chrome	57.0	13.8	24.1	<u>84.9</u>	<u>64.7</u>	-1.2	65.3	<u>3.95</u>	4	885	3	3	6	2
LCS Mint	59.4	12.7	27.2	<u>75.8</u>	67.8	-1.0	62.4	6.35	5	875	3	4	1	2
Long Branch	<u>56.6</u>	13.1	24.0	78.8	65.3	-1.1	62.1	4.32	3	<u>740</u>	<u>2</u>	<u>2</u>	6	6
Monarch	57.4	<u>12.0</u>	24.3	79.9	65.5	-0.9	61.4	5.71	6	775	3	<u>2</u>	5	4
NHH144913-3	<u>53.0</u>	13.2	<u>23.8</u>	<u>53.3</u>	<u>60.0</u>	<u>-1.5</u>	62.1	<u>3.65</u>	3	790	<u>1</u>	<u>0</u>	<u>9</u>	<u>7</u>
Oakley CL	58.8	13.5	29.1	79.6	66.8	-1.3	63.2	4.16	4	825	3	<u>2</u>	2	4
Snowmass	58.3	13.0	27.8	<u>81.6</u>	65.6	-1.1	65.3	9.63	6	960	4	4	4	1
Snowmass 2.0	57.4	12.7	26.0	<u>82.2</u>	65.0	-1.2	61.3	9.43	5	885	4	4	5	1
Sunshine	56.8	12.3	25.8	<u>71.9</u>	66.1	-0.9	63.3	6.29	5	900	4	3	5	2
SY Legend CL2	57.9	13.0	26.5	78.7	<u>63.7</u>	-1.3	62.1	4.03	3	<u>740</u>	3	<u>2</u>	4	6
SY Monument	57.1	13.0	26.2	<u>84.6</u>	68.1	-1.1	63.2	8.10	6	830	4	3	5	1
SY Rugged	<u>56.1</u>	13.2	27.4	<u>73.0</u>	67.8	-1.3	63.4	5.77	4	865	4	3	4	3
SY Wolf	59.6	13.7	26.4	79.1	66.7	-1.2	62.3	4.67	<u>2</u>	785	<u>2</u>	<u>1</u>	2	6
WB-Grainfield	<u>56.1</u>	13.0	24.2	74.9	65.9	-0.9	63.2	4.81	4	840	<u>1</u>	<u>2</u>	6	4
WB4418	57.6	12.8	<u>23.6</u>	<u>91.0</u>	<u>62.0</u>	-1.4	62.2	5.11	4	<u>750</u>	3	<u>2</u>	<u>8</u>	5
WB4462	57.5	14.0	28.8	<u>70.8</u>	67.0	-1.2	63.2	4.33	3	825	3	3	2	5
WB4721	59.4	14.2	25.9	73.6	65.7	<u>-2.1</u>	63.2	4.45	3	915	4	4	3	3
Whistler	59.0	<u>12.0</u>	26.0	76.5	68.2	-1.1	<u>61.2</u>	5.91	5	820	3	3	3	4
Winterhawk	57.4	13.4	25.2	72.0	66.2	-1.2	63.3	4.15	4	820	<u>1</u>	<u>2</u>	4	5
Average	58.0	12.8	25.5	76.1	66.5	-1.2	62.5	5.36	4.1	820	3.0	2.4		
Minimum	53.0	11.4	22.9	53.3	60.0	-2.1	59.3	3.23	2	695	1	0		
Maximum	59.6	14.2	29.1	91.0	71.2	-0.6	65.3	9.63	6	960	4	4		

Wheat Milling and Baking Quality Data - 2018 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
AM Eastwood	58.6	12.4	27.4	69.5	69.7	-1.0	61.2	4.81	3	900	4	3	5	5
Antero	59.4	<u>10.9</u>	31.1	<u>60.0</u>	70.6	-0.8	<u>59.4</u>	4.16	3	<u>755</u>	3	<u>2</u>	4	<u>7</u>
Avery	60.0	11.9	29.2	69.7	70.7	-1.2	60.3	5.75	4	855	5	4	4	3
Brawl CL Plus	60.5	12.4	28.1	65.1	71.3	-0.9	62.6	4.73	4	965	4	4	2	2
Breck	60.9	11.2	27.3	68.8	72.0	-0.5	60.4	5.40	4	910	4	4	1	3
Byrd	59.9	12.2	29.4	63.4	72.2	-1.2	61.3	7.11	5	985	4	5	3	1
Byrd CL Plus	<u>57.9</u>	11.8	28.0	61.5	70.4	<u>-1.4</u>	60.3	4.26	4	835	<u>2</u>	<u>2</u>	<u>7</u>	5
Canvas	60.4	12.0	27.6	66.6	72.9	<u>-1.3</u>	60.4	7.25	5	910	4	4	2	3
CO13D0787	60.3	13.1	28.8	70.6	71.5	<u>-1.9</u>	64.2	5.69	5	940	4	4	3	1
CO13D1479	59.5	<u>11.0</u>	29.2	67.8	69.0	<u>-1.2</u>	<u>58.3</u>	8.15	4	865	5	5	5	3
CO14A070	58.8	<u>10.5</u>	27.8	64.0	70.8	-0.6	<u>59.2</u>	6.79	5	800	4	4	5	4
CO14A136	58.7	11.5	29.8	<u>58.6</u>	70.5	-0.6	61.3	5.37	4	<u>720</u>	3	<u>2</u>	5	5
CO15A018	59.3	12.0	28.0	64.9	72.3	-0.8	62.2	<u>3.83</u>	4	<u>745</u>	3	3	3	5
CO15D098R	59.7	<u>10.1</u>	29.2	66.2	69.1	-0.7	<u>58.4</u>	5.50	4	840	3	4	5	5
CO15SFD092	59.0	<u>10.2</u>	28.3	<u>56.7</u>	70.7	-0.7	<u>58.2</u>	6.74	4	825	3	3	6	5
CO15SFD107	59.8	11.3	27.3	61.4	72.0	-0.7	60.3	5.11	4	850	5	3	4	3
Crescent AX	59.0	11.1	32.5	<u>55.1</u>	72.3	-1.0	<u>59.4</u>	5.36	5	940	4	4	3	3
Denali	60.0	<u>11.0</u>	29.8	<u>57.4</u>	69.8	-0.6	60.4	<u>3.88</u>	3	<u>715</u>	4	<u>2</u>	4	<u>7</u>
Hatcher	60.1	11.8	29.0	65.1	69.9	<u>-1.3</u>	60.3	4.30	4	815	5	3	4	4
Incline AX	58.6	<u>11.0</u>	<u>25.9</u>	67.3	69.2	-0.6	60.5	4.75	4	930	4	4	6	3
Langin	58.4	11.4	28.5	67.9	71.3	<u>-1.4</u>	60.2	7.32	6	985	5	5	5	1
LCS Chrome	<u>57.8</u>	12.0	<u>25.6</u>	72.7	69.9	-0.8	61.4	4.33	3	925	4	3	<u>7</u>	4
LCS Mint	61.3	11.4	29.3	62.4	71.8	-0.7	60.5	6.09	5	965	4	4	2	2
Long Branch	58.4	12.0	27.6	74.4	69.8	-1.0	<u>59.3</u>	<u>3.72</u>	<u>2</u>	815	<u>2</u>	3	6	<u>7</u>
Monarch	59.2	11.4	29.9	68.7	70.1	-0.8	60.5	7.00	5	800	5	3	3	3
NHH144913-3	<u>56.5</u>	12.6	27.2	<u>37.7</u>	<u>65.2</u>	-1.1	62.3	4.11	3	<u>755</u>	<u>1</u>	<u>1</u>	<u>9</u>	6
Oakley CL	59.6	11.6	31.9	69.7	70.1	-0.6	61.5	5.95	5	900	5	4	2	2
Snowmass	60.0	11.2	32.3	73.4	69.5	-0.7	61.3	?	6	925	5	5	3	1
Snowmass 2.0	60.1	11.4	30.7	72.1	70.6	-0.8	60.4	9.95	4	925	5	5	3	1
Sunshine	59.0	11.8	32.6	<u>58.6</u>	71.1	-0.9	61.5	7.59	6	925	4	4	3	1
SY Legend CL2	59.9	12.1	28.0	75.4	<u>67.8</u>	-0.7	62.3	5.02	4	825	3	<u>2</u>	5	4
SY Monument	59.6	12.6	27.0	<u>80.6</u>	71.1	-1.0	64.2	9.60	6	990	5	5	5	1
SY Rugged	<u>57.9</u>	12.5	28.2	72.7	70.7	-1.2	61.2	5.16	4	1025	5	4	6	2
SY Wolf	60.4	13.1	27.4	79.0	<u>68.7</u>	-1.1	62.1	5.84	4	805	3	<u>2</u>	5	4
WB-Grainfield	<u>58.3</u>	11.9	28.3	66.7	71.3	-1.1	60.2	5.24	3	800	3	3	5	5
WB4418	59.0	12.3	<u>24.5</u>	<u>86.0</u>	<u>67.7</u>	-1.2	61.4	4.65	4	960	4	4	<u>8</u>	3
WB4462	<u>58.4</u>	12.0	30.7	68.9	70.3	-0.7	61.3	<u>3.78</u>	4	820	5	3	4	5
WB4721	59.9	13.1	28.0	68.6	70.7	<u>-1.4</u>	62.2	<u>3.93</u>	3	870	4	3	3	4
Whistler	59.5	11.7	<u>26.9</u>	69.3	70.2	-0.9	60.4	6.59	5	900	5	5	5	2
Winterhawk	60.7	11.7	30.9	64.3	70.7	-0.9	60.4	5.13	4	825	4	3	2	4
Average	59.4	11.7	28.7	66.7	70.4	-0.9	60.8	5.78	4.2	871	4.0	3.5		
Minimum	56.5	10.1	24.5	37.7	65.2	-1.9	58.2	3.72	2	715	1	1		
Maximum	61.3	13.1	32.6	86.0	72.9	-0.5	64.2	?	6	1025	5	5		

Wheat Milling and Baking Quality Data - 2018 Burlington

* **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
AM Eastwood	55.6	13.3	23.5	<u>59.0</u>	67.3	-0.3	65.1	4.84	4	890	3	<u>2</u>	4	5
Antero	56.1	<u>12.7</u>	26.1	<u>58.4</u>	69.4	-0.6	<u>63.2</u>	4.38	4	895	<u>2</u>	3	4	6
Avery	55.4	13.5	25.8	63.0	67.1	-1.0	64.4	5.82	5	1045	5	4	4	2
Brawl CL Plus	57.1	14.0	25.7	63.4	69.9	-0.5	65.0	4.68	3	1045	3	4	1	4
Breck	55.0	14.9	27.6	66.6	69.0	<u>-1.2</u>	68.1	12.14	6	1050	4	4	3	1
Byrd	55.5	13.5	23.0	63.4	69.1	-0.8	65.1	7.60	6	1075	4	3	4	2
Byrd CL Plus	<u>51.8</u>	13.8	24.0	<u>55.8</u>	67.6	-0.7	65.1	5.72	5	915	<u>2</u>	<u>2</u>	<u>7</u>	4
Canvas	55.1	13.3	23.1	60.7	70.6	-0.5	64.2	7.76	5	1050	5	4	3	1
CO13D0787	56.1	13.9	23.9	68.6	69.0	-0.9	64.9	6.68	5	980	4	3	4	3
CO13D1479	56.2	13.4	23.8	73.9	67.8	-0.8	64.1	8.20	5	1025	5	4	5	2
CO14A070	<u>53.1</u>	14.2	<u>21.7</u>	<u>58.7</u>	68.0	-0.7	65.1	7.36	5	1075	5	4	<u>7</u>	2
CO14A136	57.3	<u>12.7</u>	26.3	<u>57.3</u>	71.1	-0.7	<u>62.2</u>	5.31	4	<u>850</u>	3	<u>2</u>	2	6
CO15A018	55.5	13.6	23.6	63.2	70.2	-0.7	65.0	4.75	4	900	3	<u>2</u>	4	5
CO15D098R	55.3	13.1	24.0	62.4	69.3	-0.7	64.1	6.35	5	1025	3	3	4	3
CO15SFD092	<u>53.2</u>	13.5	<u>22.7</u>	<u>57.5</u>	68.0	<u>-1.1</u>	64.2	7.25	5	945	4	5	<u>7</u>	3
CO15SFD107	57.0	<u>12.5</u>	24.9	<u>53.8</u>	71.3	-0.7	<u>62.9</u>	5.49	4	970	4	3	3	5
Crescent AX	57.6	<u>12.3</u>	26.3	<u>59.9</u>	70.2	-0.7	<u>62.1</u>	5.72	5	1010	5	4	3	4
Denali	56.7	13.6	24.5	60.5	68.3	<u>-1.1</u>	<u>63.1</u>	4.49	3	<u>800</u>	<u>2</u>	<u>1</u>	4	<u>8</u>
Hatcher	<u>53.1</u>	13.1	<u>22.4</u>	<u>56.9</u>	<u>66.3</u>	-0.2	65.1	5.37	5	<u>875</u>	4	3	<u>7</u>	4
Incline AX	<u>53.1</u>	13.4	<u>21.1</u>	72.2	<u>65.1</u>	-0.6	64.0	4.52	4	965	3	3	<u>9</u>	4
Langin	54.8	13.6	24.0	<u>59.3</u>	68.9	-1.0	64.6	8.70	6	1000	4	4	4	2
LCS Chrome	55.3	14.1	<u>21.7</u>	69.6	68.3	-0.9	65.4	4.13	4	935	4	3	6	4
LCS Mint	57.7	13.2	25.5	<u>58.6</u>	69.8	-0.4	64.2	5.63	5	965	4	4	1	3
Long Branch	55.4	13.1	26.3	67.9	67.9	-0.7	<u>63.1</u>	4.39	4	<u>855</u>	<u>2</u>	<u>2</u>	4	<u>7</u>
Monarch	55.0	<u>12.8</u>	25.7	64.0	68.7	-0.6	64.9	5.56	5	900	4	3	4	4
NHH144913-3	<u>51.4</u>	14.4	23.3	<u>36.3</u>	<u>60.2</u>	<u>-1.1</u>	65.0	<u>3.36</u>	3	<u>715</u>	<u>2</u>	<u>2</u>	<u>9</u>	<u>7</u>
Oakley CL	57.0	13.5	27.7	74.6	68.2	-0.3	67.1	4.94	4	885	4	3	2	3
Snowmass	56.9	13.5	26.0	71.9	67.5	-1.0	66.0	11.30	6	1040	5	4	4	1
Snowmass 2.0	55.3	13.9	26.0	69.7	68.9	<u>-1.2</u>	65.2	17.33	6	1025	4	5	4	1
Sunshine	57.1	13.3	27.1	<u>53.0</u>	71.1	-0.7	64.1	8.70	5	990	4	6	2	2
SY Legend CL2	54.6	14.0	23.9	62.9	<u>65.6</u>	-0.8	65.9	5.28	5	955	3	4	5	2
SY Monument	55.5	13.0	25.8	69.6	70.1	-0.5	64.0	9.07	6	1055	4	4	4	1
SY Rugged	56.4	<u>12.4</u>	27.6	64.3	70.1	-0.6	<u>63.3</u>	4.67	4	890	3	3	2	6
SY Wolf	57.1	14.3	25.6	70.4	68.2	<u>-1.1</u>	<u>63.1</u>	5.66	5	970	3	4	3	4
WB-Grainfield	54.7	14.0	23.8	63.3	68.9	-0.8	<u>63.2</u>	4.52	<u>2</u>	905	<u>2</u>	<u>2</u>	4	<u>7</u>
WB4418	54.2	13.7	<u>22.1</u>	76.0	<u>66.0</u>	-0.3	65.2	4.29	3	1040	4	3	<u>7</u>	4
WB4462	55.6	14.3	27.0	<u>57.5</u>	70.2	-0.3	65.2	5.57	5	1025	5	3	2	2
WB4721	57.1	14.5	24.6	<u>57.7</u>	69.8	<u>-1.4</u>	65.1	4.50	3	935	4	4	3	4
Whistler	54.4	13.8	23.6	66.0	68.3	<u>-1.1</u>	66.0	8.66	6	1115	4	4	5	1
Winterhawk	55.6	14.2	25.2	63.0	67.6	<u>-1.3</u>	64.4	3.72	4	895	3	3	4	5
Average	55.4	13.5	24.7	62.8	68.5	-0.8	64.6	6.36	4.6	962	3.6	3.3		
Minimum	51.4	12.3	21.1	36.3	60.2	-1.4	62.1	3.36	2	715	2	1		
Maximum	57.7	14.9	27.7	76.0	71.3	-0.2	68.1	17.33	6	1115	5	6		

Wheat Milling and Baking Quality Data - 2018 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
AM Eastwood	57.9	13.8	30.5	<u>59.4</u>	68.8	-0.8	63.3	4.20	<u>2</u>	1020	4	4	3	5
Antero	58.3	12.9	27.1	<u>59.8</u>	72.0	-0.7	<u>59.3</u>	3.89	<u>1</u>	<u>855</u>	4	5	4	<u>8</u>
Avery	57.9	13.1	27.2	62.6	71.2	-0.5	63.1	5.09	3	1000	5	4	3	4
Brawl CL Plus	58.9	14.7	29.5	<u>58.6</u>	70.2	<u>-1.4</u>	64.2	3.54	<u>2</u>	1175	5	3	3	3
Breck	60.0	13.8	26.8	66.0	72.2	-0.5	65.2	4.64	3	1040	5	4	2	3
Byrd	57.4	<u>12.5</u>	27.2	<u>57.3</u>	72.1	-0.5	63.3	5.17	5	1095	4	4	5	2
Byrd CL Plus	59.2	13.4	26.9	<u>55.7</u>	71.4	<u>-1.1</u>	62.0	3.65	<u>2</u>	970	4	3	4	6
Canvas	59.5	13.5	26.2	66.6	73.5	-1.1	63.0	6.48	4	975	5	5	3	2
CO13D0787	58.8	14.2	28.3	60.2	71.5	-0.9	65.2	4.83	4	1070	5	5	3	2
CO13D1479	58.2	13.2	25.7	71.3	69.4	-0.5	63.2	7.88	5	985	5	5	5	1
CO14A070	58.2	13.3	26.6	61.6	71.3	-0.4	65.0	5.69	4	<u>840</u>	4	<u>2</u>	4	4
CO14A136	57.3	14.5	27.6	<u>57.0</u>	70.9	<u>-1.1</u>	63.2	3.44	<u>2</u>	<u>870</u>	3	<u>2</u>	5	<u>7</u>
CO15A018	58.2	14.2	26.6	64.3	71.6	-0.9	63.1	<u>3.27</u>	<u>1</u>	905	3	<u>2</u>	3	<u>7</u>
CO15D098R	59.0	13.1	28.3	<u>59.5</u>	71.0	-0.9	63.2	5.95	5	1005	4	3	3	3
CO15SFD092	58.6	<u>12.0</u>	26.9	<u>52.1</u>	72.7	-0.8	<u>59.3</u>	6.02	4	<u>875</u>	4	3	5	6
CO15SFD107	58.1	13.5	<u>24.7</u>	<u>50.3</u>	72.3	-0.7	<u>61.2</u>	<u>3.35</u>	<u>1</u>	990	4	3	6	<u>7</u>
Crescent AX	58.1	13.4	27.5	<u>55.2</u>	71.4	-0.7	64.0	5.69	4	1140	6	4	4	1
Denali	60.1	<u>12.7</u>	26.4	65.3	69.8	-0.7	<u>61.2</u>	3.78	<u>2</u>	<u>765</u>	3	<u>2</u>	4	<u>8</u>
Hatcher	58.8	14.0	27.6	60.9	68.4	<u>-1.4</u>	64.0	4.46	4	<u>875</u>	4	3	5	4
Incline AX	57.5	13.8	<u>24.9</u>	69.1	<u>67.9</u>	-1.0	65.1	3.75	3	<u>880</u>	4	4	<u>7</u>	4
Langin	57.2	<u>12.5</u>	28.3	<u>57.4</u>	71.6	-0.6	63.1	7.12	5	1000	5	5	5	1
LCS Chrome	<u>56.2</u>	14.9	<u>25.0</u>	67.2	69.9	-1.1	64.2	<u>3.20</u>	<u>1</u>	1005	6	4	6	5
LCS Mint	60.4	13.4	27.1	65.2	71.4	-0.7	63.1	5.02	4	1085	6	4	2	2
Long Branch	58.4	12.8	27.1	71.6	68.6	-0.5	<u>60.3</u>	<u>2.91</u>	<u>2</u>	950	4	5	5	6
Monarch	57.9	12.9	26.6	70.4	69.5	-0.9	63.3	5.04	4	975	6	5	5	3
NHH144913-3	<u>52.7</u>	14.4	25.7	<u>24.5</u>	<u>61.0</u>	<u>-1.3</u>	63.0	<u>2.68</u>	0	<u>805</u>	<u>2</u>	<u>1</u>	<u>9</u>	<u>9</u>
Oakley CL	59.9	13.6	32.7	71.5	69.4	-0.6	65.1	4.43	4	1035	5	4	2	2
Snowmass	59.3	14.1	32.3	73.9	69.1	-1.1	67.2	8.00	6	1150	5	4	3	1
Snowmass 2.0	58.7	<u>12.6</u>	31.6	71.2	70.4	-0.6	<u>61.3</u>	8.60	6	950	5	5	4	1
Sunshine	58.4	13.9	33.0	<u>52.7</u>	71.4	-0.9	65.3	5.54	5	1105	4	4	3	1
SY Legend CL2	57.9	13.2	28.4	67.9	<u>68.0</u>	-0.7	63.1	3.93	<u>2</u>	940	4	4	5	5
SY Monument	<u>56.9</u>	13.0	26.6	70.8	72.1	-0.9	65.4	6.26	5	1035	4	4	6	1
SY Rugged	57.7	13.1	28.9	66.5	71.3	<u>-1.3</u>	62.3	4.61	4	1050	6	4	4	3
SY Wolf	58.5	14.2	26.0	69.4	68.3	<u>-1.1</u>	<u>61.1</u>	4.13	<u>1</u>	1015	3	3	5	6
WB-Grainfield	57.5	<u>12.1</u>	27.9	61.8	71.5	-0.0	63.2	4.03	3	<u>830</u>	<u>2</u>	3	4	6
WB4418	57.7	13.0	<u>25.4</u>	75.2	<u>66.6</u>	-0.7	62.0	3.60	<u>2</u>	1005	5	4	<u>7</u>	5
WB4462	58.1	13.2	31.7	<u>59.8</u>	70.2	-0.7	<u>60.4</u>	4.24	<u>1</u>	910	6	5	3	6
WB4721	58.8	14.1	27.1	65.0	70.0	-0.9	62.1	3.45	<u>1</u>	1025	6	4	4	5
Whistler	57.8	13.2	26.5	70.8	70.5	-0.8	63.2	5.55	4	1040	5	4	5	2
Winterhawk	59.2	13.3	32.4	61.7	71.0	-0.9	63.3	4.31	4	1080	5	4	2	2
Average	58.2	13.4	27.8	62.7	70.3	-0.8	63.1	4.79	3.1	983	4.5	3.8		
Minimum	52.7	12.0	24.7	24.5	61.0	-1.4	59.3	2.68	0	765	2	1		
Maximum	60.4	14.9	33.0	75.2	73.5	-0.0	67.2	8.60	6	1175	6	5		

Wheat Milling and Baking Quality Data - 2018 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
AM Eastwood	57.8	12.8	29.8	63.0	69.6	-0.5	62.3	3.30	<u>2</u>	995	5	4	4	4
Avery	58.5	12.2	33.7	<u>56.2</u>	72.9	-0.8	62.4	3.79	3	1025	5	4	3	3
Brawl CL Plus	59.8	13.4	<u>25.8</u>	65.0	71.8	-0.6	62.4	2.95	<u>1</u>	1155	5	4	3	4
Breck	60.8	12.9	29.3	65.9	71.4	-0.9	60.5	2.82	<u>1</u>	900	5	4	2	6
Byrd	58.2	12.3	<u>28.2</u>	<u>57.6</u>	73.7	-0.9	61.4	4.31	3	1130	4	4	4	2
Canvas	59.8	12.0	30.7	64.9	73.3	-0.4	61.4	3.73	<u>2</u>	1030	5	4	1	4
CO13D0787	59.0	13.1	29.1	70.6	72.0	<u>-1.3</u>	61.4	3.92	<u>2</u>	1070	4	4	5	4
CO13D1479	58.3	12.0	32.2	61.2	71.0	<u>-1.1</u>	61.4	5.28	4	1040	4	4	4	2
CO14A070	58.8	12.0	30.3	60.2	72.5	-0.8	59.5	4.24	<u>2</u>	890	4	3	4	5
CO14A136	59.0	12.0	35.4	<u>54.4</u>	73.2	-0.9	61.3	3.56	3	<u>745</u>	3	<u>2</u>	3	6
CO15A018	57.8	12.5	29.4	63.1	73.0	-0.6	60.5	2.66	<u>1</u>	910	5	3	4	6
CO15D098R	59.1	11.9	35.8	<u>55.7</u>	72.0	-0.4	61.3	4.08	3	1045	4	3	3	4
Crescent AX	59.4	12.0	35.1	62.5	73.0	<u>-1.1</u>	61.4	3.59	3	1045	4	4	2	4
Denali	59.9	<u>11.5</u>	30.7	60.3	71.1	-0.5	59.4	2.60	<u>1</u>	<u>820</u>	3	<u>2</u>	3	<u>8</u>
Langin	<u>57.6</u>	<u>10.8</u>	33.6	62.9	71.4	-0.5	60.4	5.67	4	1025	4	4	5	2
LCS Chrome	57.9	13.6	31.3	61.7	70.8	-0.2	62.3	<u>2.11</u>	<u>0</u>	895	4	3	3	<u>7</u>
Long Branch	<u>57.3</u>	11.6	32.2	72.2	<u>68.7</u>	-0.7	59.4	<u>2.10</u>	<u>0</u>	895	4	3	<u>7</u>	<u>7</u>
Monarch	58.2	<u>11.3</u>	30.7	67.5	70.3	-0.7	<u>58.5</u>	4.16	<u>2</u>	945	4	5	5	5
Snowmass	58.5	12.0	36.2	72.6	<u>69.0</u>	-0.5	66.5	6.21	5	1110	5	4	4	1
Snowmass 2.0	58.6	12.0	34.4	69.0	71.5	-0.8	63.4	5.74	5	1075	6	5	4	1
Sunshine	59.9	13.0	37.2	<u>54.8</u>	71.3	<u>-1.1</u>	63.4	3.40	3	1095	4	3	2	3
SY Sunrise	60.0	12.5	34.3	<u>54.4</u>	70.8	<u>-1.2</u>	59.4	<u>2.01</u>	<u>0</u>	<u>835</u>	4	<u>2</u>	4	<u>8</u>
SY Wolf	59.1	12.8	31.7	65.5	70.2	-0.8	59.3	3.64	<u>1</u>	925	3	3	4	6
Thunder CL	<u>57.7</u>	12.6	31.4	61.3	71.0	-1.0	61.4	3.70	<u>2</u>	1085	4	4	5	4
Underwood	57.8	13.4	<u>28.3</u>	74.9	70.2	<u>-1.3</u>	60.4	<u>2.29</u>	<u>0</u>	910	4	3	<u>7</u>	<u>7</u>
WB-Grainfield	58.6	11.9	34.6	<u>59.3</u>	71.4	-0.6	59.5	2.60	<u>0</u>	910	4	<u>2</u>	4	<u>7</u>
WB4303	<u>56.8</u>	12.7	31.0	<u>58.0</u>	<u>69.2</u>	-0.7	60.5	2.68	<u>0</u>	1095	3	3	<u>7</u>	6
WB4418	<u>57.0</u>	12.2	<u>26.9</u>	74.5	<u>66.2</u>	-0.4	60.5	2.90	<u>1</u>	925	5	4	<u>9</u>	6
WB4458	59.1	13.3	33.9	<u>57.0</u>	<u>67.7</u>	<u>-1.3</u>	61.4	<u>2.08</u>	<u>0</u>	925	3	3	6	<u>7</u>
Whistler	58.8	<u>11.0</u>	30.5	68.6	70.8	-0.9	<u>57.4</u>	4.09	<u>2</u>	880	5	4	5	6

Average	58.6	12.3	31.8	63.2	71.0	-0.8	61.0	3.54	1.9	978	4.2	3.5		
Minimum	56.8	10.8	25.8	54.4	66.2	-1.3	57.4	2.01	0	745	3	2		
Maximum	60.8	13.6	37.2	74.9	73.7	-0.2	66.5	6.21	5	1155	6	5		

Wheat Milling and Baking Quality Data - 2018 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
AM Eastwood	58.2	13.4	26.9	72.6	<u>68.6</u>	-0.4	65.1	3.91	3	995	4	3	5	3
Brawl CL Plus	59.6	13.9	28.6	64.6	71.2	-0.2	66.0	3.52	3	1045	4	4	2	2
Breck	61.6	12.9	29.0	70.6	71.7	-0.7	63.4	4.05	3	1080	6	4	1	2
Canvas	58.2	13.4	<u>25.8</u>	69.9	71.6	-0.9	63.4	4.57	4	985	4	3	4	3
CO13D0787	58.7	13.3	27.8	69.2	71.1	-0.4	64.1	4.93	5	1085	3	3	3	1
CO14A070	59.0	13.0	<u>25.0</u>	69.7	71.4	-0.9	63.1	4.42	4	965	3	<u>2</u>	4	4
CO14A136	<u>56.9</u>	<u>12.3</u>	26.6	68.0	71.3	-0.3	64.0	4.17	4	<u>840</u>	3	<u>1</u>	6	6
CO15A018	<u>57.3</u>	13.3	29.8	64.3	70.3	-0.7	63.2	<u>2.63</u>	<u>2</u>	940	<u>2</u>	<u>1</u>	5	<u>7</u>
CO15D098R	58.6	13.3	28.5	67.9	71.5	-0.8	65.0	4.62	4	955	4	3	3	3
Crescent AX	58.9	<u>12.3</u>	31.2	63.3	71.7	-0.2	63.1	3.95	4	1025	4	4	3	3
Denali	58.8	13.1	29.1	64.3	70.0	-0.9	63.0	<u>3.09</u>	3	<u>810</u>	<u>2</u>	<u>1</u>	5	<u>8</u>
LCS Chrome	58.3	14.5	26.8	72.1	69.7	<u>-0.9</u>	64.1	<u>2.87</u>	<u>1</u>	950	3	<u>2</u>	4	<u>7</u>
Long Branch	57.5	<u>12.3</u>	<u>26.3</u>	74.2	69.5	-0.1	63.2	<u>3.22</u>	3	935	<u>2</u>	<u>2</u>	6	<u>7</u>
Monarch	<u>56.9</u>	<u>12.2</u>	<u>24.4</u>	75.9	69.9	-0.4	63.1	4.73	4	980	4	3	<u>8</u>	3
Snowmass 2.0	57.8	13.2	29.3	69.4	70.6	-0.6	66.1	5.48	5	1030	5	4	4	1
Sunshine	58.3	13.2	31.0	60.5	70.9	-0.6	65.1	4.79	4	1000	5	3	4	2
SY Sunrise	58.2	<u>12.3</u>	27.7	71.6	<u>68.2</u>	-0.7	63.2	3.51	4	<u>850</u>	<u>2</u>	<u>2</u>	5	<u>7</u>
SY Wolf	59.7	14.4	30.0	74.8	69.8	<u>-1.5</u>	<u>61.2</u>	3.94	<u>1</u>	970	4	4	3	<u>7</u>
Thunder CL	57.8	12.8	28.1	70.6	69.9	-0.5	64.2	3.63	4	985	5	3	5	3
Underwood	58.0	13.6	30.7	74.7	71.1	-0.7	64.0	3.95	4	985	4	3	3	4
WB-Grainfield	58.6	12.8	28.0	71.1	69.9	-0.2	63.0	<u>3.23</u>	<u>2</u>	<u>890</u>	3	3	4	<u>7</u>
WB4303	57.7	13.5	28.9	69.2	70.1	-0.0	65.2	4.01	3	1035	5	4	3	3
WB4418	59.1	13.3	27.7	<u>80.3</u>	<u>67.2</u>	-0.6	64.0	4.33	3	950	4	4	6	4
WB4458	59.3	13.2	31.8	62.8	69.4	-0.2	64.0	3.47	<u>2</u>	1000	4	3	3	5

Average	58.5	13.1	28.3	69.7	70.3	-0.6	63.9	3.96	3.3	970	3.7	2.9		
Minimum	56.9	12.2	24.4	60.5	67.2	-1.5	61.2	2.63	1	810	2	1		
Maximum	61.6	14.5	31.8	80.3	71.7	-0.0	66.1	5.48	5	1085	6	4		