

**Progress Report for the Agricultural Research Foundation
Oregon Wheat Commission**

Title: **Oregon Wheat Quality Program**

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Abstract:

The OSU wheat quality program conducted wheat quality tests on grain collected from OSU elite variety trials harvested in 2004 and from hard-wheat nurseries harvested in 2005. The latter testing provided critical milling, kernel, and dough rheology data on 35 hard wheat lines so selection decisions could be made before replanting in the fall. For the 2004 harvested grain, comprehensive quality profiling was conducted on 251 samples. Results confirmed the soft kernel texture and superior break-flour yields of ORSS-1757. Overall it was very encouraging to see the numbers of OSU SW lines that had better quality than the check variety in a number of quality attributes. Not all these lines will be advanced to release. Some will be omitted because of agronomic and disease factors, because they do not have a balanced suite of quality attributes, or because they may contain a “fatal flaw” with respect to quality. However, these data remain vital as they indicate not only which lines might be advanced based on quality, but also indicate where sources of superior quality reside within the OSU elite germplasm pool. Cross-checks of quality tests with the WWQL showed again the validity of the OSU lab protocols. The OSU wheat quality program also provided quality based selection recommendations on 141 entries across 7 winter wheat breeding nurseries from the 2004 harvest, provided updated SW winter and spring preferred variety lists, and applied early generation selection pressure on quality of around 1000, 2005 harvested, F3 to F5 lines. Development of steamed bread manufacturing and assessment capability for the quality program was completed, although some fine tuning remains to be done.

Objective(s):

1. Systematically assess the effects of growth environment and growing season on the composition, functionality, and end-use performance of wheats grown in Oregon.
2. Provide comprehensive data to the breeding program on wheat end-use suitability and on the stability of kernel traits across locations and years.
3. Provide preferred varieties lists for Oregon wheats, based on the suitability of varieties for existing market classes.

4. Enhance cost effectiveness and improve outcomes of the OSU breeding program by using the wheat quality program to validate innovative selection techniques.
5. Identify potentially valuable novel quality traits that could be incorporated into Oregon wheats.

Procedures:

Grain was obtained from the Oregon Winter Elite Yield Trials harvested in 2004. These trials were managed by the OSU wheat breeding program. From the 2004 harvest, only soft wheats were tested. This resulted from an absence of suitable and appropriately advanced hard-wheats from 2004 harvested material. Additional quality testing was also performed on selected hard-wheat samples harvested in 2005. For the 2004 harvested material, 95 individual location x genotype entries were tested by WWQL. These 95 entries comprised a subset of the 126 individual location x genotype entries (125 of which were represented by 2 field replicates) tested at OSU. WWQL performed conventional quality testing on the materials submitted to that laboratory and this data was used by OSU to compile the Oregon preferred lists. The additional quality testing done at OSU used grain from 4 selected locations with appropriate protein contents for soft-wheat end-uses. At OSU, 2004 harvest material was tested for single kernel characteristics, milling attributes, solvent retention capacities [SRC], wire-cut cookie diameter and breaking force, and noodle water-absorption, texture and color. Method development for southern-style steamed bread analysis was done on a limited number of samples and the method is ready for the 2005 harvest samples. These samples have been milled as of March 9 2006.

Report of Accomplishments:

Hard wheat testing from 2005 harvested grain:

An example of the beneficial impact of on-site quality testing was the unscheduled analysis of the milling, kernel, and dough attributes of 35 hard wheat samples. It was crucial that Dr Peterson obtained quality-based information on these lines in the short time available between harvest and replanting. To achieve this the quality program temporarily diverted resources from less time-critical work to this high priority need. Of the material tested, the lines recommended to Dr Peterson for advancement based on quality had better flour yields in test milling and comparable dough mixing characteristics to the check varieties used. Checks included a plains HWW, one recent HRW release from WA (Bauermeister), and an ID line scheduled for industry merit testing through the PNW wheat quality council in 2007 (IDO621). IDO621 is reputed to have improved quality over an existing HRW variety; Boundary.

Soft wheat testing from 2004 harvested grain:

The primary scheduled task for the OSU wheat quality program was the quality profiling of experimental SWW lines and selected existing varieties. In all, 251 samples from the 2004 harvest were tested. This represented 4 locations with up to 40 samples per location and each sample, except for one, with 2 field replicates. The 4 locations were Madras, Condon, Corvallis, and Pendleton.

Wheat and flour protein content:

Average wheat protein at the 4 locations ranged from 7.8 % at Condon to 11.3 % at Pendleton. The 5 lowest protein lines and varieties over the 4 locations were Dune, Tubbs, Rod, Finch, and OR9900598. Of note, both ORSS-1757 and Brundage-96 ranked lower in wheat

protein than the check variety Stephens but were not separable from Stephens statistically. Wheat and flour protein contents were highly correlated ($r = 0.97$) and there were no location x variety (L x V) interactions. The latter indicated that the rankings of lines and varieties were effectively the same across locations for wheat and flour protein content.

Single kernel hardness:

Average single kernel hardness values at the 4 locations ranged from 29.2 at Madras to 34.1 at Corvallis. Location means were well within the range expected of SWW wheats. The 5 softest lines and varieties across the 4 locations were OR9900553, ORSS-1757, OR2010239, Brundage-96, OR9900548. However, there were significant L x V interactions. These seemed to be related to shuffling of the ranks of the lines of intermediate hardness, as the overall softest lines were generally ranked amongst the softest samples at each location. The 5 hardest lines were, from softer to less soft, Madsen, ORI2020015, Coda, Clearfirst, and Clear Club. The variety Tubbs (hardness index = 35.8), was not significantly harder overall than Stephens (hardness index = 32.9). Correlation with the hardness data from the WWQL was positive and high ($r = 0.93$). Note; this high correlation resulted despite the fact that the WWQL and OSU analyses were done on a different field replicates of the same location x genotype entries. These comparisons with WWQL data, where they occurred out of necessity (e.g.; both laboratories need to mill the grain), are crucial external checks of our laboratory equipment, protocols, and procedures.

Flour milling:

Average flour yields (FY) at the 4 locations when calculated using only the genotypes common to all 4 locations, ranged from 64.3 to 66.1%, and break flour yields (BFY) ranged from 32.2 to 33.4%. There were no L x V interactions indicating that the rankings of lines and varieties were also effectively the same across locations for FY and BFY. Of the soft white commons, separated from the clubs, the highest ranked across locations for FY were ORI2020015, Simon, Coda, Madsen, Clearfirst, Finch, Dune, and Tubbs. Of the SW commons, the highest ranked for BFY were Finch, ID92-22407A, Brundage-96, ORSS-1757, and OR2010239. Club wheats ranked highly in both FY and BFY as expected. However, details are not reported here as there were no OSU experimental club lines in the sample set. Comparison with FY data from the WWQL, which used a different test mill, gave a positive and significant correlation ($r = 0.51$). However, the relatively low value reflects the idiosyncratic nature of flour mills, not procedural problems with the milling protocols at either laboratory. The correlation for BFY was stronger ($r = 0.64$) suggesting that our milling data is in broad agreement with the WWQL data.

SDS sedimentation volume:

SDS sedimentation volume (SDS-SV) is a proxy for dough strength; higher SDS-SV equals a higher likelihood of stronger dough characteristics. Average SDS-SV at the 4 locations ranged from 11.1 mL (Condon) to 19.9 mL (Pendleton). However, SDS-SV was highly correlated with flour protein content ($r = 0.84$), reflecting the strong influence of protein content on SDS-SV. When corrected for protein content (cSDS-SV) the spread of location averages was lower, with the highest location only greater than the lowest by a factor of 1.21, compared to a factor of 1.78 for the uncorrected data. There was no significant L x V interaction for SDS-SV. As expected across locations, the varieties with the lowest SDS-SVs and cSDS-SV were club

wheats: Coda, ClearClub, and Chukar. The SW commons with the lowest SDS-SVs and cSDS-SVs were ORI2010051, OR9900598, Stephens, OR2010353, and ORSS-1757. At the other end of the scale, the varieties with the highest values were OR3970965, OR 941611, OR9900513, OR9900553, and Gene. The low SDS-SV value of ORSS-1757 was reflected its shorter Farinograph mix time and lower stability, compared to Stephens, in the 2006 PNW wheat quality council (WQC) testing performed by WWQL.

Solvent retention capacity tests:

Performing solvent retention capacity (SRC) tests and monitoring the results remains an imperative for the OSU wheat quality program. This situation has accrued as a result of the burgeoning use of SRC tests in other breeding programs, in industry, and in industry assessments of pre-release wheats in the PNW WQC. Correlations between SRCs done at WWQL and OSU were generally strong. However, lockstep agreement was not anticipated given that the SRCs were performed on flour milled from grain from different field replicates. Additionally, the samples were milled on different mills. Different flour mills have grind roll surfaces, speeds, and speed differentials, different feed rates of mill stock into the grinders and sieves, and different sieve apertures and sieving times. These factors can all change the amount of starch damage, and non-endosperm material included in the flour, and hence the SRC values. Nonetheless, correlations between water and alkaline SRCs from the 2 laboratories had r values of 0.75 and 0.73 respectively. The correlation between sucrose SRCs was less strong ($r = 0.57$). Work is continuing to determine if there are real differences in sucrose SRCs created by the mills, or whether any misalignment is a result of a procedural issue at one of the 2 laboratories. Lactic acid SRC is to be dropped from our testing as it is highly correlated with SDS-SV ($r = 0.73$, 2004 harvest; $r = 0.88$, 2003 harvest).

In general, for water, carbonate, and sucrose SRCs in soft wheats, lower values are considered better. Over the 4 locations, Corvallis had the highest and Pendleton the lowest water, carbonate, and sucrose SRC values. This result held whether the subset of common varieties, or the whole sample set was used to calculate the average values. These locations also had the lowest and highest *flour* protein contents respectively, suggesting a gross negative relationship between protein content and these 3 SRC tests. For sucrose SRC, when the varietal data was pooled within locations, the correlation with flour protein content had a r value of -0.92 . This makes sense if one anticipates a general increase in gliadin synthesis as protein content increases as sucrose SRC is reputed to indicate flour gliadin levels along with arabinoxylans. The implications of this result need to be investigated with more detailed examinations of the protein compositions of selected varieties from different locations. There were no significant $L \times V$ interactions for any SRC test. The SW commons with lowest water SRC values across locations were Brundage96, OR9900553, OR2010242, OR9901619, and ID92-22407A. In all, 9 OSU experimental lines and the variety ORSS-1757 ranked lower than the check for water SRC. The SW commons with lowest carbonate SRC values across locations were Brundage96, OR9900553, ID92-22407A, OR2010353, and OR9901887. In all, 10 OSU experimental lines and the variety ORSS-1757 ranked lower than the check for carbonate SRC. For sucrose SRC, the SW commons with lowest values across locations were Madsen, ORH010918, ID92-22407A, Stephens, and OR9901887. The water, carbonate, and sucrose SRC tests will continue to be monitored for their effectiveness.

Wire-cut cookies:

Wire-cut cookies have been shown to rank varieties somewhat differently than do sugar-snap cookies (as made at WWQL). Additionally, because wire-cut cookies are formulated with less sugar, more shortening, and the addition of high-fructose corn syrups, data on the texture of the wire-cut cookies can be retrieved. Texture data that can distinguish flour types is not retrievable from the harder sugar-snap cookies. Of the locations, the largest cookies came from Condon, with the smallest from Corvallis. However, the location averages only ranged from 7.8 to 8.0 cm. Intriguingly, cookie break force (the inverse of tenderness) was positively related to flour protein content ($r = 0.99$) when the location averages were compared. However, no significant correlation was observed when the analysis was performed on the raw data. More investigations are anticipated on this issue. The top 5 SW common varieties and lines across locations for wire-cut cookie diameter were OR9900598, OR9900553, Brundage96, OR9900513, and OR2010353. For break force, the lowest (tenderest) 5 SW common lines were OR9901887, Dune, OR9900513, OR2010353, and ID92-22407A. The varieties, Mohler, Simon, Chukar, ORCF-101, Westbred528, Brundage96, Tubbs, and ORSS-1757 all ranked lower in break force than Stephens. There was a small range of values for wire-cut cookie diameter in this years samples (7.7 – 8.1 cm) compared to the WWQL sugar-snap cookies made from the same location x genotype entries (9.1 – 10.2 cm). However, when compared to wire-cut cookie diameters obtained by OSU from 2003 harvest samples (7.4 – 8.1 cm) this does not seem quite so anomalous. Nonetheless, additional attention will be paid to specific procedural details that were discussed recently with the scientists who developed the wire-cut cookie approved method. This will enable us to determine whether the small range of diameters is a methodology problem, or is an inherent aspect of the wire-cut cookie method.

Chinese raw noodles:

Chinese raw noodles are a noodle type formulated with flour, water, and salt. Their desired quality traits are a firm (hard) bite for cooked noodles along with a bright appearance not marred by background discoloration (e.g.; redness from microscopic bran fragments in the flour, or from the reaction products of enzymatic darkening).

Location averages for noodle-dough water absorption, and brightness and redness both 0 and 24 h after processing were significantly correlated with location averages for flour protein content. This is not surprising given the well documented effect of flour protein content on these parameters. More surprisingly, location averages for flour protein content were not correlated significantly with any location averages for texture parameters. However, the trends were as expected with higher flour protein related to harder, chewier, and springier cooked noodles. When overall correlations between flour protein and noodle parameters were performed on the raw data, the pooled results were confirmed. Flour protein content was significantly and negatively correlated with noodle-dough water absorption ($r = -0.73$) and brightness 0 h after processing ($r = -0.81$), and positively with redness 24 h after processing ($r = 0.62$). Flour protein was also positively correlated with cooked noodle hardness ($r = 0.69$) and chewiness ($r = 0.66$). Correlations between cooked noodle texture and SDS-SV were slightly stronger ($r = 0.73$ for both hardness and chewiness), indicating some additional impact of protein composition on noodle texture. There were no significant L x V interactions for noodle-dough water absorption or brightness, or for any of the cooked noodle texture parameters. Ranks for varieties across locations are not detailed here as a result of the overriding effect of flour protein content.

There is another factor that impacts noodle texture, flour swelling volume, which is primarily a starch based phenomenon. When flour swelling volume results from WWQL were compared to cooked noodle hardness they were correlated significantly and negatively as expected ($r = -0.57$). Attempts have been made to find a transformation of the data that will allow a better prediction of noodle texture from the raw flour protein and starch swelling data. For example, when flour swelling volume was divided by the square root of SDS-SV, then the relationship between this transformed factor and cooked noodle hardness improved to $r = -0.79$. A more sophisticated prediction model using both starch and protein composition data was created by Dr Jae Ohm that was able to predict noodle hardness with an r value of 0.94. Validation of this model using 2004 harvest data is not yet complete.

With respect to noodle sheet color, the enzyme polyphenol oxidase (PPO) has been identified as the primary cause of darkening of the noodle doughs during processing. The WWQL lab measures this with an analytical test on whole grain using an added substrate (L-DOPA), which darkens in proportion to the level of PPO present. The OSU lab measures the functional outcome, which is the darkening of the noodle doughs, which are made from flour, not whole wheat. Nonetheless, the L-DOPA test correlated significantly and negatively with brightness ($r = -0.58$) and positively with darkening ($r = 0.61$) at 24 h after processing. These results confirmed the value of the L-DOPA test a useful pre-selection tool. All varieties and lines tested had darkening values of $> 10 L^*$ (brightness) units over 24 h under our conditions. However, among the 36 lines with average darkening values of less than 5 L^* units, 10 had L-DOPA values > 1.0 . This suggests that the simple transfer of the L-DOPA targets from hard whites to soft whites may not be as simple as first considered. The potential differences between HW and SW may be due to inherent milling differences, or the different selection pressure placed on HWs by the pre-screening done using L-DOPA in many breeding programs. This L-DOPA based pre-screening at early generations has not been so widely applied to SW wheats, and only at OSU in the last 3 years.

Steamed breads:

Development of steamed bread manufacturing and assessment capability for the quality program was a key component of this year's activities. This year the focus was on the southern style steamed breads, an appropriate SW end-use. Method development was achieved by adaptation and miniaturization of existing Wheat Marketing Center formulations and methods. Steamed bread testing will be rolled into routine testing from the 2005 harvest. There is still some fine-tuning to be done regarding measurements of color of the skin and crumb of the miniaturized steamed breads, which do not conform readily to our available color measurement equipment.

Additional activities:

The OSU wheat quality program provided quality based selection recommendations on 141 entries across 7 winter wheat breeding nurseries (F6 to F10) from the 2004 harvest using previously defined quality scoring protocols and WWQL derived data. A customized scoring system that was developed by the PI reflects the weightings used for the preferred lists, but is under annual review so that it specifically fits the needs of the OSU breeding program. The system has been boiler plated into a computer spreadsheet for streamlined application to

incoming quality data. The OSU wheat quality program also provided updated SW winter and spring preferred variety lists using the latest data. Finally, using student labor supplied by the breeding program, early generation selection pressure on quality was applied to around 1000, 2005 harvested, F3 to F5 lines. This early generation quality screening continues to significantly improve breeding efficiencies.

Acknowledgements:

I'd like to acknowledge the dedicated work of Dr Jae-Bom Ohm and Mr Mike Beilstein who generated the data, and in Dr Ohm's case, made the majority of the required statistical analyses. Dr Ohm also analyzed data and made selection recommendations on the early generation material. Thanks also to the breeding program crew for collecting, labeling, cleaning, and packaging the samples. It is these services that allow the quality testing to happen smoothly.

Impacts:

The primary impact of this work is the enhancement of the variety development efforts of the OSU wheat breeding program. We have seen over the last few years, the increasing impact of the quality testing, as more and more of the advanced lines are of acceptable to excellent quality. This gives the breeder better odds of advancing a high quality line when needing to cull materials for other reasons. We believe as a group that the impact of the on-site quality program has been to improve the over all effectiveness of wheat variety development efforts in Oregon. This has led to short term benefits to the industry through release of a high quality variety. Medium and longer term benefits should accrue though the increased probability that any wheat variety released for Oregon will be desired in the marketplace. These efforts are our component in a coordinated effort, the end result of which is increased prosperity for the growers, their communities, and the state of Oregon. This OWC funded work also enables the wheat quality group to have serious and considered inputs to the ongoing discussions of quality-based preferred lists in the region, and to discussions of the desired quality targets for individual market classes of wheat.

Finally, the work has a great impact on the research activities of the quality program more widely. Active involvement in quality testing and data analysis has generated many new ideas, some of which have been published, or are in the laboratory stage. One idea is currently the subject of a new grant proposal. These ideas and publications help raise the profile of this quality program, therefore making it a more attractive option when others are seeking research collaborators. This year this has occurred with overtures from researchers at WSU and the U of Idaho to participate in a collaborative grant proposal based on the science of wheat quality. This proposed grant is targeted for submission to the USDA NRI competitive grants program.

Relation to other research:

This work is wholly integrated with the state-funded AES project of the PI and graduate projects supported by the Fulbright Foundation, Endowed Chair, and other OSU research funds. The work done here is also a key component of the wheat breeding program at OSU. The work also generates pilot data that is leveraged to help catalyze new collaborations, and create new funding opportunities both within and external to OSU.

Related publications and presentations

Publications

- Ross A. S., 2006. Instrumental measurement of physical properties of cooked Asian wheat-flour noodles. *Cereal Chem.* 83: 42 –51.
- Ohm J. B., Ross A. S., Ong Y. L., and Peterson C. J. 2006. Using multivariate techniques to predict wheat-flour dough and noodle characteristics from size exclusion HPLC and RVA data. *Cereal Chem.* 83: 1 – 9.
- Ross A.S., Hatcher D.W. 2005. Guidelines for the laboratory manufacture of Asian wheat-flour noodles. *Cereal Foods World.* 50 (6): 296-304.
- Ross A.S. 2005. Selecting for Quality II. The importance of market feedback. *Oregon Wheat*, 57: 10-12.
- Crosbie G.B., Ross A.S. 2004 . “Asian Wheat Flour Noodles ”, pp 304 –312 in, *The Encyclopedia of Grain Science*, Vol 2. C.W. Wrigley, H. Corke, and C.E. Walker, eds. Elsevier Academic Press, Oxford UK

Presentations and posters.

- S.B. Gehlhar, C.J. Peterson, A.S. Ross, J. Ohm, M.C. Verhoeven, B. Hoefler, M. Larson, and C. Saint Pierre. Characterization of Pacific Northwest Hard White Wheat Lines for End-Product Functionality. in *Breeding and Genetics for Quality: II. Wheat, Rice.* The ASA-CSSA-SSSA International Annual Meetings, November 2005. Salt Lake City, UT.
- C. Saint Pierre, C.J. Peterson, S.B. Gehlhar, A.S. Ross, J.B. Ohm, and M.C. Verhoeven. Influence of Moisture Stress and N on Molecular Weight Distribution of Winter Wheat Grain Protein. in *Small Grain Management and Quality: I.* The ASA-CSSA-SSSA International Annual Meetings, November 2005. Salt Lake City, UT.
- Castro, M., Peterson, C.J., Dalla Rizza, M., Díaz Dellavalle, P., Vázquez, D., Ibáñez, V., and Ross, A.S. Influence of heat stress on wheat grain characteristics and protein molecular weight distribution. 7th International Wheat Conference. Mar del Plata. Argentina. Nov – Dec 2005.
- Ross A.S., Ohm J.B., Peterson C.J. 2005. Relationship of noodle characteristics with size exclusion HPLC chromatogram of wheat protein extract in soft white winter wheats. 90th Annual Meeting of the American Association of Cereal Chemists, Orlando FL, USA
- Ross A.S., Ohm J.B., Ong Y.L., Peterson C.J. 2005. Wheat protein molecular weight distributions and noodles. 55th Australian Cereal Chemistry Conference. Sydney, NSW
- Ohm J.B., Ross A.S., Ong Y.L., Peterson C.J. 2005. Relationship of flour proteins with noodle color parameters in white winter wheats. Poster Proceedings of the 2005 meeting of the American Association of Cereal Chemists. AACC Press, St Paul MN
- Ohm J., Ross A.S., Peterson C.J., Engle D.A., Morris C.F. 2005. Relationships of cookie diameter with wheat and flour characteristics in club and soft wheats. Poster Proceedings of the 2005 meeting of the American Association of Cereal Chemists. AACC Press, St Paul MN
- Ohm J., Ross A.S., Peterson C.J., Engle D.A., Morris C.F. 2005. Relationships of quality characteristics with size exclusion HPLC chromatogram of wheat protein extracts in soft white winter wheats. Poster Proceedings of the 2005 meeting of the American Association of Cereal Chemists. AACC

Wheat varieties:

- ORSS-1757. C.J. Peterson, M. Verhoeven, M. Larson, B. Hoefler, W.E. Kronstad, R. Karow, J. Bassinette, A. Ross, J. Ohm, C. Morris D. Engle, R. Smiley, C. Mundt, Z. Chen, G. Vollmer., J. Robinson.