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 2005. Fast-tracked testing of hard-wheat nurseries harvested in 2006 provided critical milling, kernel, and dough rheology data on 16 hard wheat lines, enabling selections of seed increase candidates to be made with access to current-harvest quality-data. For the 2005 harvested grain, comprehensive quality profiling was conducted on 128 soft and hard elite samples including investigations of noodle and steamed bread performance. Quality-based selection recommendations were made to the breeder on 580 breeding lines across 19 winter wheat nurseries from the 2005 harvest. The program also delivered updated SW winter and spring preferred variety lists, and supervised quality screening testing and performed the data analyses on 1650 2006-harvested F3 to F5 lines. With the help of the quality-data produced or analyzed by the OSU wheat quality program Dr Peterson released SWW variety ORSS-1757, advanced 3 lines (ORN00B553 HRW, OR2052046H HWW, and ORH010920 SWW) to foundation seed increase, and advanced 2 lines (ORH010085 and ORI2042037 SWWs) to breeder seed increase. Development of micro-scale cake baking procedures was set back as a result of the loss of our visiting expert due to visa issues.

OBJECTIVES:

1. Provide extended quality profiles on selected Oregon elite breeding lines.
2. Monitor the effects of genotype, environment, growing season, and crop management.
3. Provide quality based selection recommendations to OSU Wheat Breeding program; for F4 and F5 generation material, from in-house testing; for F6 to F10 material using in-house quality scoring system.
4. Provide preferred variety lists for Oregon wheats, based on the suitability of varieties for existing market classes.
5. Enhance cost effectiveness and improve outcomes of the OSU breeding program by using the wheat quality program to research and validate innovative selection techniques.
6. Identify potential economically valuable novel quality traits that could be incorporated into Oregon wheats or other winter cereals.

Procedures:
Grain was obtained from Oregon Winter Elite Yield Trials and Hard Elite Yield Trials harvested in 2005. Sixty two soft-white wheat samples (10 lines x 2 field reps x 3 locations + 1 line x 2 field reps x 1 location) and 66 hard-wheat samples (11 lines x 2 field reps x 3 locations) were tested. Fast-tracked quality testing was performed on 2 field replicates of 16 selected hard-wheat lines harvested in 2006. Samples from the 2005 harvest underwent standard analyses; kernel hardness, grain and flour protein, moisture, milling performance, Mixograph dough properties, as well as extended quality profiling of wire-cut cookie, noodle, and steamed bread performance. Fast-track analyses focused on milling and dough properties. Approximately 1650 headrow samples from the 2006 harvest were tested for kernel hardness and polyphenol-oxidase activity, of these over 350 were tested for SDS-sedimentation values or solvent retention capacities (SRCs). The ARS WWQL laboratory performed conventional quality testing on the materials submitted to that laboratory and this data was used to compile the Oregon preferred lists and to generate quality-based selection recommendations for the intermediate generation lines.

REPORT OF ACCOMPLISHMENTS:

Objectives 1 and 2:

O1a: Fast-track testing. Selected hard-wheat lines and check varieties from the 2006 harvest were tested in the period between harvest and compilation of planting lists. Because of this effort, for the first time in Oregon's variety development activities, current harvest data was available to the breeder when making decisions on which lines to advance to seed increase. This fast-tracked testing has a substantial impact on the effectiveness of the breeding program. Using this confirmatory data Dr Peterson advanced ORN00B553 hard red winter wheat to foundation seed increase in the fall of 2006.

O1b: Soft-wheats (Appendix 1). *Overall:* Wheat protein content is an important index of the marketability of wheat. As such, it was instructional to see which other quality factors it relates to. Highly significant positive correlations ($p \leq 0.001$) (r values in brackets) were observed between grain protein and flour protein (0.97), protein loss on milling (0.59), SDS sedimentation volume (0.58), wire-cut cookie breaking force (0.44), noodle dough redness (initial 0.69; 24 hour 0.64), and steamed bread height (0.47), redness (skin 0.62; crumb 0.67), springiness (0.54), and chewiness (0.48). Negative correlations were observed between grain protein and noodle dough initial brightness (-0.46), cooked noodle hardness per unit protein (-0.80), steamed bread volume per unit protein (-0.82), steamed bread yellowness (skin -0.44; crumb –0.49), and Mixograph peak time (-0.65).

Locations: For the 3 locations (Arlington, Kaseberg, and Moro) grain protein contents averaged over the 10 entries were 11.1, 10.5, and 9.3 % respectively. Mean grain protein content from Arlington exceeded the SW target of 10.5%. The intermediate protein site (Kaseberg) showed slightly greater signs of stress with lower average grain weight than the other 2 sites. Kaseberg grain weight (32 mg) was below the SW target of 35 mg. The other 2 sites met the target. As site-average protein content decreased total flour yields also decreased slightly, and break flour yield and Mixograph peak time increased. At higher site-average protein content initial Chinese noodle color was slightly duller and redder, and cooked noodle hardness per unit protein (specific hardness) was lower. Average steamed bread skin brightness and crumb springiness increased with increasing grain protein content. The increase in skin brightness with increasing grain protein was contrary to observations for initial noodle brightness. Steamed bread skin and crumb redness increased slightly at higher protein, in this case consistent with trends for noodle color. Interestingly the apparently slightly stressed site of intermediate protein content had significantly higher SRCs for all 3 solvents (water, sucrose, alkali), slightly but not significantly lower wire-cut cookie diameters, higher noodle, steamed bread and Mixograph water absorptions, yellower noodles, and higher 24 h noodle brightness.

Varieties. 5 check varieties (ORSS1757, Brundage96, Tubbs, Stephens, Coda) and 5 elite experimental lines (OR2010239, OR2010241, ORH010918, ORH010920, OR9901619) were assessed across the 3 locations. Except for a few parameters varieties ranked similarly for quality parameters regardless of growth location. Averaged across locations no entries significantly exceeded the SW target of 10.5% for grain protein, although Brundage96 (11.1%), Coda (10.9%), and ORSS1757 (10.6%) were nominally higher. Similar was observed for flour protein content. In this case only Brundage96 (9.0%), Coda (8.9%), and Stephens (8.7%) nominally exceeded or equaled the SW target of 8.7% for flour protein. Grain size was generally good. Only Coda (29.3 mg) had significantly lower average grain weight than the SW and SW Club targets of 35 mg. Of the SW commons Brundage96 (32.8 mg) had the lowest and Stephens (41.8 mg) the highest average grain weights. Average kernel hardness indices were all lower then the SW target of 45. Notably, Brundage96, ORSS1757, OR2010239, and OR2010241 were grouped as softest.

Test-scale flour mills are each distinctive. Accordingly, it is not valid to compare absolute values of flour and break flour yields from mill to mill. The SW targets are based on the test-mill and milling protocol of the ARS WWQL laboratory, as such milling data from the WWQL test-mill is used here to rank varieties. The data is from single field replicates across 6 locations (Pendleton, Moro, Lexington, Arlington, Madras, Condon). Except for Coda (higher), and Tubbs, OR2010241, and ORH010920 (lower), total flour yields were not significantly different from the SW target of 68.2%. In the case of break flour yields, arguably the more important milling parameter for SW flours, average break flour yields of all entries significantly exceeded the SW target of 46.8%. For the SW commons break flour yield split 2 groups, a higher group (ORSS1757, Brundage96, OR2010239, OR2010241, OR9901619) and a lower group (Tubbs, Stephens, ORH010918, ORH010920). It needs reiterated that even the lower break flour yield group far exceeded the SW target for this quality attribute. As expected, Coda the club wheat had the highest break flour yield.

For all 3 solvent retention capacity tests lower values are better. SRC tests are sensitive to the amount of fine bran particles remnant in the flour and the amount of starch damage. Accordingly, SRC values are also mill dependent and so WWQL data is presented here as it is the basis of the SW target values. All entries met or were lower than the water-SRC target of 58%. Notably, the high quality check lines ORSS1757 and Brundage96 had the lowest water-SRC values. For sucrose- and alkaline-SRCs all entries were ranked equal to, or not significantly different from, the SW targets of 95% and 75% respectively. Mixograph water absorptions all met the SW target value.

There are no SW quality targets for the range of products tested in the "extended quality profiling" done in the OSU labs. Additionally, there are many individual quality parameters for the wire-cut cookies, noodles, and steamed breads, so only selected highlights are reported here.

Although SW wheat is not generally targeted at noodles, trips to Asia have highlighted the use of SW as a blending partner in the composition of noodle flours. Consequently it seems to be of value to observe some properties of Chinese salted noodles made from SW wheat. Noodle color was generally acceptable, overall initial brightness (L* = 84.5 to 86.3) was about 1 to 1.5 L* units darker than the elite hard wheats reported below, primarily as a result of the required average 2.5% higher water addition to the lower protein SW flours. OR9901619, OR2010241, OR2010239, Stephens, and Tubbs (86.3 to 85.9) were the best for initial noodle brightness. All entries were brighter than the HWW target for 24 hour L* of 72 and met the HWW color stability criterion of a decrease in L* of < 10 units over 24 hours storage. There are no HWW or SW targets for noodle dough redness (a*) values. However, my experience shows that redness values of > ~ 1 a* unit (red side of neutral) are sensed as discoloration by experienced evaluators. All entries except Coda (-0.01) had a* values < -0.5. Three entries, Stephens, Tubbs and ORSS1757 were grouped together with the lowest a* values. Noodle doughs from all lines became slightly redder after 24 hours, as expected, but only Coda registered a positive a* value. HWW targets indicate a maximum yellowness value of 25 b* units in noodle doughs after 24 hours and OR2010241, OR2010239, ORH010918, and ORH010920 met this criterion. Stephens, Tubbs, OR9901619, OR9801757, Coda, and Brundage96 (b* range 27.6 to 30.1) exceeded the target. However, as minor components in blends for white salted noodles these varieties should not create flaws, and may even serve as opportunities to fine tune flour and noodle color. In alkaline noodles, where their use would be somewhat less likely, the additional yellowness would be an advantage.

Steamed bread water absorption was significantly correlated with OSU determined values for water-SRC ($r = 0.44$; $p \leq 0.001$), and flour protein content ($r = -0.35$; $p \leq 0.01$). Highest absorptions, which may be of advantage in this product, were exhibited by Stephens, ORH010918, ORH010920, and Tubbs. Brightness of the steamed bread skin is important and 5 entries (ORH010920, Stephens, Tubbs, ORSS1757, OR2010241) had L* values > 98 for this attribute. Brundage96 and Coda, as with initial noodle brightness were ranked lowest. Stephens, Tubbs, and ORSS1757 also had low skin redness values, a positive attribute in this product, but steamed bread skins from these lines were slightly more yellow than the other entries, but still < 25 b* units and likely not to constitute a flaw. Instrumentally measured steamed bread hardness did not vary significantly between entries. However, 5 lines (OR2010239, Stephens, Coda, OR2010241, Tubbs) had significantly ($p \leq 0.05$) higher springiness when tested by texture-meter.

O1c: Hard-wheats (Appendix 2). *Overall.* Wheat protein content was highly significantly ($p \leq 0.001$) correlated with a number of quality attributes for these hard wheats. Positive correlations (r values in brackets) were observed with flour protein (0.95), SDS sedimentation (0.77), noodle redness 24 hours (0.52), cooked noodle hardness and chewiness (0.69 and 0.70), steamed bread volume and height (0.44 and 0.39), steamed bread skin and crumb brightness (0.55 and 0.54), and Mixograph water absorption (0.73). Negative correlations were observed with kernel weight (-0.55), noodle water absorption (-0.56), cooked noodle cohesiveness and resilience (-0.39 and –

0.54), steamed bread volume per unit protein (-0.60), and steamed bread crumb yellowness (-0.41).

Locations. For the 3 locations (Arlington, Lexington, Pendleton) grain protein contents averaged over the 10 HRW varieties and 1 SW variety were 11.3, 12.5, and 13.1% respectively. Only Arlington failed on average to meet the grain protein target (12.0%) for HRW wheat published by the USDA/ARS Grain Marketing and Production Research Center, Hard Winter Wheat Quality Laboratory, and devised by the HWW Quality Targets Committee. The high protein site (Pendleton) had lowest average grain weight of 33.0 mg but still met the HRW target of 30 mg. Site-average kernel hardness indices were within the HRW target range at all 3 sites.

At higher site-average protein content SDS sedimentation value was higher, Chinese noodle water absorption decreased, 24 hour dough brightness was lower, and noodle doughs were redder. A tendency for noodle dough yellowness to also increase with site-average grain protein content was evident after 24 storage. Average noodle color stability declined with increasing site-average grain protein but still met the HWW target of a decrease in L* of < 10 units over 24 hours storage. Cooked noodle hardness increased with increasing site-average grain protein content. Steamed bread water absorption, volume per unit protein, and springiness decreased, and steamed bread height, volume, and hardness increased with site-average grain protein content. Steamed bread skin and crumb brightness values, again contrary to the results for noodle brightness, also increased with grain protein content.

Varieties: Eleven entries were tested; 3 HRW varieties from the PNW (Paladin, Bauermeister, Declo; checks), 1 SW variety (Eltan; noodle color and steamed bread check), and 5 HRW (00B507, 00B553, NSA 98-0995, Apache, IDO621) and 2 HWW (N97S277, W96-359W) elite experimental lines. Averaged across locations, 4 entries ranked lower than the HRW grain protein target of 12.0%, but only IDO621 was significantly lower. There is no specific HRW flour protein target, but taking a protein loss on milling of 2.0% as the maximum permissible then all entries had flour protein content statistically equivalent to or higher than the “target”, although a minority ranked lower. Kernel hardness index was within the HRW target range (60 to 80) for all entries except W96-359W and Declo, but these both fell within the HWW target range (65 to 90). All entries easily met the HRW target for grain weight (30 mg) and all hard wheats exceeded the HWW target for minimum grain diameter of 2.5 mm (there is no HRW target).

Once again, as the HRW milling targets are based on a specific mill, it is not valid to make direct comparisons to the targets. However, we can observe the relative rankings of the entries. For total flour yield the entries fell into 3 groups; higher total flour yield (> 68%; NSA 98-0995, 00B507), intermediate flour yields (65 to 68%; Apache, Bauermeister, 00B553, Paladin, N97S277, IDO621), and lower yields (< 65%; Eltan, W96-359W, Declo). For break flour yields arguably the less important milling parameter for hard-wheat flours, average break flour yields again fell into 3 groups; higher break flour yield (> 30%; Eltan), intermediate break flour yields (25 to 30%; Apache, Bauermeister, 00B553, Paladin, N97S277), and lower yields (< 25%;, IDO621, W96-359W, Declo). In both instances Declo was ranked clearly lower in milling yields than all other entries. Flour loss on milling is important. Flour millers buy wheat based on grain protein content but sell flour often based on flour protein content. To maximize the amount of higher protein, arguably higher value, flours millers would like to minimize protein loss on milling (bran is far higher in protein than endosperm but the bran proteins are not “functional” from a dough-making perspective). I estimate as a rule-of-thumb that 2% protein loss would be the most one could reasonably accept. All but 3 entries (W96-359W, Apache, N97S277) met this rule-of-thumb “target”. Very notably, most entries showed increased protein loss as site average protein increased. This was also observed overall for the soft-wheats. However, 4 entries did not exhibit this behavior. 00B553, Bauermeister, IDO621, and NSA 98-0995 bucked the trend. It is unclear if this trait is heritable, or is mill dependent (likely) and it will be monitored over future seasons.

Work is proceeding in other labs regarding the use of SRC tests for hard wheats. At OSU we have a hypothesis that water-SRC could be a good index of overall water holding capacity of flour. Water SRC for these samples grown in Oregon ranged from 54.7 to 72.3%. This accords almost exactly with reported water-SRC values from hard-wheats grown in Kansas in 1999 and 2000[1]; range 54.4 to 72.1%. Water-SRC was highly and positively correlated ($p \leq 0.001$) with kernel hardness (r = 0.64), and steamed bread (r = 0.66), and Mixograph water absorptions (r = 0.47) and was negatively correlated with break flour yield (r = -0.80), and steamed bread specific volume (r = 0.45). Although there is yet no sense of what might constitute a minimum water-SRC for hard wheats, 8 entries (Declo, W96-359W, IDO621, Paladin, Bauermeister, Apache, 00B553, NSA 98-0995) exceeded 60%. The water-SRC of Eltan (56.4%), a soft wheat, would certainly constitute a lower boundary below which I would tender that hard wheats should not fall. Eltan was ranked lowest for water-SRC in this data set.

Dough properties are critical to the end-use of hard-wheats. The first criterion is that flours should absorb a minimum amount of water at “optimum” consistency. Water absorption is better determined using a Farinograph than a Mixograph, or by water-SRC (see above). Nonetheless, a rough guide to water absorption can be gained from the Mixograph. In this instance only 3 entries (W96-359W, Paladin, and Declo) met the HRW target of 62% minimum. Another group (N97S277, 00B553, 00B507, NSA 98-0995, Bauermeister, IDO621) fell in the range 57 to 60%. Apache fell below 56% Mixograph water absorption and was equivalent to the soft wheat Eltan, which was expected to have low water absorption. All entries but Declo met the HRW target for Mixograph peak time (3.0 to 6.0 minutes). Declo exceeded the target (average across locations 6.5 min). Apache was ranked lowest for Mixograph peak time (3.8 min). There are many other Mixograph parameters, but these are the only ones where direct targets can be addressed.

As with SW, HRW wheat is not targeted specifically at noodles, but HRW is also used as a blending partner in the composition of noodle flours. Consequently it also seems to be of value to observe some properties of Chinese salted noodles made from HRW, in this instance focused on noodle brightness. Initial brightness was acceptable, but the entries fell into 2 groups, a brighter group ($L^* > 86.5$; 00B553, Eltan, Declo, N97S277, IDO621, Bauermeister, Apache) and a less bright group ($L^* < 86.5$; 00B507, Paladin, W96-359W, NSA 98-0995). It was a surprise to see the HWW W96-359W in the less-bright group. After 24 hours there were 3 distinct groups, $L^* > 80$ (IDO621, Eltan, Bauermeister), L^* 78 to 80 (N97S277, Declo, W96-359W, Paladin, 00B553, Apache) and $L^* < 76$ (00B507, NSA 98-0995). However, all entries, red or white, hard or soft, met the HWW minimum brightness of $L^* > 72$ after 24 hours.

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[1] Chung et al 2006 Cereal Chem. 83(5):465–471

Overall steamed bread skin brightness from the hard-wheats was ~ 3 or more L* units duller than observed for the SW wheats reported above. Six entries had skin L* > 94 (W96-359W, Paladin, Declo, 00B553, 00B507, Eltan). Skin of steamed bread made from Apache flour was significantly less bright than steamed bread skin of all other entries. Crumb brightness was highly correlated to skin brightness (r = 0.80) with W96-359W and Apache again ranked highest and lowest respectively. Whiteness (lack of yellowness) is a positive quality attribute for steamed breads. Skin and crumb yellowness values were highly correlated (r = 0.94) so it is convenient to simply report steamed bread yellowness. Again the entries were grouped. Three entries (W96-359W, Paladin, 00B553) were ranked least yellow. Steamed breads from these entries were also ranked amongst the brightest, suggesting that these entries have an advantage related to steamed bread appearance. Steamed bread from Apache was significantly yellower than all other entries. Steamed bread volume was acceptable, and 5 entries constituted the highest volume group (Eltan, W96-359W, 00B507, 00B553, Paladin). Interestingly a number of these high volume lines were also superior for steamed bread appearance.

Further analyses on this data are underway to identify sources of greater or lesser trait stability for varieties across locations and within locations for groups of varieties

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<u>Objective 3.</u>

O3a: F4 and F5 generation material, from in-house testing. Approximately 1650 F4 and F5 headrow samples from the 2006 harvest were tested for kernel hardness and polyphenol-oxidase activity, of these over 350 were tested for sedimentation values or solvent retention capacities.

O3b: F6 to F10 material using our in-house quality scoring and ranking system. Quality-based selection recommendations were made to the breeder on 580 breeding lines across 19 winter wheat nurseries from the 2005 harvest. Recommendations were made using WWQL data.

<u>Objective 4.</u>

Preferred variety lists for Oregon spring and winter wheats were both updated during 2006.

<u>Objective 5.</u>

This objective is wrapped into objectives 1 and 2, particularly the observation of the relevance of SRC tests to hard wheats. The objective has also been advanced through innovative analyses of the data outputs from the single-kernel characterization system, research into the specific characteristics of noodle doughs and the relationships of glutenins to noodle dough behaviors, and the new prediction methods for determinations of Mixograph water absorption. Development of micro-scale cake baking procedures was set back as a result of the loss of our visiting expert due to visa issues.

<u>Objective 6</u>.

This objective has been addressed through new work relate to food uses of barley and observations of traits in the elite lines such as the apparently higher level of endosperm pigmentation in the elite HRW Apache.

Impacts:

The primary impact of this work is the enhancement of the variety development efforts of the OSU wheat breeding program. We continue to see the increasing impact of the quality testing, as more and more of the advanced lines are of acceptable to excellent quality. This has been borne out by the superb ratings OSU's newest varieties have received in pre- and post-release merit testing by both potential domestic customers and through USWheat's Overseas Varietal Analysis program.

Related publications and presentations

Publications

- Crosbie G.B. Ross A.S. eds. 2007. The RVA Handbook. AACC-International Press.
- Rogers R, Ross A.S. 2007. "Starch refining and modification applications", pp 63-74. In "The RVA Handbook". Crosbie G.B., Ross A.S. eds. AACC-International Press.
- Bennett L., Pollard A. Ross A.S. 2007. "Protein-rich foods and ingredients", pp 95-104. In "The RVA Handbook". Crosbie G.B., Ross A.S. eds. AACC-International Press.
- Ohm J-. B., Ross A. S., Peterson C. J,. and Ong Y-. L.. Wheat flour proteins and color characteristics of noodle doughs. Submitted. Cereal Chem.
- Saint Pierre C., Peterson C.J, Ross A.S., Ohm J.B., Verhoeven M.C., Larson M., Hoefer B. Winter wheat cultivars under different levels of nitrogen and water stress: i. Changes in grain quality. Submitted. J Cereal Sci.
- Saint Pierre C., Peterson C.J, Ross A.S., Ohm J.B., Verhoeven M.C., Larson M., Hoefer B. Winter wheat cultivars under different levels of nitrogen and water stress: ii. Changes in grain protein composition. Submitted. J Cereal Sci.
- Verbyla R., Appels A., Saint-Pierre C., Ross A.S. 2007. Fourier modelling, analysis and interpretation of high-resolution Mixograph data. Accepted. J Cereal Sci.
- Ross A.S., Ohm J.-B. 2006. Sheeting characteristics of salted and alkaline Asian noodle doughs: Comparison with lubricated squeezing flow attributes. Cereal Foods World. 50 (4): 191-196.
- Ross A. S., 2006. Review: 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.

Presentations

- Saint Pierre C., Peterson C.J, Ross A.S., Ohm J.B., Verhoeven M.C., Larson M., Hoefer B. Grain Protein Contents and Composition of Winter Wheat Cultivars Under Different Levels of N and Water Stress. 2007 Western Nutrient Management Conference Salt Lake City, UT. March 2007.
- Ross A.S. Selecting for Quality. Presented to Idaho Wheat Farmers Tour, Idaho Wheat Commission, Portland, Oregon January 2007.
- Ross A.S. Jae-Bom Ohm, C. James Peterson, Carolina Saint-Pierre, Byung-Kee Baik, Kerry C. Huber, Craig F. Morris. Tri-state wheat research update. 2006 Pacific Northwest Grains Conference, Portland, Oregon December 2006.
- Ross A.S. A review of instrumental measurements of physical properties of cooked Asian wheat-flour noodles". In symposium entitled, "Have Your Whole Grain Cake and Eat It Too: Challenges of Delivering Texture in Food Systems." World Grains Summit and 91st AACC-International Annual Meeting. San Francisco CA. September 2006.
- Ross A.S. Ohm J.B. Laboratory-scale sheeting and lubricated squeezing flow behavior of Asian noodle doughs. In symposium entitled, "Noodles: From Raw Materials to Finished Products to Consumers." World Grains Summit and 91st AACC-International Annual Meeting. San Francisco CA. September 2006.
- Ross A.S., Ohm J.B., Ong Y.L., Peterson C.J. New approaches to identification of gluten proteins with enhanced impacts on Asian noodle texture. AACC-International Pacific-Rim Asian Foods Symposium, 55th Australian Cereal Chemistry Conference and 12th Royal Australian Chemical Institute National Convention, Sydney, Australia, July, 2005.