Final Report to the Oregon Wheat Commission

Title: Investigation of the relationship between glutenin allelic composition of wheat and noodle making performance

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Abstract:

15 hard wheats were used to evaluate high molecular weight glutenin subunit (HMWGS) composition, chromatographic analyses, and Mixograph characteristics for prediction of noodle texture. As expected, flour protein content had a positive correlation with noodle hardness. HMWGS "functional" scores were related to dough strength and mixing tolerance, and to specific chromatographic analyses related to HMWGS composition. However, HMWGS "functional" scores had no significant correlations with noodle hardness. Analyses of variance produced a different picture of the effect of HMWGSs on noodle texture. Presence of *GluA1* HMWGS-1 in lower protein lines was associated with noodles of equal hardness to those made from higher protein *GluA1* HMWGS-null lines. This suggested that the presence of *GluA1* subunit-1 had a compensatory effect on noodle hardness, over and above the effect of protein content alone. For the other glutenin loci, *GluB1* and *GluD1*, flour protein content had more influence on noodle hardness than HMWGS composition. Overall, there were few significant univariate relationships between indicators of dough strength and noodle texture in this sample set. Where there were significant relationships between dough strength indicators and noodle texture, interpretation of the results was clouded by co-variance with flour protein content. This suggested that indicators of dough strength were not effective for predicting noodle hardness compared to protein content, with the exception of proteins coded at the *GluA1* locus. Ongoing multivariate analyses are proving valuable. These analyses are continuing beyond the OWC funded portion of the project. The results have been incorporated as pilot data in a USDA grant application relating gluten composition to noodle texture. The results have also guided selection of HW lines in the OSU breeding program, as currently there seems to be no impediment to selecting HMWGS compositions that are best suited to breadmaking, when breeding for the dual-use HWs.

Impact

The data reported below have served to progress our efforts in the wheat quality and wheat breeding programs at OSU in the following ways:

- The results have been incorporated as pilot data in a ~$500,000 USDA grant application based on investigations of the relationships between gluten composition and noodle texture.

- The results were immediately incorporated into the selection strategies of the OSU breeding program. Selections of parents and progeny were guided by the observation that there seemed to be no impediment to selecting HMWGS compositions that are best suited to breadmaking, when breeding for dual-use noodlemaking and breadmaking HW wheats.

- The data have provided knowledge that advances overall understanding of the role of HMWGS in cooked noodle texture. The data will be presented at the 2004 American Association of Cereal Chemists annual meeting in San Diego. Dissemination of results in this manner serves to highlight the credibility of the OSU wheat quality research program. Accordingly, the OSU wheat quality research program becomes a better candidate for external funding, and becomes more attractive to the high quality researchers we need to advance variety development in the future.

- The data have provided little knowledge understanding of the roles of the gluten proteins in noodle processing, especially sheeting. However, after observing this gap in the experimental design, we thought it salient to include consideration of this aspect in the larger project that seeks funding from USDA.

- The primary experimental scientist (Caryn Ong) is a Malaysian national. She intends to return to Malaysia and may enter the cereal processing industry there. The training she received, and the knowledge of US wheats she gained while in the USA, serve the US wheat industry well in fostering future business relationships, and US wheat sales, in Malaysia. Malaysia is a net importer of wheat.

- The data are being further scrutinized using sophisticated multi-variate analyses, beyond the OWC funded portion of the project.

Report of Accomplishments:

-Fifteen hard wheat genotypes and three soft white checks from the Oregon State University breeding program were characterized for high molecular weight glutenin subunit (HMWGS) composition, gluten molecular weight distributions (GMWDs), Mixograph characteristics and other traditional characterizations related to noodlemaking performance.

-These lines were variable for HMWGS composition (Table 1). This makes them a useful resource for future hard white improvement, both within and beyond the current targets for the HW market class. Lines highlighted in bold type (Table 1), were found to possess glutenin compositions compatible with our objectives to develop superior, dual-use, bread and noodlemaking HWs. Specific hard-white lines, highlighted in italic type (Table 1), have potential if targeted solely as noodle wheats. However this single-use objective is outside the current nationally agreed guidelines for the HW market class. Other lines were shown to have HMWGS compositions that would make it unlikely that they would ever fit quality guidelines for either single-use or dual-use HW. Accordingly, these lines will not be advanced, and no longer be used as parents, unless they provide substantial agronomic benefits, or unique quality benefits for other applications, that are not available elsewhere.

-It was observed for one group of HMWGSs, that there was an effect of the presence of specific HMWGSs on the texture of Asian noodles. The samples were grouped by their *GluA1* HMWGSs. The presence of either HMWGS-1 or HMWGS-2*, and the resulting increase in Mixograph peak time, gave a considerable buffer for noodle hardness against the lower protein content of this group of samples. This was observed when compared to the higher protein *GluA1* null group (absence of a HMWGS). An example using HMWGS-1 is presented in Table 2. In this case, flours of lower protein content which contained *GluA1* HMWGS -1, produced noodles not significantly different in hardness to the higher protein samples that possessed *GluA1* null allele. This is considered to be an important finding. The data presented in Table 2 was incorporated into the USDA grant application;

"*Identification of protein characteristics of U.S. hard and soft wheat for making Asian noodles*".

This proposal, seeking $497,467 of funding, was submitted jointly by specialist wheat researchers at Oregon, Michigan and Washington State Universities. The proposal was submitted to USDA National Research Initiatives, Competitive Grant Program 71.1, "Enhancing value and use of agricultural and forest products; Food Characterization/Process/Product Research".

Table 1: HMWGS composition of 18 wheat genotypes grown at Arlington, OR and harvested in summer 2002.

Variety	*Glu A1*	*Glu B1*	*Glu D1*	Potential use category
Nuplains	**2***	**13+19**	**5+10**	**dual-use**
OR942496	**1**	**6+8,17+18,7**	**5+10**	**dual-use***
OR953475	**2***	**7+9**	**5+10**	**dual-use**
OR9902410	**1**	**17+18**	**5+10**	**dual-use**
OR2020003	**2***	**7+9**	**5+10**	**dual-use**
OR2020006	**2***	**7+9**	**5+10**	**dual-use**
OR2020007	**2***	**7+9**	**5+10**	**dual-use**
OR943576	*2**	*6+8*	*3+12*	*noodle only*
OR941048	*2**	*7+9*	*2+12*	*noodle only*
OR3971156	*2**	*6+8*	*2+12*	*noodle only*
OR952577	2*	7	5+10	unsuitable for current targets
Ivory-8	2*	7	2+12	unsuitable for current targets
OR9900364	2*	7	5+10	unsuitable for current targets
OR9900374	n	17+18	5+10	unsuitable for current targets
OR9900384	n	7+9	5+10	unsuitable for current targets
Stephens (SW)	2*	7+9	2+12	soft, not categorized
Eltan (SW)	1	7+9	5+10	soft, not categorized
Madsen (SW)	2*	7	2+12	soft, not categorized

*Requires reselection for the *GluB1* HMWGS 17+18 line.

Table 2: Mean values of flour protein, noodle hardness, Mixograph peak time and corresponding f-scores[1] from ANOVA of comparisons of the varieties grouped by *GluA1* composition

	GluA subunit group	n	Flour Protein (%)	Noodle Hardness (g)	Mixograph Peak time (min)
Mean values	1	3	10.6	708.7	3.9
Mean values	null	2	12.0	725.5	2.5
ANOVA f-scores	1 VS NULL		16.3***	NS[#]	100.1***

***: f score indicates significant difference at P< 0.001.
[#]:NS: f score indicates no significant difference at P<0.05

- GMWDs were observed using size exclusion high performance liquid chromatography (SEHPLC, Figure 1). This technique separates gluten proteins based on their molecular weights, or size. Higher GMWDs are heritable traits and are related to higher dough strength and improved breadmaking performance. Few studies have sought to determine if higher GMWDs have any relationship to Asian noodle texture. Raw peak areas from SEHPLC were significantly related to noodle texture through co-variance with flour protein content. However, peak 1 area, an indication of the amount of the highest molecular weight, polymeric, flour proteins, had a higher correlation with noodle hardness (r = 0.511) than did protein content alone (r = 0.377). This suggests, even in this sample set, where dough strength was negatively related to protein content, that there was an advantage to having higher GMWDs in order to achieve the hardest noodle texture at a given protein content. This result is in accordance with the results of the comparison between the HMWGS-1 and HMWGS-null groups presented in Table 2.

Figure 1: Typical SEHPLC trace of wheat flour proteins extracted from flour using dilute detergent solution and ultra-sonic disruption. Peak 1 and peak 6 are labeled as examples.

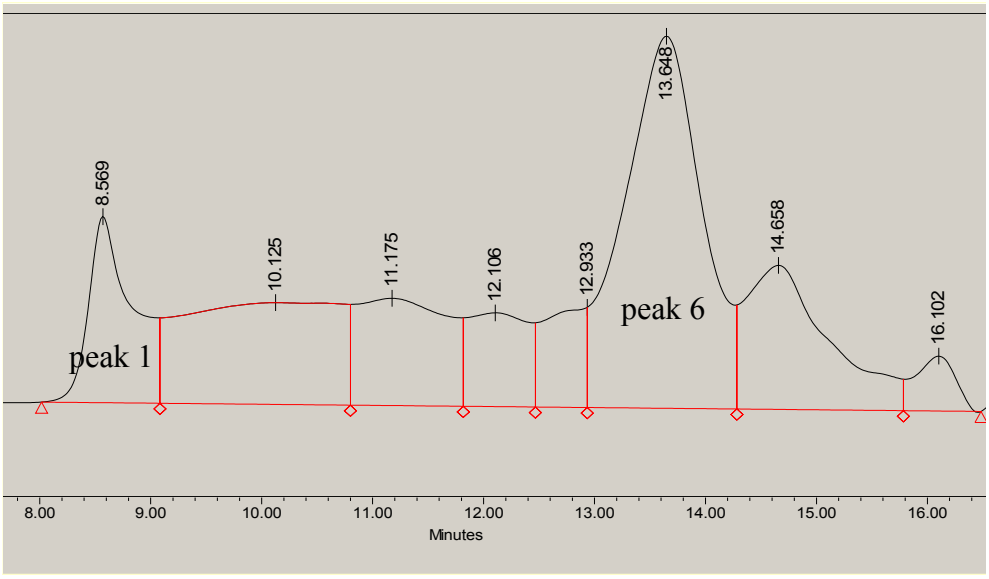

Table 3: Correlation coefficients between Payne score, selected Mixograph characteristics, and SEHPLC % peak 1[1]

	Payne Score
Mixograph peak time	0.849***
(%) Mixograph Midlinewidth 6 min after peak	0.731***
SEHPLC Percent Peak 1	0.459**

[1] ** and ***: Correlation coefficient is significant at P<, 0.01 and 0.001 respectively.

-Presence or absence of specific glutenin subunits was related to systematic changes in GMWDs and functional tests of dough strength (Table 3). This was most obvious through the use of "Payne Scores" which assign a "quality" score to each of the common

HMWGSs in commercial hexaploid wheat varieties. The SEHPLC peak area 1%, which effectively minimizes the effect of differences in protein content between samples, also showed significant correlations with Mixograph water absorption (r = 0.408), Mixograph peak time (r = 0.440), and Mixograph bandwidth 6 min after peak (r = 0.431). This is consistent with the literature, indicating that higher GMWDs reflect higher wheat protein quality and higher dough strength. The correlation of peak area 1 % with Mixograph characteristics was another illustration of how high amounts of polymeric protein are related to dough characteristics – in this case, with both increased strength and tolerance to overmixing. These results, as confirmations of relationships commonly observed between glutenin parameters and functional dough characteristics, allow us to have considerable confidence in other, less commonly observed, results of this study. However, there was no relationship between the peak 1 % values and noodle texture. This accords with the observations that neither HMWGS functional scores or Mixograph peak time were related to noodle hardness.

Conclusions

A diverse group of hard and soft grained wheat was available for this study. In addition, this group also had a large variation in HMW-GS composition (Table 1).

Flour protein content had a positive correlation with cooked noodle hardness

The *GluA1* null lines with higher flour protein content produced noodles in equal hardness, therefore, softer than expected, when compared to lower protein lines containing *GluA1* subunit 1. The picture was somewhat similar in comparing *GluA1*null lines with *GluA1* subunit 2* lines. At the *GluB1* and *GluD1* loci, higher protein content had more influence on noodle hardness than did HMW-GS composition.

SEHPLC absolute peak area data suggested that there was some relationship between GMWD and noodle hardness. However, this was contradicted by the results from the relative peak area data. There was no significant relationship between % peak 1 and noodle hardness. When combined with the HMWGS functional scores and the Mixograph data this result confirms our suspicion that HMWGS composition was not an effective way of predicting noodle hardness compared to protein content, except in the case of *GluA1*.

Our data from this sample set indicated that HMW-GS, SEHPLC and Mixograph characteristics were not effective for screening for noodle hardness (or texture). Flour protein and starch pasting properties were the dominant factor in determining noodle hardness.