Significance of Gluten Content as an Index of Flour Quality[1]

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ABSTRACT

Gluten content is an important factor in assessing flour quality. In this study, 40 samples of hard red winter and 17 samples of hard red spring wheat flours were analyzed for wet and dry gluten contents using the Glutomatic 2200 gluten washing system. Statistical analysis showed high correlation coefficients (0.92–0.97, $P < 0.05$) between wet and dry gluten values and protein content. Correlation coefficients between farinograph absorption and gluten were greatly improved when starch damage was included as a factor. Correlations for whole wheat glutens with flour protein, whole wheat, and gluten and farinograph parameters were higher when the whole wheat flours were sieved first.

The amount of gluten in flour is an index of the protein content, and the physical properties of the washed-out gluten provide an index of flour strength (Dill and Alsberg 1924). When gluten is washed by hand, a "personal factor" contributes to variations in the results obtained (Fisher and Halton 1936). Several mechanical devices, e.g., the Berliner-Ruter washer (Fisher and Halton 1936) and the Theby machine (Kent Jones and Amos 1957), have been introduced to improve the reproducibility of gluten recovery. The latest development is the Glutomatic gluten washing systam (Falling Number AB, Stockholm, Sweden). Little work has been published on this system (Greenaway and Watson 1975).

The objectives of this study were to determine gluten contents with the Glutomatic 2200 system in a series of straight-grade and whole wheat flours milled from hard red winter (HRW) and hard red spring (HRS) wheats and to correlate the gluten contents with protein values and some farinograph parameters of the samples.

Flour Samples

HRW flours. Forty HRW flours included 16 large-scale and 24 small-scale samples. The term large scale refers to samples of straight-grade flour produced in relatively large quantities (1,200 lb/hr) in the Kansas State University pilot mill; small scale designates straight-grade flours milled in smaller scale quantities (90 lb/hr) in the same location using the Miag Multomat mill. Both sets of flours were prepared for the 1979 collaborative study of the Wheat Quality Council (Anonymous 1980).

HRS flours. The 17 samples of HRS straight-grade flours were from North Dakota State University where they had been milled on the Double Multomat mill.

Whole wheat flours. Whole wheat flours for gluten determinations were prepared according to Redman and Burbridge (1979). Wheat kernels were ground in a small, coffee-type grinder (Varco Inc., France), then hand-sieved through a 65-mesh sieve (210 μm), recovering 55–60% throughs as sieved whole wheat flour.

Analytical Methods

Moisture, protein, farinograph, and starch damage determinations were performed by standard AACC methods 44-15A, 46-11, 54.21, and 76-30A, respectively (AACC 1976).

Flour Gluten Determination

Gluten contents were determined using the Glutomatic 2200 system by the procedure described by the Falling Number company (Falling Number AB 1985). The equipment comprises a combined dough mixer and washer, a centrifuge, and a drier. The mixing chamber is a plastic cylinder that fits around a mixing head, with a rotating stainless steel hook; the bottom of the chamber holds an 80-μm screen supported by a stainless steel plate. The sieve is moistened before use, to achieve a capillary water bridge that prevents flour loss.

A 10-g flour sample is introduced into the plastic chamber, and 5.2 ml of 2% sodium chloride solution is added by a built-in syringe. The plastic chamber is attached to the mixing head and mixing is started. After 20-sec (the mixing sequence is programmed), the steel hook is automatically lowered further into the chamber, and a 5-min washing cycle with 2% sodium chloride is initiated at a liquid flow rate of 50–60 ml/min.

After washing, the gluten is impaled on spikes and centrifuged at 6,000 rpm for 1 min. The wet gluten weight is determined, and the wet gluten is positioned and flattened between the twin hot plates of the drier, where it is heated for 4 min. The dried, thin sheet of gluten is then weighed and recorded as dry gluten.

Whole Wheat Flour Gluten Determination

Gluten washing for whole wheat flour was similar to that for straight-grade flour, except the washing cycle consisted of 2 min

TABLE I
Flour Characteristics

Flour Characteristic, %[a]	Range	Mean
HRW (16 large-scale samples)		
Protein	11.2–14.6	12.9
Wet gluten	20.9–40.0	30.45
Ash	0.40– 0.47	0.43
Flour extraction	70.5–77.8	74.92
Dry gluten	10.7–24.5	12.6
Starch damage	3.87– 5.72	4.76
Farinograph absorption	59.2–65.6	62.4
Farinograph peak, min	2.25–15.00	8.63
HRW (24 small-scale samples)		
Protein	10.4–15.0	12.7
Ash	0.35–0.45	0.41
Flour extraction	69.7–75.9	72.6
Wet gluten	25.9–42.1	34.0
Dry gluten	9.4–15.1	12.25
Starch damage	2.75–5.77	4.26
Farinograph absorption	59.2–71.6	65.4
Farinograph peak, min	3.6–23.75	13.67
HRS (17 samples)		
Protein	12.0–15.0	13.5
Ash	0.35–0.45	0.42
Flour extraction	69.7–75.9	72.71
Wet gluten	31.0–41.9	36.45
Dry gluten	11.7–15.3	13.5
Starch damage	5.43–8.97	7.2
Farinograph Absorption	54.0–66.0	60.0
Farinograph peak, min	3.5–25.5	14.5

[a] HRW = Hard red winter, HRS = hard red spring. All values except farinograph peak are percentages.

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TABLE II
Correlation Coefficients for Flour Characteristics Given in Table I

Flour Characteristics[a]	Protein	Absorption	Mixing Time	Starch Damage
HRW large-scale				
Wet gluten	0.96*[b]	0.79*	0.82*	−0.31
Dry gluten	0.97*	0.75*	0.80*	−0.28
Starch damage	−0.24	0.03	−0.40	···
HRW small-scale				
Wet gluten	0.94*	0.43*	0.32	−0.51*
Dry gluten	0.95*	0.36	0.41*	−0.62*
Starch damage	−0.59*	0.34	−0.42*	···
HRS				
Wet gluten	0.92**	0.58*	−0.12	0.25
Dry gluten	0.96**	0.43	−0.003	0.15
Starch damage	−0.13	0.66*	−0.41	···

[a] HRW = Hard red winter, HRS = hard red spring.
[b] * = $P<0.05$, ** = $P<0.01$.

washing in a chamber fitted with an 80-μm sieve, followed by 3 min of washing using an 800-μm sieve.

RESULTS AND DISCUSSION

Flours

Ranges and means of wet and dry gluten values, protein content, farinograph parameters, and starch damage for large- and small-scale HRW flours and the HRS flours are summarized in Table I. Correlation coefficients among these variables are shown in Table II.

Both wet and dry gluten increased with increasing protein content in the flours. The relationships were significant for HRW flours (0.94–0.97, $P< 0.05$) and highly significant for HRS flours (0.92–0.96, $P < 0.01$). That the correlation coefficient for dry gluten versus protein (0.95–0.97) was higher than that for wet gluten versus protein (0.92–0.96) indicated that determination of dry gluten should be the preferred procedure.

Significant correlations also were observed between wet gluten content and farinograph absorption (Table II). However, the correlations between wet gluten and absorption were lower for small-scale HRW and HRS flours compared to those for large-scale HRW flours. Starch damage caused by different mills may be involved in these relationships. Damaged starch is more hydrophilic than undamaged starch. Bushuk (1966) pointed out that damaged starch accounts for a substantial portion of the water uptake in dough. A significant correlation was found between starch damage and absorption for the HRS flours but not for either of the two groups of HRW flours. The correlation between gluten and absorption was significantly improved with the inclusion of starch damage for the HRW small-scale and HRS flours, but not for the HRW large-scale flours (Table III). The three groups of flours were milled by three different milling systems. Possibly the differences in milling resulted in differences in starch damage, which in turn would influence dough absorption. The predictability of absorption is known to be influenced by both gluten and starch damage (e.g., Bushuk 1966, Greer and Stewart 1959).

Whole Wheat

Data for gluten contents of the HRW large-scale whole wheats and sieved whole wheats are shown in Table IV. Gluten contents were higher for sieved whole wheats than for the whole wheats, which is accounted for by the removal of most of the bran in sieving. Correlation coefficients were significant (Table V) between whole wheat or sieved whole wheat glutens and wheat protein, flour protein, glutens, and farinograph mixing times; these correlations were improved with sieving. The sieved whole wheat gluten also showed a significant correlation with farinograph absorption, whereas the unsieved whole wheat gluten did not. The relationships indicate that the endosperm protein is the predominant factor in absorption.

TABLE III
Multiple Correlations (R^2 values) Between Flour Absorption and Gluten Values With and Without Adjustments for Starch Damage

Flour Absorption[a]	Wet Gluten Adjusted	Wet Gluten Unadjusted	Dry Gluten Adjusted	Dry Gluten Unadjusted
HRW large-scale	0.72	0.63	0.62	0.56
HRW small-scale	0.60	0.18	0.64	0.13
HRS	0.63	0.35	0.54	0.18

[a] HRW = Hard red winter, HRS = hard red spring.

TABLE IV
Protein and Gluten Contents of Whole Wheat and Sieved Whole Wheat Flours (HRW Large-Scale Samples)[a]

Flour Characteristic	Range	Mean
Whole wheat protein, %	11.9–14.9	13.3
Whole wheat		
Wet gluten, %	16.6–40.2	32.9
Dry gluten, %	9.7–14.6	12.0
Sieved whole wheat		
Wet gluten, %	33.5–48.7	38.8
Dry gluten, %	12.3–17.9	14.1

[a] HRW = Hard red winter.

TABLE V
Correlation Coefficients for Whole Wheat Flour Glutens

Flour Characteristic	Whole Wheat Wet Gluten	Whole Wheat Dry Gluten	Whole Wheat (sieved) Wet Gluten	Whole Wheat (sieved) Dry Gluten
Wheat protein	0.76*[a]	0.76*	0.83*	0.89*
Flour protein	0.63*	0.66*	0.83*	0.86*
Flour wet gluten	0.74*	0.71*	0.79*	0.81*
Flour dry gluten	0.74*	0.71*	0.87*	0.87*
Farinograph				
Absorption	0.36	0.29	0.58*	0.56*
Mixing time	0.72*	0.71*	0.70*	0.71*

[a] * = $P<0.05$.

CONCLUSION

Significant correlations were obtained between flour glutens and proteins for both HRW and HRS wheat flours. The inclusion of damaged starch as a factor in addition to the gluten, both of which are affected by the degree and type of milling, improved the correlation and predictability of flour water absorption. Significant correlations also were obtained between whole wheat or sieved whole wheat glutens and wheat proteins, flour proteins, and flour glutens. Sieving was beneficial in improving these correlations. The study indicates that gluten estimation is an important test for evaluation of wheat and flour quality.

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