Wheat Hardness: Effects of Debranning and Protein Content[1]

W. OBUCHOWSKI[2] and W. BUSHUK, Department of Plant Science, University of Manitoba, Winnipeg, Canada R3T 2N2

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ABSTRACT

Wheat hardness measurements on pearled wheat showed that the bran has some effect on the magnitude of the hardness index but essentially no effect on the ranking of cultivars within a group covering soft, hard red spring, and durum classes. Results for nine samples of one variety of hard red spring wheat from one location, all having protein contents in the 9.4–15.6% range, showed that hardness decreases with increasing protein for some indices and remains essentially constant for other indices. Results for all indices on debranned wheat showed that protein content had no effect on endosperm hardness.

Of the different parts of the wheat kernel, the endosperm is most important for bread production. Physical properties of the endosperm, such as hardness, are closely related to technologically important flour properties such as starch damage, particle size, and size distribution (Moss et al 1973, Newton et al 1927). The physical properties of the endosperm are quite different from the analogous properties of the bran and germ. Not only the properties, but also the proportions, of the morphologically distinct parts of the kernel vary among wheat cultivars. Furthermore, some kernel hardness tests probably do not express only the physical characteristics of the endosperm but are influenced substantially by the properties of the bran. To estimate the influence of bran on various indices of hardness, measurements of hardness were carried out on wheat grain debranned by pearling. The results are reported in this article.

Some confusion about the influence of protein content on wheat grain hardness exists in the literature. As early as 1927, Newton et al (1927) reported that no relationship exists between protein content and wheat hardness. According to Moss et al (1973), for a single cultivar, kernels of higher protein content are softer than kernels of lower protein content. On the other hand, Greenaway (1969) obtained a high positive correlation between wheat hardness index (WHI) and protein content. Stenvert and Kingswood (1977) found that, for wheats grown under the same environmental conditions, hardness increased with increasing protein content; however, the rates were cultivar dependent.

The results of these studies were obtained by different methods of grain hardness evaluation. Newton et al (1927) used a kernel cracking technique; Moss et al (1973) measured pearling resistance and particle size index; Greenaway (1969) used the wheat hardness index determined from measurements on the one-step Brabender Hardness Tester (BHT); and Stenvert and Kingswood (1977) used grinding resistance (time taken to produce a specific amount of flour when the wheat was ground under standard conditions). Different methods do not rank cultivars of different hardness in the same order (Obuchowski and Bushuk 1980).

In the present study, the influence of protein content on kernel hardness was investigated for one wheat cultivar.

[1]Contribution 562, Department of Plant Science, University of Manitoba, with financial assistance from the National Research Council of Canada.
[2]Present address: Institute of Food Technology of Plant Origin, Agriculture University, 60-624 Poznan, Wojska Polskiego 31, Poland.

TABLE I
Ash and Protein Contents of Wheat Samples Debranned to 65% of Yield

Wheat Class and Cultivar	Ash, %[a]				Protein, %[b]		
	Whole	Debranned	Flour[c]	Loss[d]	Whole	Debranned	Loss[e]
Durum							
Hercules	1.65	0.90	0.77	85	16.9	14.6	14
Steward 63	1.55	0.78	0.67	87	13.3	12.1	9
Hard							
Glenlea 1	2.01	0.95	0.51	70	14.0	13.3	5
Glenlea 2	1.67	0.97	0.50	60	14.3	13.2	8
Neepawa	1.86	0.92	0.50	69	12.6	11.3	10
Sundance	1.83	1.08	0.50	56	11.6	10.5	10
Chester	1.90	1.15	0.47	52	14.8	13.1	12
Manitou	1.84	1.07	0.52	59	16.5	13.4	19
Soft							
Talbot	1.67	1.07	0.44	49	14.0	12.2	13
Fielder	1.84	1.17	0.42	47	12.1	10.7	12
Pitic	1.76	1.20	0.48	43	11.2	9.9	12
Fredrick	1.62	1.08	0.40	44	13.6	11.3	17

[a]Ash and protein contents on dry basis.
[b]$N \times 5.7$.
[c]Flour milled on Buhler laboratory mill from whole wheat.
[d]Bran ash loss $= \frac{\text{whole ash} - \text{debranned ash}}{\text{whole ash} - \text{flour ash}} \times 100.$
[e]Protein loss $= \frac{\text{whole protein} - \text{debranned protein}}{\text{whole protein}} \times 100.$

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TABLE II
Some Characteristics of Samples of Wheat Cultivar (11-604) of Different Protein Contents

Grain Protein[a] (%)	1,000-Kernel Weight (g)	Hectoliter Weight (kg/hl)	Grain Ash[b] (%)	Debranned Grain Ash[b] (%)	Debranned Grain Protein[a] (%)
9.4	32.8	83.5	2.11	1.19	8.4
10.2	38.1	83.4	2.11	1.22	9.1
10.6	37.4	83.7	2.12	1.09	9.5
11.3	38.4	83.5	2.04	1.11	10.1
11.8	39.3	84.8	2.13	1.11	10.6
12.4	37.3	84.3	2.13	1.14	11.0
14.0	42.3	83.9	2.12	1.15	12.0
14.7	38.8	85.9	1.97	0.99	12.6
15.6	38.9	84.9	2.05	1.09	13.3

[a]N × 5.7, 14% mb.
[b]Dry matter basis.

TABLE III
Comparison of Results of Grain Kernel Hardness Evaluation Obtained on Whole and Debranned Grain

Wheat Variety	Energy Input, cm[a]		Torque, BU		Time of Grinding, sec		Average Particle Size, μm		Particle Size Index of Flour, %		Torque, BU[a]	
	Whole	Debranned	Whole	Debranned	Whole	Debranned	Whole	Debranned	Whole	Debranned	Whole	Debranned
Hercules	73.0	70.0	398	653	101.6	56.8	526	476	26.8	23.3	916	739
Stewart 63	72.7	67.1	364	617	114.0	57.9	516	468	29.1	29.0	879	689
Glenlea 1	67.5	61.9	366	489	101.1	67.5	499	452	37.9	36.6	777	704
Glenlea 2	66.4	63.0	370	563	101.5	60.2	499	456	38.3	36.8	685	571
Neepawa	70.4	61.6	386	560	99.6	58.9	498	446	40.9	39.4	876	629
Sundance	69.4	65.4	361	559	106.1	62.8	498	450	43.0	41.7	682	618
Chester	55.8	55.1	304	424	107.6	69.7	482	436	44.9	41.2	861	714
Manitou	65.2	58.9	347	497	106.6	62.6	484	438	45.8	40.4	808	637
Talbot	41.4	37.6	212	296	110.5	69.3	459	405	52.7	45.4	713	···
Fielder	50.5	43.5	250	308	115.3	80.5	440	402	56.0	56.2	757	623
Pitic	58.5	51.4	258	339	126.0	84.9	451	412	53.3	51.1	812	697
Fredrick	48.4	43.3	197	272	136.8	95.6	419	389	57.6	51.4	670	543
Change, %[b]	86–99		123–169		51–70		88–93		86–100		72–92	
Coefficient of correlation	r = 0.980		r = 0.899		r = 0.872		r = 0.991		r = 0.958		r = 0.578	

[a]One-step Brabender Hardness Tester.
[b]Debranned/whole × 100.

TABLE IV
Results of Kernel Hardness Evaluation for Samples of Wheat Cultivar (11-604) of Different Protein Contents

Protein Content (%)	Methods of Grain Kernel Hardness Evaluation: Wheat Hardness Index	Average Particle Size (μm)	Flour Yield (%)	Energy of Grinding (cm^2)	Torque (BU)	Time of Grinding (sec)	Particle Size Index of Wheat (%)	Pearling Resistance Index (g)
9.4	69.5	471.7	9.5	49.6	660	87.4	30.5	15.06
10.2	69.4	474.2	9.8	50.4	680	88.3	31.7	12.40
10.6	72.6	473.8	9.5	51.3	690	91.1	32.0	14.10
11.3	70.0	472.0	9.6	50.3	672	89.3	30.2	13.32
11.8	64.3	467.4	10.5	50.0	675	88.3	31.7	13.78
12.4	72.2	471.4	9.7	52.3	700	88.3	30.7	13.20
14.0	65.4	466.8	10.4	50.2	680	88.3	31.0	13.39
14.7	62.8	460.3	10.7	50.7	672	89.3	31.2	13.92
15.6	62.4	457.3	10.9	48.0	680	84.6	32.0	13.55

MATERIALS AND METHODS

The wheat samples used for the debranning experiments were the same as those used previously (Obuchowski and Bushuk 1980). The effect of protein content was examined using nine samples of an experimental variety of hard red spring wheat (11-604) grown at one location.

After being tempered to five levels of moisture content, the wheat was debranned by pearling in a Strong Scott Barley Pearler to give a yield of 65% of pearled product. The hardness of the pearled product was assessed by methods described previously (Obuchowski and Bushuk 1980). For measurements on pearled wheat, the following modifications in the two-step Brabender

TABLE V
Correlation Coefficients Between Protein Content and Hardness Indices

	Whole Grain	Debranned Grain
Wheat hardness index	−0.749[a]	−0.032
Average particle size	−0.903[a]	0.126
Flour yield	0.868[a]	0.325
Energy of grinding	−0.315	0.496
Torque	0.172	0.408
Time of grinding	−0.435	−0.337
Particle size of wheat	0.231	−0.649
Pearling resistance index	0.198	···

[a]$P = 0.01$.

TABLE VI
Results of Kernel Hardness Evaluation for Samples of Debranned Wheat Cultivar (11-604) of Different Protein Contents

Protein Content (%)	Methods of Grain Kernel Hardness Evaluation						
	Wheat Hardness Index	Average Particle Size (μm)	Flour Yield (%)	Energy of Grinding (cm^2)	Torque (BU)	Time of Grinding (sec)	Particle Size Index of Wheat (%)
8.4	52.7	439.0	11.2	64.3	590	58.1	35.2
9.1	52.8	443.6	10.7	62.1	565	58.5	35.6
9.5	56.5	443.3	10.7	65.7	605	57.7	34.6
10.1	53.6	441.5	11.0	63.6	590	57.7	35.5
10.6	56.7	444.0	10.5	64.1	595	58.1	32.4
11.0	60.9	447.5	10.1	66.0	615	56.8	32.5
12.0	52.1	438.1	11.9	68.1	620	58.1	32.5
12.6	55.3	442.9	11.3	66.7	625	56.8	31.4
13.3	52.2	443.5	11.1	64.2	580	58.1	34.2

Hardness Tester were necessary. The position of the indicator levers was set as for the 50-g farinograph mixing bowl; the damper was set to give a recovery from 1,000 to 100 BU in 4 sec; and the speed of the chart paper was changed to 7.2 cm/min from the normal speed of 1.0 cm/min. All hardness results reported are averages of duplicate measurements.

Relevant data for the cultivar samples are given in Table I and for the samples of different protein content for one cultivar, in Table II.

RESULTS AND DISCUSSION

The ash contents of whole and debranned grain (Table I) indicate that pearling to 65% yield removed approximately 43–87% of the bran ash. A greater proportion of the ash was removed by debranning in the durum and hard red spring wheat cultivars than in the soft wheat cultivars. The protein content of pearled grain was 1–3% lower than that of the original grain.

Debranning increased the torque measured by the two-step BHT by 23–69% and decreased the other indices of hardness: energy input by 1–14%, grinding time by 30–49%, average particle size by 7–12%, and particle size index of flour by 4%. Torque on the one-step BHT was decreased 8–28% (Table III). The change in the torque on the one-step BHT was opposite to that on the two-step BHT. This was probably caused by widely variable grain size, which affects the measurements in the one-step BHT.

With the exception of the one-step BHT torque, the results for debranned grain of different classes and cultivars were highly significantly correlated with those obtained for whole grain. The hardness values for debranned grain ranked the cultivars in essentially the same order as the values determined on whole wheat (Table III).

The indices for debranned wheat were strongly affected by moisture content (results not shown); the trends were in the same direction as those obtained for the original grain (Obuchowski and Bushuk 1980). With debranned wheat, the best differentiation of the wheat cultivars by most indices was obtained at a moisture content of 12.5–14.0%. The optimum moisture contents for the two-step BHT, the Quadrumat Junior mill, and the one-step BHT were 12.5, 14.0, and 15.5%, respectively.

The rankings of cultivars obtained on the basis of energy input, torque, grinding time, average particle size, and particle size index of flour obtained with the two-step BHT were similar to those obtained for the whole grain (Obuchowski and Bushuk 1980). On the other hand, the ranking made on the basis of the one-step BHT torque was quite different from that obtained with this index for the original wheat, indicating that the results obtained with this instrument are strongly influenced by the bran.

Analysis of variance of results for underbranned samples of different protein content (Table IV) showed significant differences in hardness evaluated by all but two of the methods. No difference in hardness was found among the nine samples on the basis of grinding time and particle size index. A highly significant negative correlation was obtained between protein content, WHI, and average particle size, and positive correlation was found between protein content and flour yield from the two-step Brabender Hardness Tester (Table V).

Measurements of hardness on debranned wheat (Table VI) did not show any significant correlation with protein content (Table V). This observation confirms the hypothesis that bran has a definite influence on results of grain hardness evaluation.

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