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Hardness and Moisture Content of Wheat Kernels

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HARDNESS AND MOISTURE CONTENT OF WHEAT KERNELS[1]

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ABSTRACT

The hardness of kernel sections of hard red winter and soft white winter wheat and durum wheat decreased with increasing moisture content. Small variations in hardness with variety and test plot location were detected.

The hardness of samples of several varieties of hard red and soft white winter wheat and of durum wheat, grown in crop years 1956 and 1957 in test plots in Kansas and North Dakota, was determined in relation to moisture content by means of a grain hardness tester recently developed at this laboratory (2) from a commercial hardness tester called the Barcol Impressor. In the present investigation Model II of the tester was used. This model was provided with two testing ranges, a high range used for testing hard wheat and a low range used for testing soft wheat or hard wheat at high moisture content.

Materials and Methods

The hard red winter wheat varieties used in this work were Ponca,

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Kiowa, and Wichita, grown in test plots at Manhattan, Hays, and Belleville, Kansas, in 1957. Durum varieties tested were Mindum, Vernon, and Langdon, all grown at Minot, North Dakota, in 1956. Elmar and Brevor, grown at Manhattan, Kansas, in 1956, were the varieties of soft white winter wheat used.

Following the procedure described by Katz *et al.* (2) transverse sections of wheat kernels, about 1 mm. thick, were taken from the central portion of the kernel to be tested, by use of a freezing microtome, and were cemented to glass microscope slides with Duco cement. Cracked sections, or those with skewed surfaces, were culled from the test samples through visual examination.

To ascertain whether freezing and thawing of the wheat kernels associated with use of the freezing microtome had any effect on kernel hardness, 40 kernel sections were prepared, 20 with the freezing microtome, and 20 from the same lot of durum wheat by using wax to secure them to the microtome stage during sectioning. Both groups were kept at 81% relative humidity. After 1 week one section from each group was tested every day for 20 days. No difference in hardness of the two groups was detected. It was therefore concluded that freezing and thawing on the microtome stage did not affect hardness measurements significantly.

After the Duco cement holding the sectioned kernels had set, the mounted sections were placed in a chamber containing a solution of sulfuric acid in water, of a concentration appropriate to a desired humidity (3). The hardness of kernel sections was measured after moisture equilibrium was reached at eleven different values of relative humidity, from 10 to 95%, at a laboratory temperature of 25°C. To ensure that specimens had reached equilibrium with the chamber atmosphere, a 20-g. sample of the variety being tested was placed in the humidity chamber and weighed on successive days until constant weight was reached. The time to reach moisture equilibrium varied from 10 to 18 days, the extremes of humidity requiring the longest time. When equilibrium had been reached, the 20-g. samples were analyzed for moisture content. The kernel sections were removed from the humidity chamber and examined microscopically for evidence of mold growth. Mold growth was prevented in the 95%-humidity chamber by placing an open dish of toluene in the chamber.

As indicated in the previous article (2), testing was done by placing the glass slide on the micrometer stage of the hardness tester and pressing down on the framework of the tester until the flat part of the tester spindle was in contact with the specimen, at which time the dial reading reached a constant maximum value. All kernels sufficiently hard for use of the II-H scale were measured at five different points on the kernel section; at high humidities and for soft wheat, where the II-S scale was used, three or four measurements were made on a kernel section. The II-S scale was used for all measurements on the soft white winter wheats, but both scales were used for testing the hard wheats. The use of both scales for testing one sample of wheat did not affect the results, since the two scales were related monotonically; that is, a decrease in hardness on one scale was always associated with a decrease in hardness on the other scale. The relationship between II-S and II-H hardness numbers was a linear one (2).

Hardness measurements were made on nine sections of each sample at each moisture condition. In all cases the average of the readings for a kernel was taken as representative of the kernel section. For convenience in presenting the data, hardness numbers obtained on the II-S scale with hard wheats at high humidity were converted to II-H numbers by using the relationship between the scales (2).

Results and Discussion

Hardness of hard wheat varieties (hard red winter and durum) diminished regularly with increasing moisture content. Soft white winter wheats showed no significant change in hardness up to a moisture content of 13%. Above this moisture content their hardness showed a rapid decrease. In all cases the kernel-to-kernel variation in hardness was much greater at high moisture content than at low moisture content. Durum wheat kernels were the most uniform;

TABLE I
HARDNESS OF VERNON AND LANGDON KERNELS AS A FUNCTION OF MOISTURE CONTENT

AMBIENT HUMIDITY (RELATIVE)	VERNON		LANGDON	
	Moisture	Hardness	Moisture	Hardness
	%		%	
12	6.74	93.2 ± 1.0	5.64	92.7 ± 1.8
22	7.47	92.8 ± 0.4	7.41	93.8 ± 1.2
31	8.56	92.4 ± 0.7	8.43	91.8 ± 0.9
42	10.19	92.9 ± 0.9	9.14	89.6 ± 1.7
50	10.99	91.0 ± 1.1	10.58	86.9 ± 2.3
59	11.94	90.8 ± 0.8	11.42	87.6 ± 1.7
70	13.38	88.7 ± 1.4	13.00	85.3 ± 2.6
80	15.15	[a]86.8 ± 2.0	14.86	[a]83.0 ± 3.5
85	16.51	[a]83.3 ± 1.5	16.13	[a]80.0 ± 3.0
89	17.97	[a]71.2 ± 5.3	17.36	[a]71.5 ± 3.5
94	21.20	[a]66.1 ± 5.0	20.37	[a]70.5 ± 4.5

[a] Hardness was measured with II-S scale and converted to II-H scale.

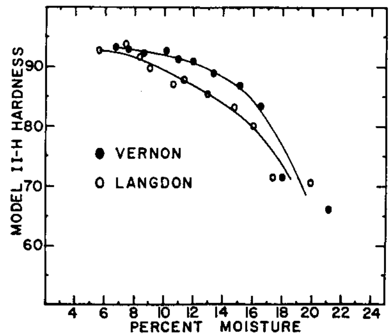

Fig. 1. Hardness of durum varieties Vernon and Langdon as a function of moisture content at 25°C. Standard deviations in the hardness number at moisture contents below 12% were about ±1.5. Above 12% moisture content the standard deviation increased with increasing moisture from ±1.5 to ±5.0.

soft white winter kernels were the least uniform.

While all varieties of durum wheat were more uniform in hardness than other types of wheat, Mindum and Vernon kernels were consistently harder than Langdon kernels in the range of 10 to 17% moisture content. The hardness of Vernon and Langdon kernels as a function of moisture content is shown in Fig. 1 and Table I. Mindum and Vernon kernels were of essentially the same hardness at corresponding moisture content.

Similar varietal differences in hardness were displayed by the soft white winter varieties Elmar and Brevor. Brevor was consistently softer, as shown in Fig. 2, the difference being greatest at higher moisture contents.

No differences in hardness due to variety or test plot location

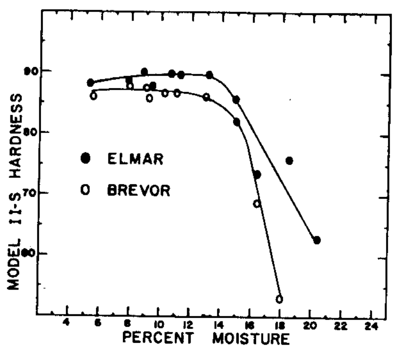

Fig. 2. Hardness of two varieties (Elmar and Brevor) of soft white winter wheat. Standard deviations in the hardness number at moisture contents below 12% were about ±3.5. Above 12% moisture the standard deviation increased with increasing moisture from ±3.5 to ±11.0.

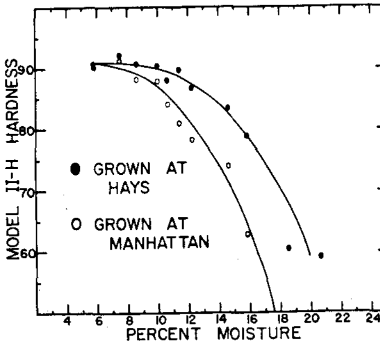

Fig. 3. Hardness of Wichita wheat (hard red winter) grown at Hays and Manhattan, Kansas. At a moisture content of 18.5%, the sample grown at Manhattan had a hardness of 38.5. This point is not shown on the graph. Standard deviations in the hardness number at moisture contents below 12% were about ±3.5. Above 12% moisture content, the standard deviation increased with increasing moisture from ±4.0 to ±10.0.

were found in the hard red winter varieties Ponca or Kiowa grown in Belleville, Hays, and Manhattan, Kansas. At the higher moisture contents some differences were found in the hardness of Wichita wheat, samples from Manhattan being somewhat softer than samples raised at Hays or Belleville. The hardness of Wichita, grown at Manhattan, and Hays, as a function of moisture content, is shown in Fig. 3.

The hardness of hard red winter wheat was nearly equal to that of durum wheat at moisture contents below 13%, but at high moisture contents the durum wheats were generally harder.

For all wheat tested, the relationship between ambient humidity and moisture content at equilibrium at 25°C. agreed with the results of Coleman and Fellows (1). The equilibrium moisture was 6% at 10% relative humidity, and 21% at 95% relative humidity.

Acknowledgments

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