NOTE

Hardness (Texture) of Hard Red Winter Wheat Grown in a Soft Wheat Area and of Soft Red Winter Wheat Grown in a Hard Wheat Area[1]

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ABSTRACT

Hardness and protein were determined in soft and hard red winter wheats grown in Billings, MT, Atchison, KS, and Lafayette, IN, and in the hard red winter wheat cultivar Newton grown at 13 locations in Kansas. Hardness was determined by three methods: time to grind, particle-size index, and near-infrared reflectance. There were large differences and no overlap in hardness between hard and soft wheats at each location and among all locations. However, times to grind both hard and soft wheats were longer in areas producing soft wheat than in areas producing hard wheat. Protein content and hardness of the cultivar Newton were not significantly correlated. In eastern Kansas, grinding time generally increased (indicating softening) with progressively higher precipitation. The correlation between time to grind and average rainfall was significant at the 10% level. Correlations among the three methods of hardness determination were highest between particle-size index and near-infrared reflectance. Correlations between hardness and protein content were either very low or insignificant.

Cereal Chem. 61(2):201-203

High yields and double-cropping of soft wheats in parts of the United States make the production of soft wheats economically attractive. When soft wheats contain large amounts of vitreous kernels, there is a temptation to sell them as hard wheats or to blend soft wheat into shipments of hard wheat. But soft wheats that appear vitreous may be unacceptable to mills that produce flours for the manufacture of cookies and cakes. Because color, kernel characteristics, test weight, and protein content are similar in soft and hard red wheats, distinguishing between the two wheat classes can be difficult. The difference in price between the wheat classes can range from $0.25 to $1.00 per bushel.

The aim of this research was to determine whether wheats retain their inherent hardness characteristics when they are grown in areas where they may not be ideally adapted.

[1]Cooperative investigations, Agricultural Research Service, U.S. Department of Agriculture, and the Department of Grain Science and Industry, Kansas State University, Manhattan 66506.
Contribution No. 84-9-J, Department of Grain Science and Industry, Kansas Agricultural Experiment Station, Manhattan 66506.
Mention of firm names or trade products does not imply that they are endorsed or recommended by the U.S. Department of Agriculture over other firms or similar products not mentioned.
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MATERIALS AND METHODS

Materials

Hard red winter (21 samples) and soft red winter (eight samples) wheat cultivars from several countries were grown in the International Winter Wheat Performance Nursery at Billings, MT, and harvested in 1979.

Leading U.S. hard red winter and soft red winter cultivars were grown at Lafayette, IN, and harvested in 1979 (19 hard and 24 soft) and in 1980 (13 hard and seven soft). Eighteen samples (eight hard and 10 soft) were obtained from Atchison, KS, where 30–35% of the 1980 crop was soft wheat. Because soft red wheat outyields hard red wheat in eastern Kansas by 10–20 bu/a, a trend to grow soft red wheat further west has developed. The movement to the west progresses at about 10 miles per year (Duckworth 1980).

Thirteen samples of the hard red winter wheat cultivar Newton from the 1980 crop were obtained from various locations in Kansas. These locations and their normal annual precipitation are given in Fig. 1.

Analytical Methods

Whole kernels were analyzed for moisture by ASAE method S352 (Agricultural Engineers Yearbook 1980). Protein was determined by AACC method 46-10 (1961).

Adjusting the Moisture Content of Wheat

The samples were stored in a humidity cabinet at 28–29°C and 56–60% rh to produce a moisture content of 12.9 ± 0.4%.

TABLE I
Test Weight, Protein Content, and Time to Grind Samples

Location[a]	No. of Samples	Test Weight (lb/bu) Range	Test Weight (lb/bu) Average	Protein (%)[b] Range	Protein (%)[b] Average	Time to Grind (sec) Range	Time to Grind (sec) Average
Billings, MT							
HRW	21	57.1–63.0	60.0	13.1–16.1	14.3	32.8– 42.9	37.2
SRW	8	55.3–60.2	57.4	12.3–16.8	13.6	90.5–166.6	117.1
Atchison, KS							
HRW	8	59.8–63.1	61.8	11.6–14.2	12.6	37.9– 46.3	41.7
SRW	10	57.4–62.1	60.6	10.9–13.6	12.2	76.2–492.2	168.2
Lafayette, IN (1979)							
HRW	19	55.6–61.9	59.6	10.6–13.4	12.2	37.1– 49.6	43.5
SRW	24	51.8–60.5	58.3	10.0–14.8	12.2	81.0–348.2	190.4
Lafayette, IN (1980)							
HRW	13	60.6–65.0	61.7	11.7–13.7	12.7	41.4– 51.4	45.2
SRW	7	59.8–62.4	60.6	12.7–13.8	13.2	124.6–220.4	177.5

[a]HRW = hard red winter; SRW = soft red winter.
[b]N × 5.7, 14% moisture basis.

Measuring the Hardness of Wheat

Wheat hardness was measured by the time to grind 4 g of wheat with a Brabender automatic microhardness tester, by the particle-size index (PSI) (Miller et al 1981), and by the near-infrared reflectance (NIR) method at 1.680 μm (Bruinsma and Rubenthaler 1978). Measurements represented averages for triplicate subsamples.

TABLE II
Time to Grind (sec) Wheats Grown at Three Locations

Cultivar	Montana	Kansas	Indiana (1979)	Indiana (1980)
Hard red winter				
Centurk	35	···	41	···
Newton	37	44	51	45.5
Triumph	···	46	49	49.2
Soft red winter				
Blueboy	116	···	159	274
Abe	···	492	···	348
Oasis	···	173	···	326
Arthur	···	178	220	237
Hart	···	116	125	120
McNair	···	159	166	···

TABLE III
Protein Content and Time to Grind Newton Wheat Grown at 13 Locations in Kansas

Location	Protein (N × 5.7, %)[a]	Time to Grind (sec)
Tribune	10.5	32.6
Colby	10.3	37.0
Garden City	12.3	35.1
Minneola	11.2	36.2
Hays	14.8	36.3
St. John	12.6	40.3
Belleville	16.3	48.8
Hutchinson	11.5	36.7
Heston	13.2	40.1
Manhattan	8.7	49.4
Powhattan	10.6	48.0
Ottawa	12.7	42.0
Parsons	12.3	37.3

[a] 14% moisture basis.

RESULTS AND DISCUSSION

Ranges and averages of test weight, protein content, and grinding time (as a measure of hardness) of the samples from Billings, MT, Atchison, KS, and Lafayette, IN, are given in Table I. At each location, test weights were higher for hard than for soft wheats. Protein content between the hard and soft wheats was not consistently different, but wheats from both classes grown in Montana were higher in protein than wheats grown at other locations.

There were large differences in hardness between hard and soft wheats at all locations. There was no overlap between wheats from the two classes at any single location or among all locations. Yet, two findings are of interest. First, both soft and hard wheats tended to be "softest" when grown in the soft wheat area (Indiana) and "hardest" when grown in the hard wheat area (Montana). Average values from eastern Kansas were intermediate.

Second, the average differences in hardness between hard and

TABLE IV
Correlation Coefficients for Protein and Three Indices of Wheat Hardness

Correlation	Wheat Samples[a] from Atchison, KS[b]	Lafayette, IN[c]	Newton Series[d]
Grinding time versus			
Protein	−0.350	0.350**	−0.039
NIR[e]	−0.591**	−0.928***	−0.945***
PSI[f]	0.342	0.914***	0.901***
NIR[e] versus			
Protein	0.311	−0.277	0.127
PSI[f]	−0.911***	−0.924***	−0.920***
PSI[f] versus protein	−0.211	0.310**	−0.193

[a] ** and *** are significant at $P = 0.05$ and $P = 0.01$, respectively.
[b] 0.468 and 0.590, $n = 18$.
[c] 0.304 and 0.393, $n = 43$.
[d] 0.553 and 0.684, $n = 13$.
[e] Near-infrared reflectance.
[f] Particle-size index.

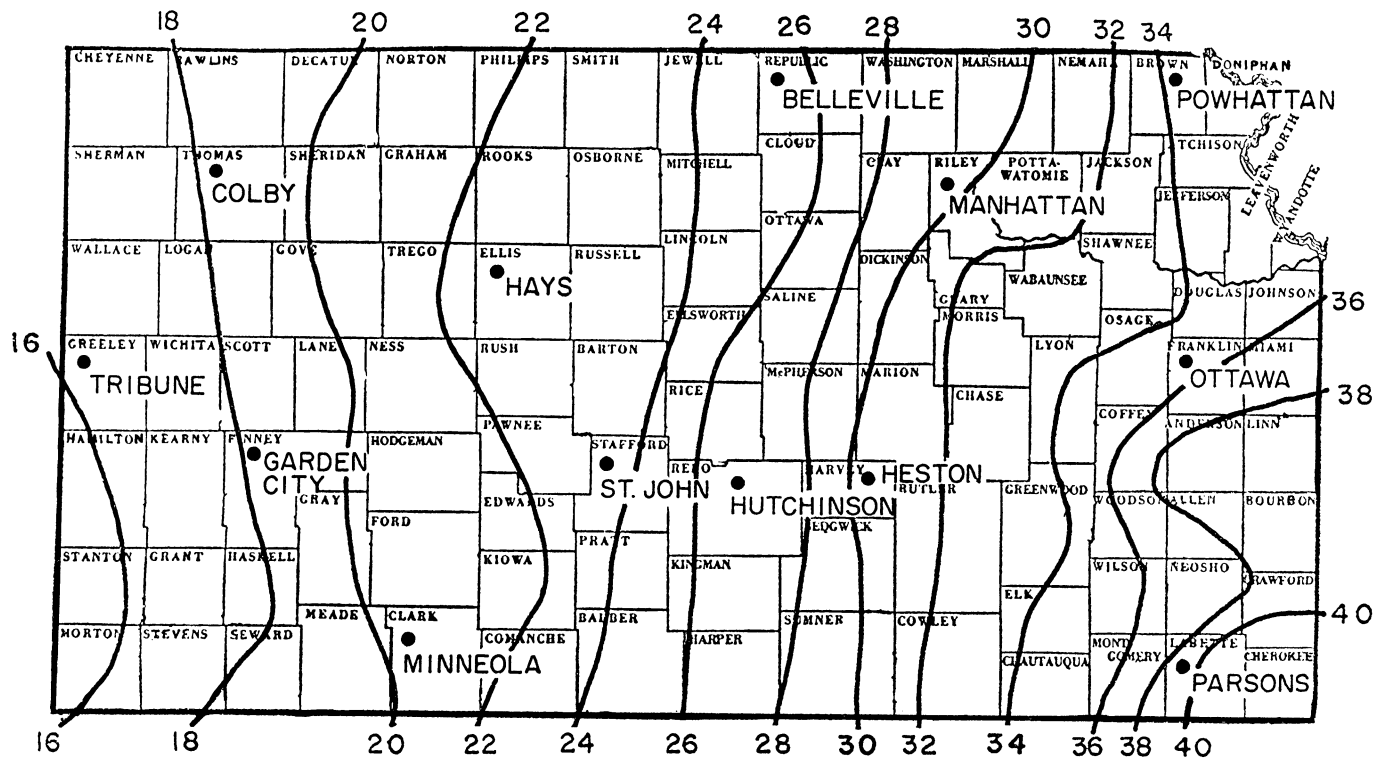

Fig. 1. Normal annual precipitation (inches per year) for Kansas and for locations from which wheat samples were obtained.

soft wheats were greatest in Indiana (146.9 and 132.3 sec), smallest in Montana (79.9 sec), and intermediate in eastern Kansas (126.5 sec). This probably reflects the greater effect of wheat softening and the wider range of experimental values of time to grind for soft wheat. The ranges for hard wheats were 10.1, 8.4, 12.5, and 10.0 sec and for soft wheats, 76.1, 416.0, 267.2, and 95.8 sec, for samples from Montana, Kansas, Indiana in 1979, and Indiana in 1980, respectively.

Because different wheat cultivars were grown at the three locations, the above comparisons are mainly of statistical value. Therefore, we compared hardness in cultivars grown at two or three of those locations. Again, times to grind the wheats were longest for Indiana, shortest for Montana, and intermediate for eastern Kansas (Table II).

The results obtained when the 13 Newton samples were analyzed are summarized in Table III. The locations are listed in order from west (lowest rainfall) to east (highest rainfall) (Fig. 1). The protein content pattern of wheat from these locations is highly erratic and mainly reflects amounts of fertilizer used and time of application. There is, however, a fairly good sequence of increasing time to grind as we move from the typical hard to soft wheat areas. Correlation coefficients and linear regression lines for the relations between average rainfall, protein content, and time to grind were: rainfall versus protein content, $r = 0.070$, $y = 11.6 + 0.02x$; rainfall versus time to grind, $r = 0.537$, $y = 29.18 + 0.41x$; and protein versus time to grind, $r = 0.040$, $y = 38.57 + 0.12x$. For a significant correlation at the 5% level, an r value of 0.553 was required.

Correlation coefficients for protein and three indices of wheat hardness, for samples from three locations, are given in Table IV. The correlation coefficient between protein content and time to grind was insignificant (Table IV). Obuchowski and Bushuk (1980) reported results for nine samples of one variety of hard red spring wheat from one location, all having protein contents of 9.4–15.6%. Hardness decreased with increasing protein content for some indices and remained essentially constant for other indices. Table IV shows correlation coefficients among three hardness indices and protein content for the samples from Atchison, KS, Lafayette, IN (1979), and Newton series from 13 locations in Kansas. Correlation coefficients were highest between PSI and NIR reflectance at 1.680 μm, two measures of particle size. Correlation coefficients between protein and any of the indices of hardness (with the exception of the low coefficient of protein versus grinding time for the Indiana samples) were insignificant.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1961. Method 46-10, approved April, 1961. The Association, St. Paul, MN.

BRUINSMA, B. L., and RUBENTHALER, G. L. 1978. Estimation of lysine and texture in cereals by NIR. Page X-BR-1 in: Proc. 8th Technicon Int. Congr. Technicon Instruments Co., Ltd., London, England.

DUCKWORTH, E. 1980. Economic situation causing farmers to 'forget.' Kansas Crop Council Newsletter, Vol. 14. The Council, Topeka, KS.

MILLER, B. S., AFEWORK, S., POMERANZ, Y., and BOLTE, L. 1981. Wheat hardness: Time required to grind wheat with the Brabender automatic micro hardness tester. J. Food Sci. 46:1,863.

AGRICULTURAL ENGINEERS YEARBOOK. 1980. ASAE standard S352. Moisture measurement—Grain and seeds. Am. Soc. Agric. Eng., St. Joseph, MI.

OBUCHOWSKI, W., and BUSHUK, W. 1980. Wheat hardness: Effects of debranning and protein content. Cereal Chem. 57:426.

[Received July 25, 1983. Accepted December 5, 1983]