NOTE

Wheat Sections—Their Preparation and Characterization

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ABSTRACT

A rotary cutter was developed to prepare 0.057-in. cross sections of wheat. The sections were suitable for examination under low magnification, scanning electron microscopy, crushing for determination of hardness, and variety identification on the basis of electrophoretic patterns of gliadins. The germ-end part obtained during the preparation of the cross section was viable.

Studies from our laboratories (Lai et al 1985a,b; Lookhart et al 1985) describe the use of equipment for automated measurement of hardness of single kernels. Some limitations of such equipment are that empirical hardness measurements may be significantly affected by the size and shape of the kernel (Pomeranz et al 1985b), the thickness and adherence of the hulls, and by the destructive nature of the test. The latter makes it impossible to use the grain for seeding. Sectioned kernels can be examined by low-magnification light and scanning electron microscopy (SEM) to determine the type and structure of grain endosperm. Preparation of cross-sections should make it possible to determine hardness, use the crushed sections for biochemical characterization (for example, by polyacrylamide gel electrophoresis [PAGE] or high-pressure liquid chromatography), and retain a viable germ section. Crushing a cross-section of fixed thickness eliminates the effect of kernel size, and preparing a section free of the germ and brush ends reduces the effects of pericarp layers on crushing. Crushing is done to determine, primarily or exclusively, the hardness of the starchy endosperm rather than the hardness of the "packaged" kernel. Alternatively, crushing the kernel can be replaced by indentation measurements of the starchy endosperm; such measurements cannot be made on whole kernels.

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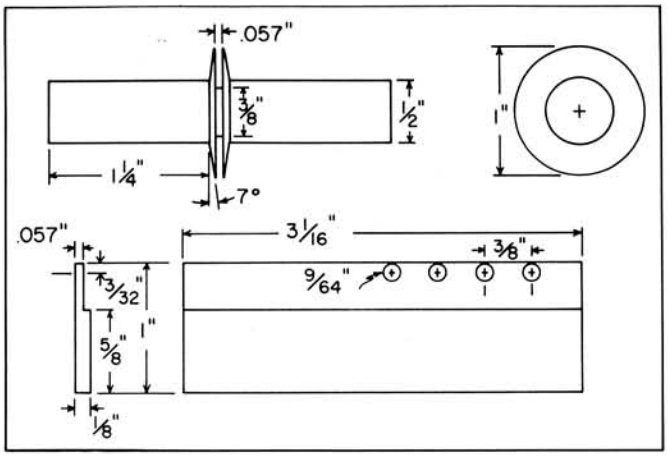

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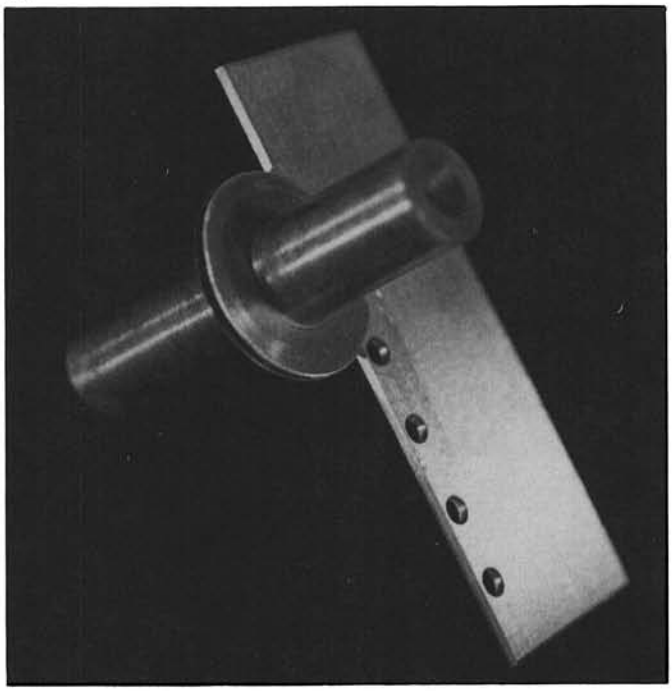

Fig. 1. Diagram (**A**) and photograph (**B**) of wheat section cutter.

TABLE I
Hardness Parameters of Bulk Samples

Wheat Class and Variety	Moisture (%)	Brabender Micro Hardness Tester[a] (sec)	Particle Size Index[a,b] (%)	Near-Infrared Reflectance[a,b] (Arbitrary units)	Stenvert Hardness Tester[c] (sec)
Hard red winter					
Brule	11.6	35.9	37.5	279.0	44.8
Centurk	11.8	30.7	32.6	275.3	53.9
Gage	12.6	33.8	34.6	286.7	56.3
Hawk	11.4	26.9	28.2	345.0	55.8
Newton	12.2	41.0	38.6	244.0	46.2
Roughrider	12.3	30.6	30.8	340.0	49.7
Soft red winter					
Arthur	12.5	91.4	43.0	202.7	30.9
Caldwell	11.3	68.4	44.1	196.7	32.6
Coker 916	12.0	77.7	41.2	189.7	31.4
Hart	11.5	101.0	41.3	185.7	31.7
Pike	11.0	182.0	50.6	164.3	29.3

[a] Average of three determinations.
[b] From material ground on the Brabender micro hardness tester.
[c] Average determination.

Admittedly, preparation of wheat sections is time-consuming, adds the complication of possible mechanical distortion, and may make even more sensitive and critical (than in whole kernels) the effect of moisture content on hardness determination. As usual, each approach has its strengths and limitations, and maximum meaningful and useful information is obtained from a combination of methods. This study concerns the preparation of wheat sections for visual and microscopic examination, determination of hardness, and PAGE of gliadins while retaining a viable germ section.

MATERIALS AND METHODS

Six hard red winter (HRW) wheats (cultivars Brule, Centurk, Gage, Hawk, Newton, and Roughrider) and five soft red winter (SRW) wheats (Arthur, Caldwell, Coker 916, Hart, and Pike) were obtained from the Federal Grain Inspection Service, USDA, Kansas City, MO.

Sound whole kernels were analyzed for moisture by ASAE method S352 (ASAE 1980). Hardness of the bulk samples was determined by four methods: 1) time to grind 4 g of wheat with a Brabender automated micro hardness tester (Miller et al 1981), 2) by particle size index (PSI) (Miller et al 1982), 3) by near-infrared (NIR) reflectance at 1,680 nm (Bruinsma and Rubenthaler 1978), and 4) by resistance to grinding by the Stenvert mill (Pomeranz et al 1985a). All determinations were made on an as-is moisture basis, which ranged from 11.0 to 12.6% (average 11.8%).

The apparatus for preparation of wheat kernel cross sections is shown in Figure 1A and B. The cutting knife was designed to prepare cross sections 0.030-, 0.057-, and 0.100-in. thick. The best results were obtained for sections of intermediate thickess. The knife was made from high-carbon steel, heat treated to a Rockwell hardness of 62 to hold an edge. The two outer surfaces of the rotary knife were flexed slightly inward by pressure on a lathe smooth surface before they were heat treated; this facilitated holding the piece against the knife, reduced breakage, and produced reproducible sections. Both the flat holding piece (with holes for kernels) and the rotary cutting knife were ground to specification. To prepare sections, the kernel was placed lengthwise through the hole and cut by the knife.

Hardness of single sections was determined by a modification of the apparatus described by Lai et al (1985b), except that the sections were placed on single stick tape and crushed between flat surfaces.

Germ-end sections and whole kernels were germinated between wet blotting papers in petri dishes for five days and examined for rate and percentage of germination and for size of acrospire and rootlets.

For examination by SEM, the samples were placed on double-sided adhesive tape mounted on 9-mm diameter aluminum specimen holders. The samples were coated with a 10-nm layer of graphite and a 15-nm layer of gold, and viewed and photographed in the ETEC autoscan electron microscope at an acceleration voltage of 5 kV.

PAGE patterns on ground bulk samples and on single sections were determined by the method of Lookhart et al (1985).

RESULTS AND DISCUSSION

Hardness of the HRW and SRW bulk wheat samples is summarized in Table I. The lower the Brabender micro hardness tester and PSI values and the higher the NIR reflectance and Stenvert hardness tester values, the harder the wheat. Among the HRW wheats, Brule and Newton were relatively soft; among the SRW wheats, Arthur and especially Coker 916 were relatively hard.

When surfaces of sections cut from HRW wheat and SRW wheat were compared, the cellular structures of the hard kernels contrasted sharply with the starchy-amorphous appearance of the cut soft kernels (not shown).

Crushing curves of sections are illustrated for the HRW wheat Hawk and the SRW wheat Pike in Figure 2. These curves are composites of 10 curves each for the two wheats. In each,

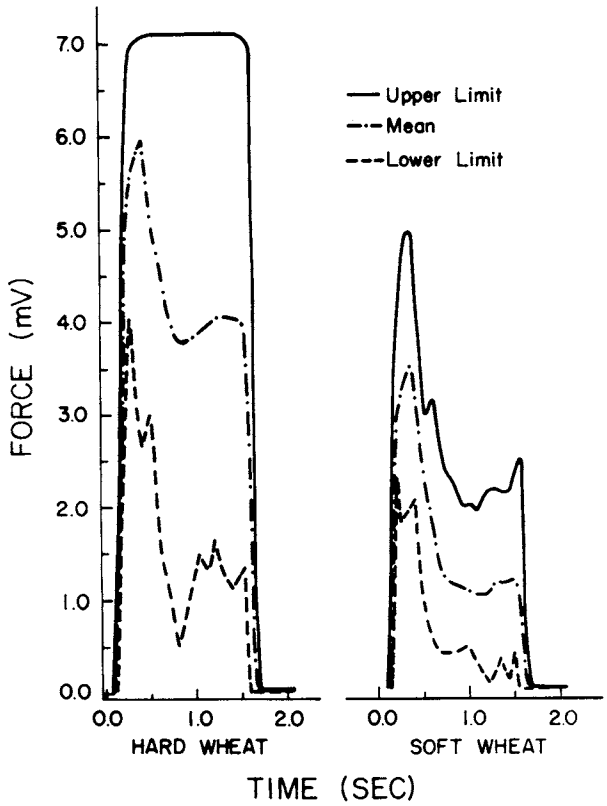

Fig. 2. Composite crushing curves of ten wheat sections: from a hard red winter (Hawk) and a soft red winter (Pike) wheat.

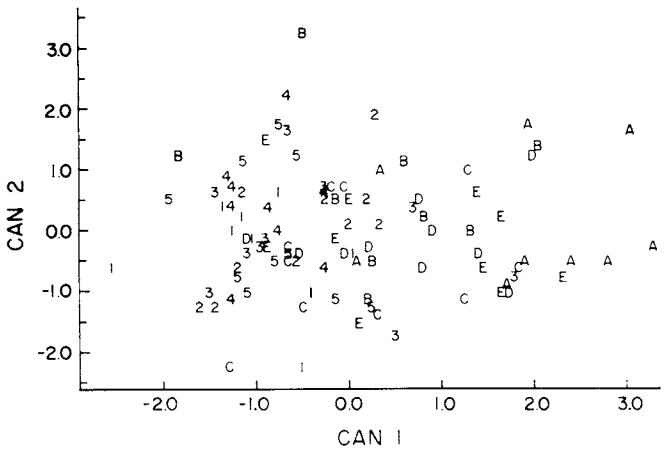

Fig. 3. Plot of canonical discriminant functions for differentiation of hardness among wheat sections; letters denote hard red winter and numbers soft red winter wheats. **A** = Hawk, **B** = Newton, **C** = Brule, **D** = Roughrider, **E** = Centurk, **1** = Hart, **2** = Coker 916, **3** = Arthur, **4** = Pike, and **5** = Caldwell.

minimum, maximum, and mean values are given.

Data from crushing tests (10 sections each of five HRW wheats and five SRW wheats) were used in discriminant analysis (as described by Zayas et al 1986); the results are shown in Figure 3. For these results, half of the sections (selected at random) for each variety were used for calibration data and half for testing. Of the 50 tested sections, 39 were characterized according to varietal identification. Of the 11 that were not characterized according to varietal identification, seven were marginal or atypical according to the bulk hardness tests (Brule, Newton, Arthur, and Coker 916).

Rate and percent germination and appearance of the germinated germ sections were not significantly different from those of the intact whole wheat kernels (not shown here).

Crushed hard wheat breaks along the lines of cell walls and produces particles in the form of whole cells or multiples of cells. In soft wheats, the endosperm breaks down in a random fashion and the cells are disrupted (Greer and Hinton 1950). Microscopic (SEM) examination of the sections showed much more extensive breakdown of cell contents in the central starchy endosperm of the SRW Pike than of the HRW Gage (not shown here).

Electrophoregrams of Gage and Pike samples indicated no basic difference (in number of bands or in their mobility) for the single kernels, ground bulk samples, endosperm sections, and germ-end sections of the two wheats. The only differences were in intensity of all bands in a preparation, resulting from application of various amounts of gliadin extract to a slot (not shown here).

In summary, the wheat-section cutter developed in our laboratories makes it possible to characterize single kernels as to their visual and microscopic appearance, hardness, and electrophoretic identity of gliadins, while retaining a viable germ section.

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