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A Novel, Multi-Sample, Tangential Abrasive Dehulling Device (TADD)[1]

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ABSTRACT

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The design and testing of a novel, laboratory tangential abrasive dehulling device (TADD) is described. The TADD can process eight 10-g samples at a time to provide a measure of grain hardness and an extraction rate based on flour color. When barley and grain sorghum were tested with the TADD, coefficients of variation ranged from 1.0 to 3.8 for the percent kernel removed at a given time. For 31 samples of sorghum, the abrasive hardness index ranged from 5.0 to 12.8 and extraction rates from 69 to 98%.

Laboratory decorticating mills have been the subject of many studies (Griffin 1978, Maxson et al 1971, Rooney and Sullins 1969, Scott et al 1964, Shoup et al 1957). However, many of these mills are inconvenient to operate and give relatively poor reproducibility. The most recent abrasive dehulling mill for small samples of grains was a modified Udy Cyclo-Tec grinding mill described by Shepherd (1979). Although convenient to use, it can process only one sample at a time and requires special procedures and adjustments for each type of grain.

Hogan et al (1964), Normand et al (1965), and Barber (1972) have described mills that permit controlled removal of successive layers from cereal grains by tangential abrasion. Because of the very fine grit size of the abrasive surface in these devices, 30 min was required to remove 2–5% of the grains. We have used the concept of tangential abrasion to develop a rapid, highly reproducible, multi-sample dehulling device (TADD). Barley and grain sorghum were used to evaluate the TADD, which can process eight samples at a time to give a measure of kernel hardness and extraction rate. In the determination of extraction rate, flour color was used as the criterion for the degree of dehulling required to produce acceptable flour.

MATERIALS AND METHODS

Equipment

Figure 1 is a photograph and Fig. 2 a schematic drawing of the TADD. A resinoid steel cut-off disk 10 in. in diameter and 1/8 in. thick is mounted directly on a 1/20 hp, 1,725 rpm electric motor, which is supported on the stand. A spring-operated solenoid rubs on two "O" rings on the disk mount to act as a brake when current to the motor is discontinued. An aluminum head plate holds eight stainless steel sample cups (1 7/8 in. in diameter and 11/16 in. deep) above the resinoid disk. The cups, open at both ends, are mounted vertically with their centers equally spaced around a circle with a 7 3/8 in. diameter. A rubber-faced aluminum cover plate closes the tops of the cups when the machine is in operation. With the machine assembled, the threaded head plate supports were adjusted so that the lower edges of the cups were lightly ground by the resinoid disk to assure minimum clearance between the cups and disk.

In operation, weighed samples of grain are placed in the cups, the cover plate fastened in position, and the resinoid disk rotated under the cups at 1,725 rpm for a specified time. The abraded samples are then removed from the sample cups with a vacuum sample collector shown in Fig. 3. The vacuum source was a small, tank-type vacuum cleaner. The 20-mesh screen on the air outlet from the collector retained the dehulled grains but allowed the abraded fines to be removed.

Materials

Barley (c.v. Betzes) was obtained from Early Seed and Feed Ltd., Saskatoon, Saskatchewan. A vitreous, red-branned sorghum was obtained from Maiduguri, Nigeria, and U.S. Yellow No. 2 sorghum from Terminal Grain Corp., Sioux City, IA. In addition, 31 small samples of sorghum were obtained from ICRISAT laboratories in Hyderabad, India, and Ouagadougou, Upper Volta, and from the Ethiopian sorghum improvement project in Nazareth, Ethiopia.

Methods

Two types of resinoid disks were tested in the TADD. One disk, manufactured by Universal Simonds Abrasives, Brockville, Ontario, had a dense grit spacing and a coarse grit size. The other, manufactured by Samuel Osborn Canada Ltd., Brampton, Ontario, was reinforced with fiberglass and had a much smoother face. Abrasion rates were determined for 10-g samples of barley and compared to those of a Strong-Scott laboratory barley pearler, using a 25-g sample as described by Reichert and Youngs (1976).

The effects of sample size and sample moisture content on abrasion rate were determined for sorghum. Samples of the red-branned Nigerian sorghum were equilibrated over saturated solutions of $MgCl_2$, K_2CO_3, $Ca(NO_3)_2$, and $NaCl$ to give moisture contents of 8.6, 9.8, 12.0, and 14.0%, respectively. The reproducibility for a given sample size and moisture content was determined for both barley and sorghum.

Whole and dehulled grain samples were ground to flour in a Udy Cyclo-Tec grinding mill (1-mm screen). Reflectance values of whole and dehulled grains, flour, and flour-water slurries were measured on an Agtron M-500A spectrophotometer (Shuey and Skarsaune 1973) on all four color modes (blue, green, red, and yellow). The machine was standardized at 0 and 100% transmittance, using the 00 and 90 color standards. Fifteen grams of whole seed were used for reflectance measurements. Flour samples (5 g) were packed as firmly and evenly as possible in the sample cup with a brass weight that fitted the cup. Flour-water slurries were prepared according to the method of Patton and Dishaw (1968). Flour (2 g) was weighed into the Agtron sample cup, and distilled water was added (6 ml for barley and 3 ml for sorghum) to give a thin slurry. The slurry was well mixed as described by Murthy and Dietz (1974) and allowed to stand for a few minutes before readings were taken. A graph of flour color vs percent kernel removed was used to determine extraction rates for the various sorghum samples.

RESULTS AND DISCUSSION

The abrasion rate of barley kernels with the two types of resinoid disks in the TADD and with the Strong-Scott barley pearler are given in Fig. 4. The Simonds disk removed fines at about the same rate as the Strong-Scott pearler, whereas the Osborn disk gave a much lower abrasion rate. To remove 24% of the kernel, 16 min were required with the Osborn disk, but only 3 and 4 min were needed for the Strong-Scott pearler and the Simonds disk, respectively. The Simonds disk was used for all remaining experiments.

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Eight replicates of barley samples (10 g) were dehulled at various retention times. The percent kernel removed, standard deviation, and coefficient of variation are given in Table I. Reproducibility was very good, with the standard deviation increasing with time and the coefficient of variation decreasing somewhat with time. Because samples were run in each of the sample cups, any variation between cups is included in the deviations.

Sixteen replicates of Yellow No. 2 sorghum (8 × 5 g and 8 × 10 g) were dehulled for 2 min. The 5-g samples had 18.49% of the kernel removed, with a standard deviation of 1.90. The 10-g samples had 17.37% of the kernel removed, with a standard deviation of 0.65. The variation in percent kernel removed is within experimental error, but the larger 10-g samples had a much lower standard deviation. Ten-gram samples were used in all subsequent tests.

The 31 samples of sorghum from India, Upper Volta, and Ethiopia were dehulled in duplicate in the TADD for 1, 2, 4, and 6 min. Details of these results will be given in a subsequent article, but a brief summary is given in Table II. The hardest and the softest samples showed the largest differences in percent kernel removed. The low values for the average standard deviation and coefficient of variation for the 31 samples is indicative of the good reproducibility of the TADD. Linear relationships with high correlation coefficients (r) were obtained when the retention times were plotted against the percent kernel removed for the individual samples, as shown in Fig. 5 for the hardest and softest samples. The inverse of the slopes of these regression lines were multiplied by 60 to give a convenient abrasive hardness index (AHI), defined as the time in seconds required to remove 1% of the kernel as fines. The AHIs of the 31 sorghum samples ranged from 5.0 to 12.8. The red-branned Nigerian sorghum samples equilibrated to different moisture levels from 8.6 to 14.0% did not differ significantly in hardness, having AHI values of 8.7 to 8.9.

Flour color was selected as the quality factor to determine the extraction rate, ie, the percent of the kernel that could be recovered as acceptable flour. For both barley and sorghum, the blue and green modes of the Agtron M-500A spectrophotometer gave greater changes with progressive pearling than the yellow and red modes did. The blue mode (436 nm) was selected as being more indicative of the desirable yellow color of the flours (Murthy and Dietz 1974). The whole dehulled kernels were not satisfactory for reflectance measurements because of the large sample required (a minimum of 15 g) and the variations due to uneven packing. Dry flours required careful packing to give uniform results and showed less change in reflectance with progressive pearling than the flour-water slurries did. Reflectance values of a flour-water slurry at 436

TABLE I
Reproducibility of the Tangential Abrasive Dehulling Device on a Sample of Barley

Retention Time (min)	Mean Percent Kernel Removed[a]	Standard Deviation	Coefficient of Variation
0.5	8.26	0.18	2.23
1	11.25	0.16	1.43
3	19.79	0.19	0.97
5	26.47	0.32	1.20
8	35.37	0.53	1.48

[a] Based on eight observations.

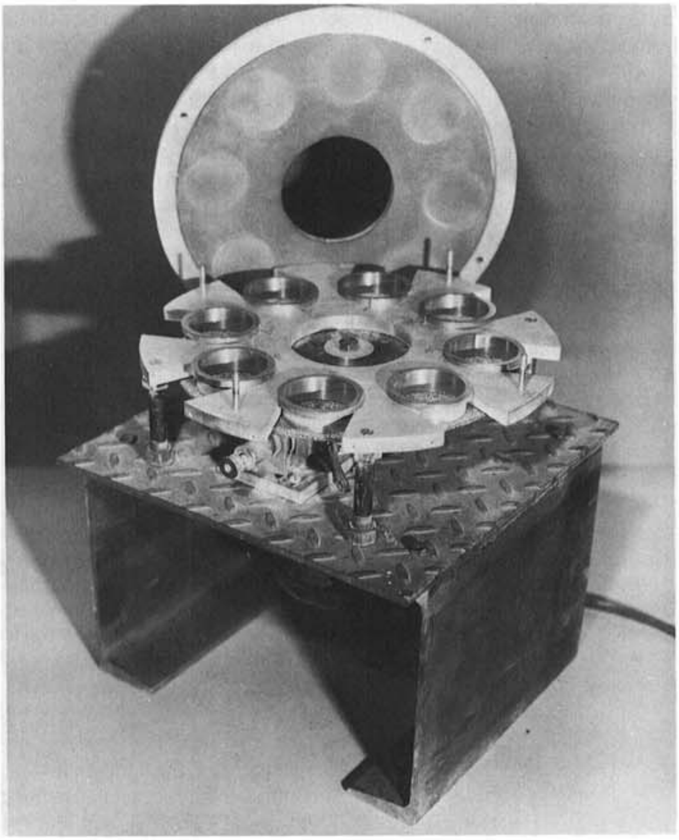

Fig. 1. The TADD.

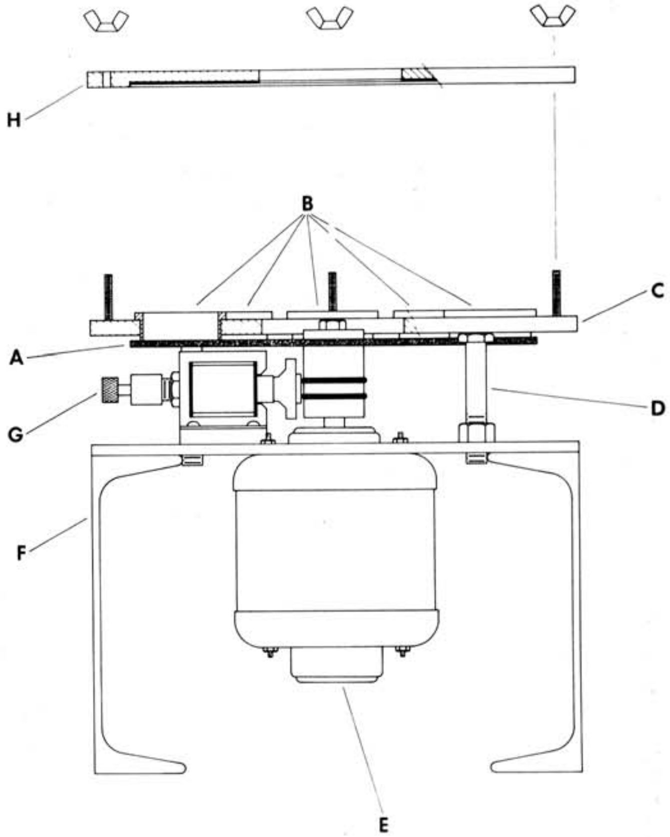

Fig. 2. The TADD. **A,** Resinoid disk; **B,** sample cups; **C,** head plate; **D,** head plate supports; **E,** motor; **F,** stand; **G,** solenoid; **H,** cover plate.

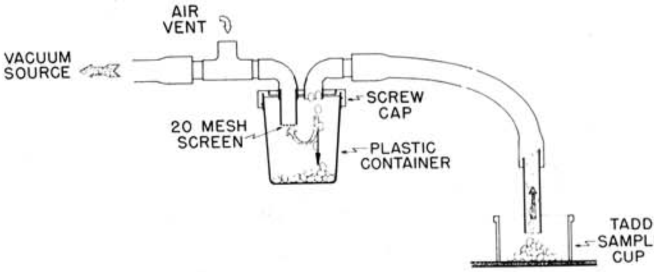

Fig. 3. Vacuum sample collector.

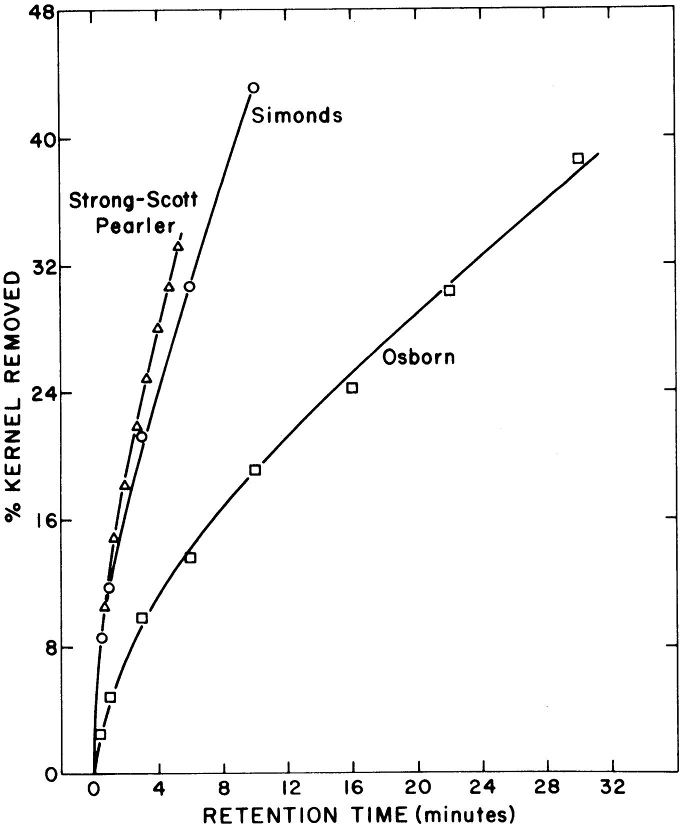

Fig. 4. Retention time of barley vs percent kernel removed for two disks and a barley pearler.

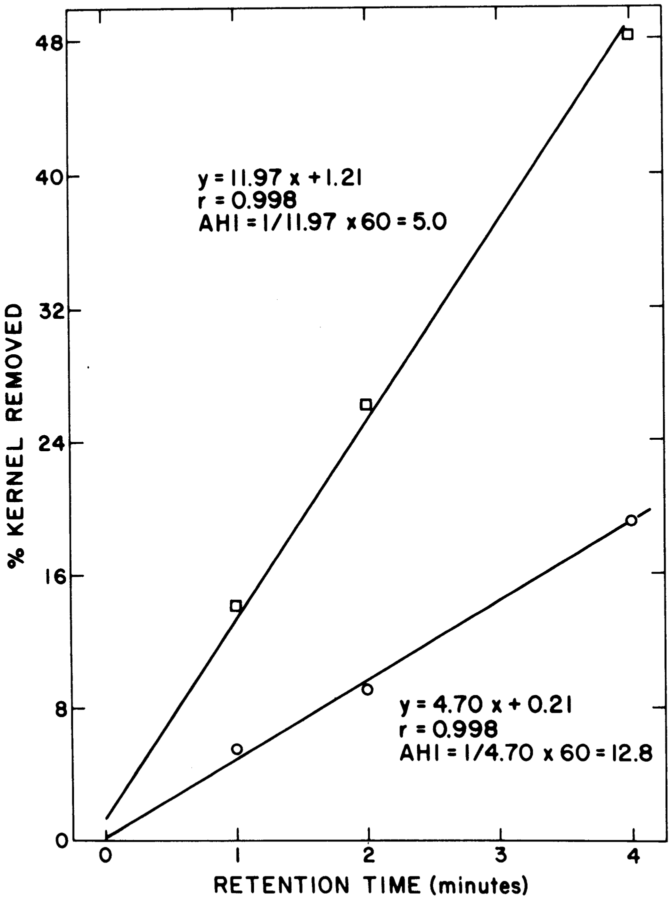

Fig. 5. Regression of retention time on percent kernel removed for hard (○) and soft (□) sorghum samples (extremes of 31 samples). AHI = abrasive hardness index.

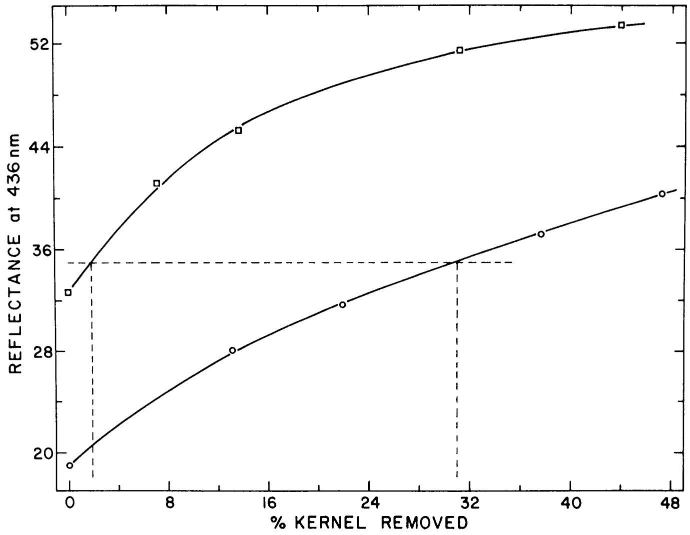

Fig. 6. Determination of extraction rates for two samples of sorghum (extremes of 31 samples). Extraction rates (100 minus percent kernel removed) are 98% (□) and 69% (○), based on a reflectance value of 35 for a traditionally acceptable flour.

TABLE II
Reproducibility of the Tangential Abrasive Dehulling Device on Thirty-One Sorghum Varieties

Retention Time (min)	Mean Percent Kernel Removed[a] Minimum	Mean Percent Kernel Removed[a] Maximum	Average Standard Deviation	Average Coefficient of Variation
1	5.50	14.30	0.35	3.75
2	8.90	27.80	0.53	3.29
4	19.40	49.20	0.68	2.16
6	28.10	60.10	0.94	2.17

[a] Based on duplicate observations.

nm was, therefore, chosen in determining extraction rates. A plot of reflectance value vs percent kernel removed was used to obtain an extraction rate at a selected reflectance value. This value depends both on the grain and on what is traditionally considered acceptable flour. A sample of traditionally processed and acceptable sorghum flour from Nigeria had a reflectance value of 35; on this basis, the extraction rate of the 31 sorghum samples ranged from 69 to 98%. The determination of the extraction rates for the two extreme samples is illustrated in Fig. 6.

CONCLUSIONS

The TADD provides a rapid, reproducible mill for evaluating dehulling characteristics of grains. It is a simple, compact unit with minimal maintenance requirements and adjustments. The TADD should prove useful to sorghum and other grain breeders in selection of good dehulling characteristics at an early stage in the breeding program.

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Effect of Starchy Kernels, Immaturity, and Shrunken Kernels on Durum Wheat Quality[1]

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ABSTRACT

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The effect of starchy kernels, various degrees of immaturity, and shrunken kernels on durum wheat characteristics and end-use quality was investigated. As starchy kernel content increased, semolina granulation became finer and more flour was produced during milling. Protein content decreased with increased starchy kernel content, resulting in a deterioration in spaghetti cooking quality. The main effect of immature, grass green, and frosted green kernels was to increase ash levels, which led to duller and browner spaghetti. The presence of shrunken kernels caused reduced test weight, high ash, reduced milling yield, higher speck count, and poorer spaghetti color quality.

Unfavorable weather conditions during the growth and harvest of cereals can result in considerable crop damage. Not only does the appearance of the grain become less desirable, but the end-use quality often is adversely affected. To establish a fair market value for grains, and to ensure that foreign buyers get consistent quality from shipment to shipment, producing countries must adopt a grading system.

The effectiveness of the Canadian grading system is aptly illustrated by the superior milling quality, color characteristics, and spaghetti cooking quality of the top grades of Canadian durum wheats compared to those of the lower grades (Canadian Grain Commission 1979). The quality differences between grades are usually a result of the combined effects of many degrading factors. However, very little published information is available on the effect of individual degrading factors on durum wheat quality. We therefore determined the quality differences attributable to some of the common degrading factors associated with the 1979 Canadian durum wheat crop. This article reports the effect of starchy kernels, various degrees of immaturity, and shrunken kernels on durum wheat quality. Subsequent reports will deal with some of the other major degrading factors.

MATERIALS AND METHODS

Sample Preparation

To determine the effect of starchiness and immaturity on durum wheat quality, samples were prepared such that quality differences could be attributed to the degrading factors rather than to environmental or varietal effects. Envelope samples from the 1979 Canadian durum wheat crop survey were segregated according to the type of degrading factor present. For each type of degrading factor, each envelope sample was handpicked to yield two or more samples of equal weight: a control essentially free of the degrading factor and one or more samples enriched in the degrading factor by various amounts. At least 20 envelope samples of controls and of corresponding enriched samples were bulked to yield a series of samples weighing at least 600 g.

To determine the effect of shrunken kernels on durum wheat quality, three large individual farm samples possessing various levels of shrunken kernels were obtained from the Grain Inspection Division. For each sample, the shrunken kernels were sieved out and reintroduced in varying proportions to yield a series of 1-kg samples with a fairly wide range of shrunken kernels.

Grading

Each composite was graded by the Grain Inspection Division of the Canadian Grain Commission. Where possible, the extent of each degrading factor was quantitated. Degrading factors were assessed according to the Official Grain Grading Guide (Canadian Grain Commission 1980).

Table I lists the minimum test weight and hard vitreous kernel content and the maximum content of grass green kernels and shrunken kernels tolerated for each grade of Canada Western amber durum. Weight per hectoliter was determined with an Ohaus 0.51-L measure and cox funnel. Hard vitreous kernels were defined as whole, reasonably sound kernels that exhibited the natural amber color of amber durum wheat without dissection of kernels. Nonvitreous kernels included grass green or badly damaged kernels

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