Effect of Grain Size on Dehulling of Sorghum

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ABSTRACT

Ungraded and sized grain (<4.00 mm; <3.35 and <2.80 mm, respectively) of 28 sorghum cultivars were dehulled by abrasion for 60 sec. The milling recovery varied between cultivars but generally ranged from 80 to 90%. The milling recovery was higher for grain <2.80 mm than for grain <3.35 mm, and grain <4.00 mm gave the lowest recovery. The recovery of ungraded grain did not follow a trend but often gave yields lower than what would be expected from the average size. The amount of unbroken kernels in the milled fraction also varied with grain size, with the average amounts obtained for <2.80-, <3.35-, and <4.00-mm grain being 84, 78, and 72%, respectively. Broken kernels accounted for most of the damaged grain, with only a small proportion of degermed kernels present. For optimal yields during dehulling, cultivars with grain of nonuniform size should be segregated into different sizes and each size grade dehulled for different times.

A sorghum panicle contains between 800 and 3,000 kernels. The weight of the kernels increases by about 10% from the top of the panicle to the bottom (Naumenko and Kalashmic 1978). Ali and Wills[1] surveyed 280 batches of sorghum containing commercial and experimental hybrids and pure lines and reported that grain size in most samples varied largely, from 2.36 to 4.79 mm. The size distribution was found to vary not only between cultivars but within a cultivar obtained from a different location or season. Dehulling of sorghum is necessary before food use to remove the bran layer and the nutritionally undesirable pigments (Price et al 1980). Rooney and Sullins (1969) and Anderson and Burbridge (1971) used abrasive milling to produce grits; when sorghum is used as a whole grain such as rice and in the preparation of tortillas, unbroken dehulled kernels are required. Only a few studies have been reported (de Francisco 1982, de Man 1973, Shepherd 1979) that examined the yield of unbroken kernels following milling, and even these examined only a few cultivars. The effect of grain size on milling yields has not been reported. We examined the effect of grain size on the milling characteristics of 28 sorghum cultivars, including hybrids and pure lines, of different types, textures, and colors.

MATERIALS AND METHODS

Fifteen commercial hybrids, four experimental hybrids, and nine pure lines were collected from Queensland, Northern Territory and New South Wales in Australia.

The samples were stored at 5°C for three months to equilibrate, and the resultant moisture contents ranged from 12.5 to 12.7%. Some grains from each cultivar were cut in half and examined for damage; only undamaged cultivars were included in the study. A sample (100 g) of each batch of grain was sieved for 3 min on a Tylar Rotap shaker on U.S. 4, 5, 6, 7, and 8 Tylar screens with mesh sizes of 4.80, 4.00, 3.35, 2.80, and 2.36 mm, respectively. The grain remaining on each sieve was weighed. An ungraded sample was obtained for each by sieving on 2.80-mm mesh and collecting all of the grain that remained on the sieve. Graded and ungraded samples were cleaned of glume and broken grain. Ten replicate samples of 5 g of the ungraded and the individual-size grain were dehulled for 60 sec in a pearler (Kett Husk Pearler, Kett Electric Co., Japan). The decorticated grain remaining on the no. 20 sieve (0.84 mm) provided with the pearler was weighed and termed as milling recovery. From the decorticated grain the unbroken kernels were removed manually, and the damaged kernels were divided into two parts: grain that had been degermed but with the endosperm intact, and broken grain. Each fraction was weighed to determine the yield.

[1]M. R. Ali and R. B. H. Wills. 1982. Unpublished data.

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RESULTS AND DISCUSSION

The description and size distribution of all the cultivars studied are presented in Table I. All cultivars contained a corneous endosperm except Sovereign, which was intermediate, and R116, which was waxy. With the exception of the pure line 495, each cultivar was comprised of grain of different sizes. The milling yield of grain <4.00, <3.35, and <2.80 mm in each cultivar is shown in Table II. The milling yield of each cultivar generally increased as the grain size decreased, with approximately 2 and 4% greater

TABLE I
Description and Grain Size of Sorghum Cultivars

Type	Color	Cultivar	Percent of Grain in Each Size (mm) <4.00	<3.35	<2.80	<2.36
Commercial hybrid (heteroyellow)	Bronze	Dorado	44	31	14	11
		SM10	34	39	16	10
		Leader	12	50	29	9
	Red	Goldrush	9	56	24	11
	Bronze	E57	22	40	28	10
		Pride	16	43	30	11
	Red	C43	7	44	40	9
	Bronze	F64A	17	45	27	11
		5161	2	51	41	6
		SM8	1	44	48	7
		Sunlover	1	38	51	10
		C42T	2	35	49	14
		Pacific 001	2	33	51	14
		Texas 610SR	–[a]	3	59	37
		Sovereign	14	50	12	3
Experimental hybrid (heteroyellow)	Red	21737	41	50	9	–
	White	21621	10	52	36	1
		21600	22	61	16	–
		21636	16	53	30	1
Pure line (white endosperm)	White	332	3	67	28	1
		TX623	10	49	41	1
		643	1	28	69	1
		798	72	22	6	–
Pure line (yellow endosperm)	Yellow	KS19	13	51	35	2
		495	93	5	2	–
		854	15	63	21	–
		638	27	60	12	–
Waxy	Gray	R116	28	39	28	4

[a]– = No grain size in this range.

TABLE II
Milling Recovery of Sorghum Grain After Abrasive Dehulling

Cultivar	Percent Recovery in Sorghum Grain			
	<4.00 mm	<3.35 mm	<2.80 mm	Ungraded
Dorado	87.2	88.6	90.1	85.9
SM10	85.4	87.2	88.1	85.8
Leader	83.5	87.0	88.7	84.8
Goldrush	86.1	86.0	88.7	85.7
E57	77.7	82.3	84.9	80.0
Pride	85.0	85.9	87.4	84.3
C43	84.9	86.8	86.3	86.4
F64A	81.9	82.3	90.5	83.3
5161	–[a]	87.9	90.6	89.6
SM8	–	87.5	88.8	88.0
Sunlover	–	88.1	89.6	87.3
C42T	–	80.4	82.7	81.4
Pacific 001	–	83.2	85.2	82.5
Texas 610SR	–	81.9	84.6	82.0
Sovereign	83.2	83.5	86.3	85.5
21737	89.7	90.6	92.4	92.4
21621	91.3	92.1	93.8	93.8
21600	84.3	86.4	90.0	89.2
21636	90.2	91.1	92.4	92.0
332	88.7	89.0	89.6	88.4
TX623	89.8	92.3	93.3	92.1
643	–	91.4	92.6	92.1
798	85.6	86.4	90.1	85.9
KS19	86.5	88.6	90.2	88.5
495	87.0	91.4	92.7	–
854	86.5	87.6	88.2	87.8
638	91.2	91.9	93.1	91.7
R116	86.6	90.6	92.4	86.5

[a]– = No grain in this range.

recovery for <3.35- and <2.80-mm grain, respectively, over that obtained for <4.00-mm grain. The milling yield of ungraded grain tended to be lower than what would be expected from the average grain size, and in several cultivars the yield was lower than that obtained for all individual sizes. The reproducibility of the values was good, as standard deviations of the sample means were ±0.10 (n = 10). The average yield of the commercial hybrid fractions was 86% (range 77–90%), whereas the average yield of the experimental hybrids and pure lines was 90% (range 85–93%).

Although the entire decorticated fraction can be utilized for the production of flour, for products utilizing whole sorghum grain the production of unbroken kernels is important. Table III shows the yields of unbroken, degermed, and broken grains in the decorticated fractions. The yield of unbroken kernel with the germ intact was highest in the <2.80-mm grain and ranged from 69.0 to 92.8% with an average yield of 83.5% and decreased in the <3.35-mm grain (average yield 78%) and <4.00-mm grain (72%). Most of the damaged grain was due to brokens, the percent of which increased with increasing size (average of about 5% in <2.80-mm, 7% in <3.35-mm, and 11% in <4.00-mm grain). The yield of degermed grain was small in <2.80-mm grain (average of 1%) but also increased with increasing size to about 4% in <4.00-mm grain. Although it could probably be marketed along with intact grain, degermed grain is nutritionally inferior because the germ contains disproportionately high levels of many desirable nutrients (Reichert and Youngs 1977).

Individual cultivars showed great variation in the propensity to break during milling; several cultivars produced >10% yield of brokens, but two samples, hybrid 21621 and pure line TX623, had virtually no damaged grain. This suggests that hybrids that do not break during milling should be able to be developed. A gain of even 1% in the yield of unbroken kernels would be a significant economic advantage; Spadaro et al (1980) reported that a 1% decrease in broken rice would result in an increased return of $10.5

TABLE III
Influence of Size on Breakage of Sorghum Grain After Abrasive Dehulling

Cultivar	Percent Yield of Original Grain											
	<4.00 mm			<3.35 mm			<2.80 mm			Ungraded		
	Unbroken	Degermed	Broken	Unbroken	Degermed	Broken	Unbroken	Degermed	Broken	Unbroken	Degermed	Broken
Dorado	74.3	4.2	8.7	79.9	0.5	8.2	83.0	1.0	6.1	72.8	1.9	11.2
SM10	73.4	1.0	11.0	78.6	1.2	7.4	82.3	0	5.8	72.4	0.5	12.9
Leader	68.7	2.8	12.0	77.0	1.9	8.1	81.6	0	7.1	71.2	0	13.6
Goldrush	74.2	3.4	8.5	77.2	2.0	6.8	81.9	0.6	6.2	75.6	1.1	9.0
E57	48.3	8.2	21.2	66.3	4.5	11.5	75.9	1.5	7.5	63.5	1.9	14.6
Pride	70.3	4.8	9.9	75.0	3.5	7.4	80.8	2.0	4.6	75.3	2.2	6.8
C43	70.1	4.7	10.1	76.2	4.3	6.3	83.6	1.8	4.1	76.1	1.2	9.1
F64A	62.1	4.5	15.3	65.7	2.6	14.0	75.2	1.2	9.9	69.1	1.7	12.5
5161	–[a]	–	–	81.9	1.6	4.4	87.0	0	3.6	83.3	0.4	5.9
SM8	–	–	–	79.7	0.7	7.1	85.0	0.6	3.2	80.2	0.7	7.1
Sunlover	–	–	–	79.5	2.0	6.6	83.6	0.2	5.8	76.2	0.9	10.2
C42T	–	–	–	63.5	6.6	10.3	71.4	1.7	9.6	65.1	1.4	14.9
Pacific 001	–	–	–	76.6	1.4	5.2	81.0	0	4.2	75.5	0	7.0
Texas 610SR	–	–	–	70.3	2.3	9.3	78.4	0.6	5.6	73.3	0.4	8.4
Sovereign	56.2	3.3	23.8	57.7	5.6	20.3	69.0	3.9	10.3	64.5	4.8	16.3
21737	87.2	0.4	2.1	88.6	0.6	1.4	91.6	0.4	0.4	90.6	0.3	1.5
21621	90.8	0.5	0	91.6	0	0.5	93.7	0	0	93.4	0.2	0.2
21600	60.6	7.3	16.4	71.1	6.0	9.3	81.3	3.5	5.1	75.7	5.3	8.2
21636	86.8	0.5	2.9	88.9	0.3	2.0	91.0	0.7	0.7	90.2	0	1.8
332	86.9	0.5	1.3	87.7	0.5	0.8	89.2	0	0.4	87.3	0.8	0.3
TX623	89.3	0.5	0	91.8	0.5	0	92.8	0.5	0	90.8	0.5	0.8
643	–	–	–	82.4	2.6	6.4	86.7	1.1	4.7	85.3	2.0	4.9
798	73.6	6.0	10.0	80.1	0.8	5.5	88.4	0.1	1.6	75.6	2.5	7.8
KS19	68.7	11.6	6.5	77.9	7.1	3.6	82.3	3.5	4.4	76.6	8.0	3.9
495	57.0	2.9	27.2	77.9	2.2	11.2	86.7	1.1	4.9	–	–	–
854	67.1	5.4	14.1	73.3	3.2	11.0	79.0	1.8	7.4	76.2	2.6	8.9
638	88.9	0.2	2.1	89.0	0.3	2.6	91.2	0.2	1.5	88.1	0.2	3.3
R116	57.7	8.8	19.4	77.9	2.4	9.7	84.3	1.2	6.0	72.8	2.7	10.8
Mean	72.0	3.9	10.6	78.0	2.4	7.0	83.5	1.0	4.7	77.6	1.6	7.8

[a]– = No grain in this range.

million on the milling of 4,767 million kilograms of paddy rice.

In summary, the yield of unbroken grain varied with both the size of grain and cultivar. In milling a mixed-size batch of grain from one cultivar, the larger grain tends to be overmilled and the smaller grain undermilled. Present export standards allow the admixture of different cultivars depending on color (Rooney 1973), and a similar variability in the extent of milling will occur between cultivars.

For sorghum grown for human food, consideration needs to be given to developing cultivars with a uniform size. For existing cultivars that exhibit size variation, size grading before milling should be considered. A shorter milling time for the larger grain to prevent overmilling could also be implemented. For exports, only cultivars with similar milling characteristics should be mixed.

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