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# 4TH QUADRENNIAL SYMPOSIUM

# ON

# SORGHUM AND MILLETS

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**8TH INTERNATIONAL CEREAL AND BREAD CONGRESS 1988**

**Dehulling and Milling Characteristics of Some Sorghum Cultivars[1]**

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## ABSTRACT

Dehulling and milling characteristics of seven sorghum cultivars having variation in physical grain properties were evaluated using a traditional dehulling method and two laboratory dehulling machines. Recovery was higher in grains dehulled by the laboratory machines as compared to traditional method. Per cent floaters of the grain was negatively associated with dehulled grain recovery. Grits and flours were made by grinding the grain in a Buhler mill and Udy cyclone mill. Grits (particles retained on 355 µm sieve) produced using the Buhler mill ranged from 63.7 to 73.8%. When coarse flour was produced by grinding the grain in a Buhler mill, the percentage of particles passing through 150 µm sieve ranged from 22.2 to 33.8%, and the recovery was higher in soft grain types than in hard grain types. The fine flour fraction obtained by grinding the grain in a Udy mill ranged from 35.7 to 59.8%. Results indicated that soft grain types produce a greater quantity of fine flour.

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Dehulling and milling of sorghum grain are the most important processes for making sorghum foods. Dehulling or pearling is done traditionally by pounding grain in a wooden or stone mortar with a wooden pestle, which is laborious and time consuming. Traditional dehulling is done by sprinkling water to temper the grain and pounding gently to remove the fibrous outer coat. The husk is separated by winnowing. Dehulled grain is dried in the sun for short periods before use. However, mechanical dehulling units are becoming increasingly popular in countries like Botswana, although these are mostly confined to urban areas. High yielding sorghum cultivars introduced in Mali were reported to be soft and hence could not be decorticated (Scheuring et al 1982). Thus the efforts made to increase the sorghum grain yield could be fully realized by the consumers, only with good dehulling quality. Mechanical dehulling is advantageous as it gives more dehulled grain yield with uniform dehulling of grains than traditional dehulling (Reichert and Young 1977). Further, it will reduce the drudgery of processing a large quantity of grain and thus save time.

In India and in several African countries, whole or dehulled sorghum grain is ground in village mills to a coarse flour (Subramanian and Jambunathan 1980, Volgel and Graham 1979) before being used for food preparation. Also the granulation of flour particles is important in blending sorghum flour with wheat flour for bread making. Data available on dry milling characteristics of sorghum are inadequate. Dry milling can vary from simple grinding of whole grain between stones to a complex system of using sophisticated roller mills. Sorghum, being harder than wheat, is more difficult to grind and produces coarse particles (Hoseney et al 1981). Wheat milling technology can be effectively used for grinding sorghum with suitable modification, although sorghum has different milling properties compared to wheat (Perten 1977). Modification such as the use of abrasive or hammer mills may improve sorghum flour quality. Grinding to a fine particle size has been accomplished by using impact grinders (Stringfellow and Peplinski 1966). It may be possible to select cultivars with improved milling quality that will make the utilization of sorghum competitive with other cereals.

The objective of this paper is to compare the dehulling quality using three dehulling methods and the milling performance by using two laboratory mills for seven sorghum cultivars having contrasting grain characteristics such as corneousness, hardness, etc. The interrelationship among dehulling, milling, and other grain characteristics are dicussed.

## MATERIALS AND METHODS

### Sorghum Grains

Seven sorghum cultivars were grown during the postrainy season of 1984/85 at ICRISAT Center, Patancheru, India. The grains were harvested and stored under medium-term storage conditions (4°C and about 25% relative humidity) until used. The details of seven cultivars are given in Table I.

### Physical Measurements of Grain

The thousand-grain mass was determined from five replications and mean value is reported. Grains were cut in half and examined for the extent of floury endosperm and subjectively scored on a 1-5 scale (1 is floury and 5 is corneous). Grain hardness was measured with 20 grains from each sample and the force (kg) required to break the grains in the Kiya hardness tester was recorded and mean values are given. Floaters % was tested according to the method of Hallgren and Murty (1983). Pericarp content was estimated after soaking the grain in cold water (4°C) for 1 h and manually removing the pericarp using forceps. The content was expressed as percent of total grain after drying the excised pericarp in oven at 50°C for 24 h.

**Dehulling**

**Traditional method :** A quantity of 250 g grain was used for dehulling using a stone mortar and wooden pestle. Grains were wetted with varied quantity of water in the mortar according to the grain types used. Grains were gently and uniformly pounded with a pestle. The number of strokes required and the time to dehull 250 g grains were noted and expressed per 1 kg of grain. Grains were removed and separated into dehulled grains, brokens, and husk by passing through a 1/12 mesh round-holed sieve. The materials were dried in an oven at 50°C to dryness and percent recovery in each fraction was calculated.

**Scott-barley pearler method :** One hundred grams of grain was dehulled for 1 min and 40 sec in a Scott-barley pearler (Burrows, USA). The dehulled material was passed through 1/12 sieve and separated into dehulled grain, brokens and husk. The quantities recovered were expressed as percent of original grain used.

**Tangential Abrasive Dehulling Device method:** A quantity of 20 g of grain was dehulled for 4 min in a Tangential Abrasive Dehulling Device (TADD) by the method of Mwasaru (1985). The dehulled grain and brokens recovery was calculated on a percent basis, and the husk portion was not recovered as it was siphoned into a receptacle in the machine.

**Milling**

Grains were equilibrated to about 8% moisture by keeping them in an oven maintained at 37°C for 24 h. They were dehulled in a Scott barley pearler and grits and flours were prepared as indicated below.

**Grits/flour preparation:** One hundred grams of dehulled grain was ground in a Bühler mill (laboratory type, DLFU, Buhler-Miag, Uzwil, Switzerland) by setting it to point 4, in a calibrated ring to yield grits and at point 1 to yield fine particles. The ground material, in the former was sifted for 15 min through a set of sieves having openings of 850, 355, 250, 180, and 150 µm (USA standard testing sieve - ASTM E 11 specification) fitted on a Tylor model RX-24 portable sieve shaker while in the latter one all the sieves except 850 µm were used. Two rubber stoppers were kept on each of the seives to disperse the flour particles during the operation of the equipment. The fractions retained on top of each sieve were collected, weighed, and expressed as percentage of total initial weight of the dehulled grain.

Fifty grams of grain were ground in a Udy cyclone mill (UD Corporation, Boulder, Colorado) fitted with 0.5 mm screen for 2 min. The ground material was sifted as above and the distribution of flour particles expressed as percentage..

## RESULTS AND DISCUSSION

Grains of seven cultivars showed a variation for 1000-grain mass, endosperm texture, grain hardness, pericarp content, and floaters percent. SPV 472 recorded the least floaters percent while Dobbs and WS 1297 had 100% floaters indicating the soft nature of the grains of the latter two cultivars (Table I). Floaters % give indirect estimate of grain softness in sorghum (Hallgren and Murty 1983) and closely related to flour particle size.

A comparative statement of dehulling quality of grain using the three methods are given in Table II. The dehulling quality of M 35-1 (control) was exceptionally good when the traditional method was used. It required less time to dehull with fewer strokes and the recovery of dehulled grain was higher as compared to other cultivars (Table II). Soft grain types Dobbs and WS 1297 recorded low dehulled grain recovery, and yielded high quantities of husk and fines. The brokens percent was also higher for them as compared to other cultivars. Lulu dwarf also had more brokens due to dehulling by traditional method. Dobbs and WS 1297 grains also had high percent floaters. It was very difficult to dehull Dobbs satisfactorily. The data suggest that soft grain types are not suitable for traditional dehulling.

When the grains were dehulled using the Scott barley pearler, the recovery of dehulled grain increased considerably for all the cultivars as compared to the traditional method (Table II). M 35-1 gave better dehulling recovery than other cultivars. The cultivars having low percent floaters (CO 4, SPV 472, and M 35-1) yielded high dehulled grain recoveries by barley pearler method. A similar trend was observed for the dehulled grain recovery using TADD (Table II). The data clearly indicate that even soft grains can be dehulled comparatively better by mechanical methods as compared to the traditional method. This confirmed the earlier report of Reichert and Youngs (1977). Maxon et al (1971) indicated that milling performance is highly related to endosperm texture; sorghum kernels with floury endosperm shatter during milling and give low yield of endosperm fragments. Barley pearler method is based on vertical rotation of the hard or rough surface to come into contact with grains while the TADD method is based on horizontal rotation of the hard surface. Though these two are different laboratory models, and work on different principles, the results are similar for the cultivars tested and it may be useful in developing a prototype model of dehullers.

The Bühler mill was used to prepare grits from the grains of seven cultivars by setting the disc at position 4, and to prepare coarse flour by setting the disk at position 1. Soft-grain types WS 1297 and Dobbs yielded low proportion of flour particles (grits) which were retained on 355 µm sieve (Table III) than other flour particles. Among the cultivars, Lulu Dwarf, SPV 472, and CO 4 yielded high quantities of particles retained on 355 µm sieve. The results suggest that genotypic variation exists for grits production.

In general, hard grain type like SPV 472, yielded low distribution of coarse flour particles in the 355 µm sieve and high in 180 µm and 150 µm sieves (fine particles) as compared to other cultivars. Soft grain type WS 1297 and Dobbs were different than other cultivars in the distribution of flour particles, as they yielded comparatively higher proportion of particles passing through the 150 µm sieve (fine particles). Lulu Dwarf and SPV 472 were similar in their flour particles distributions, when ground under setting 4 as well as 1 using Bühler mill (Table III). The lower the fine particles, the harder is the grain (Kirleis and Crosby, 1982). The distribution of a high fine flour fraction indicated that grain was not showing resistance to grinding and could be considered soft.

The Udy mill, in general, yields fine flour particles as compared to the Buhler mill used in this study. When grains were ground in a Udy mill, flour particles passing through the 150 µm sieve showed appreciable variation among the cultivars. WS 1297 gave high recovery of flour particles passing through the 150 µm sieve and CO 4 gave low recovery. Cultivars WS 1297 (soft) and SPV 472 (hard) yielded higher fractions of flour retained on 180 and 150 µm sieves and flour passing through a 150 µm sieve. This suggests that factors other than hardness of the grain may influence the particle size distribution and thus milling characters of the grain.

## Correlations

Simple correlations among the various grain factors, dehulling characters, and distribution of flour particles due to milling were worked out. A few of the correlations are indicated in Table IV. Dehulled grain recovery by the three methods of dehulling was negatively associated with percent floaters. But the husk recovery showed positive correlation with percent floaters. The data suggest that floaters percent give an indirect assessment of dehulling quality. Dehulling by traditional method and mechanical methods showed positive and significant correlations. The magnitude of correlation was strong between the two mechanical methods of dehulling, indicating that either of the methods can be used for evaluating dehulling quality of sorghum grains in the laboratory.

With regard to milling characters, percent floaters was negatively associated with flour particles that were retained on the 150 µm sieve using Bühler setting 1, while it was positively associated with similar flour particles produced with Bühler setting 4. This was probably due to variation in grain properties to yield grits and flours. Yield of fine flour particles (passing through the 150 μm sieve) was highly and positively significant when ground in setting 1 or 4 using the Bühler mill. Fine particles yield obtained from Udy mill grinding was positively associated with grits yield obtained from Bühler mill and negatively with flour yield (250 μm retained) obtained from Bühler mill with setting 1. This indicated that flour particle size can be varied by using an appropriate mill. However, this needs detailed study with larger numbers of cultivars.

## CONCLUSIONS

The results from this study indicated that soft-grain types were not suitable for traditional dehulling. Mechanical dehulling, as evaluated by laboratory models, yielded increased dehulled grain recoveries including soft-grain types like Dobbs, which otherwise were very difficult to dehull using the traditional method. Yield of grits and flour particles is variable character and needs detailed investigation on grain factors that governs it, although there are indications that soft-grain types produce greater quantity of fine flour.

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TABLE I

Physical Characteristics of Sorghum Grains

| Cultivars | Origin | 1000-grain mass (g) | Endosperm texture[a] | Grain hardness[b] kg sq $cm^{-1}$ | Pericarp content (%) | Floaters (%) |
|---|---|---|---|---|---|---|
| SPV 472 | ICRISAT | 39.2 | 4.0 | 9.1 | 6.9 | 28.5 |
| CO 4 | India | 30.5 | 1.0 | 4.0 | 4.5 | 54.5 |
| ET 3491 | Ethiopia | 39.9 | 1.5 | 3.5 | 5.0 | 82.0 |
| Lulu dwarf | Tanzania | 21.5 | 2.5 | 4.5 | 8.3 | 84.0 |
| WS 1297 | Ethiopia | 37.5 | 1.0 | 4.4 | 6.8 | 100.0 |
| Dobbs | Uganda | 21.2 | 1.0 | 4.9 | 13.0 | 100.0 |
| Control<br>M 35-1 | India | 39.5 | 2.0 | 5.3 | 3.4 | 56.0 |
| Mean | | 32.8 | 1.6 | 6.0 | 6.8 | 72.1 |
| SE | | ±3.18 | ±0.50 | ±0.71 | ±1.2 | +10.10 |

[a]Endosperm texture was scored on a 1-5 scale, where 1 is floury and 5 is corneous.

[b]Grain hardness was measured using Kiya hardness tester.

TABLE II

Comparison of Dehulling by Traditional, Barley Pearler, and Tangential Abrasive Dehulling Device (TADD) Methods[a]

| Cultivars | Traditional dehulling: Water used ml $kg^{-1}$ | No. of strokes to dehull 1 kg. | Time for dehulling min $kg^{-1}$ | Recovery (%): Dehulled grains | Brokens | Husk and fines | Barley pearler: Recovery (%): Dehulled grains | Brokens | Husk and fines | TADD: Recovery (%): Dehulled grains | Brokens |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SPV 472 | 90.0 | 1880 | 40.5 | 66.7 | 9.6 | 20.0 | 81.9 | 4.0 | 13.5 | 82.6 | 2.5 |
| CO 4 | 81.2 | 1600 | 37.8 | 60.7 | 13.5 | 21.5 | 81.2 | 3.2 | 15.3 | 77.9 | 2.3 |
| KT 3491 | 76.0 | 1624 | 28.1 | 50.1 | 19.0 | 25.9 | 72.1 | 6.7 | 20.6 | 72.6 | 2.5 |
| Lulu Dwarf | 88.0 | 2076 | 43.5 | 47.9 | 25.0 | 21.7 | 67.2 | 15.8 | 17.0 | 58.8 | 5.8 |
| WS 1297 | 76.0 | 1328 | 29.5 | 34.1 | 24.1 | 37.1 | 52.2 | 15.1 | 31.1 | 50.4 | 6.7 |
| Dobbs | 118.8 | 2592 | 57.0 | 25.3 | 21.3 | 48.4 | 70.6 | 3.9 | 25.2 | 60.0 | 1.9 |
| <u>Control</u> M35-1 | 57.2 | 1504 | 30.7 | 82.4 | 4.0 | 10.8 | 84.0 | 4.0 | 13.0 | 84.6 | 0.8 |
| Mean | 84.0 | 1800 | 38.2 | 52.5 | 16.6 | 26.5 | 72.8 | 7.3 | 19.4 | 69.7 | 3.2 |
| SE | ±7.11 | ±160.9 | ±3.80 | ±7.34 | ±2.97 | ±4.69 | ±4.19 | ±2.09 | ±2.53 | ±4.94 | ±0.87 |

[a]Mean of two determinations.

TABLE III

Particle Size Distribution of Grits, Coarse Flour, and Fine Flour of Sorghum Cultivars

| Cultivars | Grits[a] | | | | | | Coarse flour[b] | | | | | Fine flour[c] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Particles retained on sieve (μm) | | | | | Passed through 150 μm | Particles retained on sieve (μm) | | | | Passed through 150 μm | Particles retained on sieve (μm) | | | | Passed through 150 μm |
| | 850 | 355 | 250 | 180 | 150 | | 355 | 250 | 180 | 150 | | 355 | 250 | 180 | 150 | |
| SPV 472 | 4.0 | 71.2 | 8.2 | 4.2 | 2.3 | 10.4 | 5.5 | 35.4 | 25.3 | 8.8 | 24.8 | 2.4 | 16.7 | 26.1 | 15.1 | 42.2 |
| CO 4 | 1.8 | 70.2 | 7.6 | 4.2 | 2.3 | 13.5 | 13.3 | 38.9 | 15.3 | 5.0 | 27.6 | 5.2 | 25.9 | 24.5 | 7.7 | 35.7 |
| KT 3491 | 3.1 | 67.1 | 8.4 | 5.0 | 2.6 | 13.0 | 12.9 | 40.2 | 15.3 | 5.0 | 25.3 | 4.7 | 19.3 | 23.1 | 8.0 | 44.3 |
| Lulu Dwarf | 2.1 | 73.8 | 8.1 | 4.9 | 2.4 | 8.8 | 15.6 | 41.5 | 15.4 | 4.7 | 22.7 | 3.1 | 19.4 | 26.0 | 8.7 | 41.5 |
| WS 1297 | 1.2 | 63.7 | 8.7 | 5.1 | 2.8 | 17.5 | 16.4 | 28.0 | 15.6 | 5.0 | 33.8 | 1.9 | 11.1 | 15.4 | 9.4 | 59.8 |
| Dobbs | 1.3 | 65.9 | 8.5 | 5.4 | 2.9 | 15.1 | 10.1 | 36.3 | 17.4 | 5.4 | 30.3 | 4.5 | 15.3 | 25.3 | 7.5 | 45.4 |
| Control<br>M 35-1 | 3.2 | 68.6 | 8.5 | 4.9 | 2.6 | 12.0 | 5.3 | 33.9 | 24.0 | 6.2 | 28.4 | 4.5 | 20.0 | 21.0 | 7.1 | 46.0 |
| Mean | 2.3 | 68.6 | 8.3 | 4.8 | 2.6 | 12.9 | 11.3 | 36.4 | 18.3 | 6.0 | 27.5 | 3.7 | 18.3 | 23.1 | 9.1 | 45.0 |
| SE | ±0.27 | ±0.88 | ±0.11 | ±0.13 | ±0.09 | ±0.76 | ±1.70 | ±1.63 | ±1.66 | ±0.65 | ±1.45 | ±0.31 | ±1.2 | ±1.04 | ±0.87 | ±2.04 |

Grains were dehulled in Scott-barley pearler

[a]Dehulled grains were ground in a laboratory Bühler mill with a setting 4.

[b]Dehulled grains were ground in a laboratory Bühler mill with a setting 1.

[c]Dehulled grains were ground in a Udy mill for 2 min to pass through a 0.5 mm screen.

TABLE IV

Simple Correlation Coefficients (r) Between Grain, Dehulling, and Milling Characteristics of Sorghum

| Characteristics | r |
|---|---|
| **Dehulling** | |
| Dehulled grain recovery (TD) vs | |
| Dehulled grain recovery (BP) | 0.78* |
| Dehulled grain recovery (TADD) | 0.89** |
| Dehulled grain recovery (BP) vs | |
| Dehulled grain recovery (TADD) | 0.95** |
| Percent floaters vs | |
| Dehulled grain recovery (TD) | -0.83* |
| Dehulled grain recovery (BP) | -0.81* |
| Dehulled grain recovery (TADD) | -0.88* |
| Husk recovery (BP) | 0.84* |
| Husk recovery (TD) | 0.85* |
| Brokens recovery (TD) vs | |
| Brokens recovery (BP) | 0.78* |
| Brokens recovery (TADD) | 0.97** |
| **Milling characterstics** | |
| Floaters per cent vs | |
| Flour reacovery Bü 1 in 150 µm sieve | -0.76* |
| Flour recovery Bü 4 in 180 µm sieve | 0.88** |
| Flour recovery Bü 4 in 150 µm sieve | 0.79* |
| Flour recovery Bü 1, 150 µm passed through vs | |
| Flour recovery Bü 4 in 355 µm sieve | -0.88* |
| Flour recovery Bü 4 in 150 µm sieve | 0.94** |
| Flour recovery, Udy, 180 µm sieve | -0.77* |
| Flour recovery in Udy, 250 µm sieve vs | |
| Flour recovery Bü 4, 250 µm sieve | -0.85* |
| Flour recovery in Udy, 150 µm passed through vs | |
| Flour recovery in Bü 4, 250 µm sieve | 0.85* |
| Flour recovery in Bü 1, 250 µm sieve | -0.82* |

*, ** Significant at 0.05, and 0.01, respectively
TD : Traditional dehulling; BP: Barley pearler dehulling;
TADD: Tangential abrasive dehulling device;
Bü 1: grains ground in Bühler mill with setting 1
Bü 4: grains ground in Bühler mill with setting 4
Udy : grains ground in Udy cyclone mill.

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