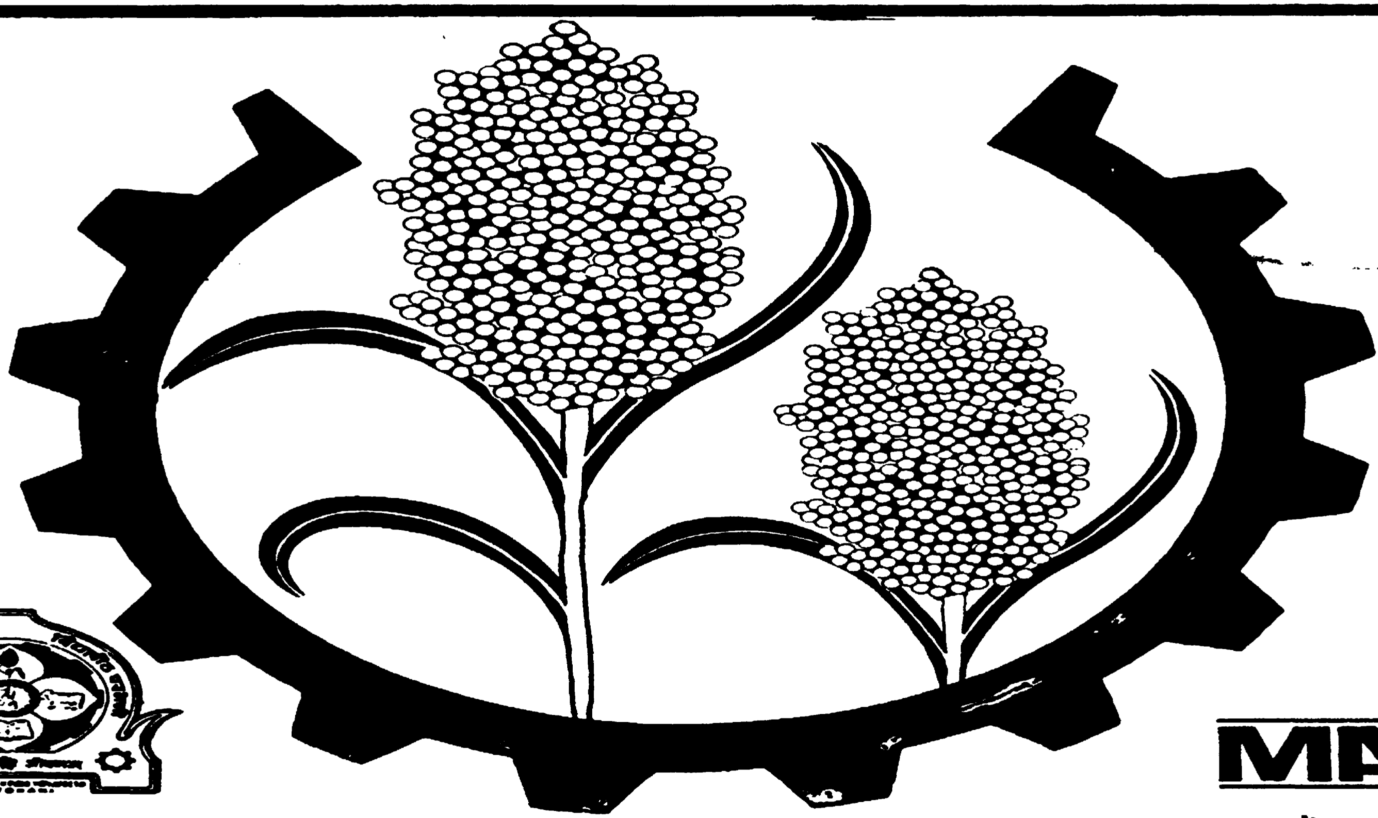
CP346

TECHNOLOGY AND APPLICATIONS FOR
ALTERNATIVE USES OF SORGHUM



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HELD ON FEBRUARY 2-3, 1987 AT
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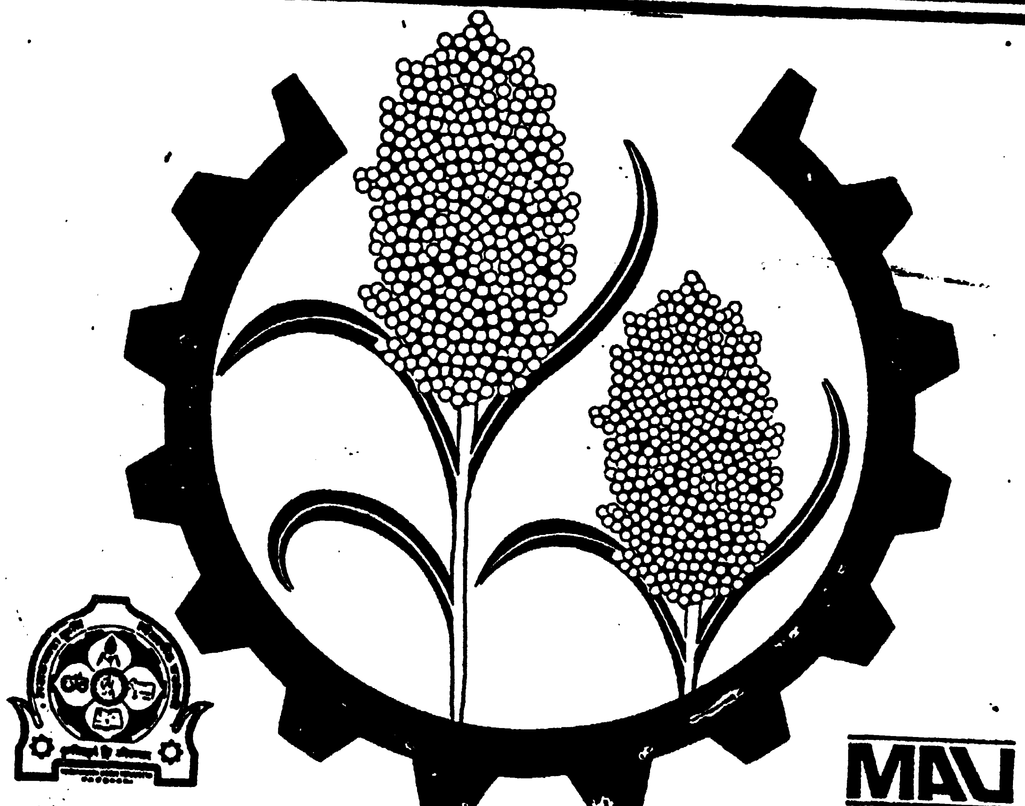

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CP 31

DRY MILLING CHARACTERISTICS OF SORGHUM GRAINS AND THEIR RELATIONSHIP TO PRODUCT QUALITY

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Flour particle size distribution, when grains ground under similar conditions varied among 52 sorghum cultivars. Protein content was high in the coarse flour fraction while starch damage was high in fine fractions. Relationships among flour particle size index (PSI), starch damage, and food quality are reported. The potential of sorghum for alternative food uses through modification of milling has been discussed.

Sorghum [**Sorghum bicolor (L.) Moench**] is considered a coarse grain and generally used for traditional foods. Whole or dehulled sorghum grain is ground in village mills to a coarse flour in India[1] and in several African countries[2] before being used for the preparation of foods. 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[3]. This characteristic is inherited in Mendelian fashion[4]. Although several methods exist for sorghum hardness measurement, the pearling index, and particle size index (PSI) appear to be superior to other methods that relate to sorghum milling performance[5]. Out of the four indirect methods to determine sorghum grain hardness, the Stenvent hardness tester is useful for rapid screening of sorghum cultivars[6].

With increased propuction, there is a need to intensify research on alternate uaes of sorghum. It may be possible to select cultivars with improved milling quality which will make the utilization of sorghum competitive with other cereals. Work on the dry milling of sorghum is currently inadequate. Wheat milling technology can be effectively used for grinding sorghum with suitable modification, although sorghum has different properties compared to wheat[7]. Modification such as use of abresive or hammer mills may improve sorghum flour quality. Grinding to a fine particle size has been accomplished by using impact grinders[8]. The granulation of flour particles is important in blending sorghum flour with wheat flour for bread making. Casier et al.[9] reported that although bread production was possible with whole flour, the quality of bread improved by using sorghum flour without the bran fraction, obtained after passing through sieves. Badi and Hoseney[10] demonstrated the use of sorghum flour for making cookies by blending it with wheat flour. Blending up to 10% of sorghum flour with wheat flour did not markedly affect the bread quality and blends up to 45% gave acceptable biscuits[11]

Our objective was to test several sorghum cultivars for their milling performance and to study the distribution of particle size, and starch damage after milling the grain in a UDY cyclone mill. A UDY mill is similar to an abrasion milling system wherein varying layers of grain are progressively rubbed off against a hard surface [12] variation in flour particle size and starch damage in 52 sorghum cultivars varying in their grain hardness and the relationship of the above factors to food quality are described in this report.

Materials and Methods

Grain samples

Grain harvested from 52 sorghum cultivars of hard and soft endosperm types grown during the post-rainy season of 1980 at ICRISAT Center, Patancheru, India, were milled. After harvest, the grain samples were dried to uniform moisture level (10±1%).

Milling sorghum grains

All analytical tests, unless stated otherwise were made in duplicate and mean values are given. Grains were cut in half and examined for the extent of floury endosperm, and scored on a 1-5 scale (1 is more corneous and 5 is floury).

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 [13].

A sample of grain (50 g) was ground for 2 min in a UDY mill fitted with a 0.4 mm screen, to which a vacuum cleaner was attached. Grains of three selected cultivars (500 g in each) were ground in three village mills (disc type). The ground material was collected and oven dried at 70°C for 12 h. This avoided lump formation and agglomeration of flour particles. The flour was sifted through a set of sieves having openings of 355, 350, 180, and 150 µm (USA standard testing sieve - ASTM E 11 specification) fitted on a Tyler Model RX-24 portable sieve shaker for 15 min. Two rubber stoppers were kept on each sieve 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 the total initial weight of ground flour. The weight of the fractions that passed through the 150 µm seive was expressed as a percentage of total flour and was denoted as the particle size index (PSI), as reported by Abdelrahman aud Hoseney[14].

Starch damage

Starch damage was determined in the flour fractions by incubating a 75 mg sample with 25mg glucoamylase (Sigma grade) in 1.0 ml of 2 M sodium acetate buffer (PH 4.8) for 2 h. The glucose released was measured by the phenol sulphuric acid method of Dubois **et al**[15].

Protein content

Protein contents of the flour fractions were analyzed using the Technicon Auto Analyser (Jambunathan **et al**[16]).

Roti and porridge quality

The quality of roti prepared from whole grain flour of the cultivars was determined according to Murty and Subramanian[13]. A Taste panel evaluation of **rotis** was conducted using 12 panelists. Porridge was made by cooking 10 g flour in 50 ml water for 7 min on a hot plate maintained at 270°C. The cooked material was allowed to cool for 20 min and evaluated for consistency by a panel of 5 members.

Results and Discussion

Village mills, called **chakki** in India, are generally used for grinding whole grain sorghum to flour. A Comparison of the particle size distribution of grain groud in a village mill and grain ground in a UDY mill showed that the flour yield in a fine fraction (<150 µm) was lower when ground in the village mill(Table 1). The particle size distribution showed minor variations between other sieve fractions (250, 180 and 150 µm) When grain ground in UDY mill, variations among the 52 cultivars were observed for the the distribution of starch damage content and protein content besides particle size distribution (Table 2). Flour particles retained on the 355 µm sieve were much lower as compared to other sieve fractions. Wide variations for particles retained on the 250, 180 and 150 µm sieves were observed.

Flour particles which passed through the 150 µm sieve showed appreciable variation for the cultivars used and this was defined as the particle size index (PSI) which ranged from 35.7 to 70.6%). Several cultivars with a high recovery of fine flour were observed. The cultivars yielding higher quantities of the fine fraction (Table 2) can be useful for blending with wheat for producing biscuits, cakes, and bread The method described may be useful as a selection criteria of grains for specific food uses. The lower the particle size index, the harder is the grain[5]. The distribution of a higher fine flour fraction indicated that the grain was not showing resistance to grinding and could be considered soft. Pomeran **et al.**[17] indicated that in corn the coarse fraction contained a substantially higher proportion of floury particles. The distribution of fine or coarse particles would indicate relative degrees of resistance to grinding.

Starch damage in sorghum flour varied from 9.8 to 37.4% when ground in a UDY mill (Table 2). This suggested that sorghum grains behave different than wheat with respect to starch damage. However, Murty et al.[18] indicated that sorghum grains ground in a UDY mill produced flour with 10.1 to 20.9 % starch damage They indicated that starch damage in flour obtained from the village mill (disc) and the laboratory mill (Milcent mill) were higher than the same flours from UDY mills. Starch damage in flour influences the ability to absorb water & the quality of bread depends on the extent of starch damage[15]. Dough rolling quality of sorghum was correlated with starch damage[58].

Starch damage was also determined using particles retained on different sieves. Though appreciable variation was observed for starch damage between flour fractions for the cultivars, the extent of damage in particles of 150 µm and less than 150 µm was higher than other fractions (Table 2). Damaged starch content progressively increased from coarse particles to fine particles. Starch damage values in flour particles which passed through the 150 µm sieve ranged from 12.0 to 46.1 % (mean 26.4%). It has been indicated that wheat flour should contain adequate damaged starch to supply sugar during fermentation, and excess damage produced an adverse effect on the quality of bread[18]. The data indicated that it was possible to select sorghum cultivars with a desired level of starch damage depending upon the requirement.

The protein content of whole sorghum flours varied from 7.8 to 14.8%. Miche et al.[20] indicated that sorghum with high protein content should be selected for pasta making. Protein distribution in flour fractions of the 52 cultivars varied from 8.4 to 19.1% (Table 2). The coarse fractions contained higher levels of protein, which may be due to the presence of outer layers of endosperm, although the differences were not large among fractions. Outer layers of the endosperm contained more protein [21,22]. The fine fractions had lower protein content as they may have particles from the floury endosperm which have been reported to contain less protein[8]. It may be possible to obtain large quantities of a fraction with high protein from sorghum with suitable modification of milling procedures[23].

Twelve cultivars which showed 19 5 to 34.7% damaged starch content in the fine practicles (< 160 μm) were studied for their **roti** characters (Table 3). The PSI for these flours showed a large range between 36.1 and 70.6%. The data support the observation of Murty **et al**[24] that the variation in flour particles was affected by cultivars and mills. The texture of the **roti** assessed by a taste panel was scored between 1.3 and 3.2. General acceptability of **roti** was rated between 2 0 and 2.8 in order to study the effect of PSI on porridge quality, cultivars showing a narrow range of PSI were compared for starch damage and porridge quality. PSI values varied from 58.8 to 70.2%, while starch damage showed wide variations from 19 5 to 34.7% (Table 4). The porridge quality score ranged from 1.2 to 3.7 where 4 is rated good and 1 as poor.

The PSI (< 150 μm) was negatively correlated with starch damage(Table 5). **Roti** texture showed negative correlation with starch damage. Flours with more starch damage produced **roti** with hard texture as evaluated by the taste panel. However, starch damage was influenced by the quantity of fine particles due to milling. Flours having lower starch damage produced good quality porridge (r = - 0.85) (Table 5).The data suggest that it is possible to obtain fine flour with least starch damge as in cultivars like Surat-1, BP 53, Vidhisha, etc. Such types of sorghum can also be used for blending with wheat, where low starch damage flour is required.

The present study suggest that variation exists for particle size of sorghum flour ground under similar conditions. There is a possibility to grind sorghum to the desired particle size and starch damage, so that it can be used for a variety of foods such as making breads and cookies, by blending with wheat flour. Laboratory evaluations of milling quality of sorghum grain will be one of the methods to assess the usefulness of various cultivars for uses based on PSI and starch damage. This will be useful for development or modification of mills, so that new varieties could be tasted for milling quality, thereby making sorghum more competitive with other cereals.

Acknowledgement

we thank C. D. Ramaiah. A. Laxma Reddy & K.A.R. Zafar for their technical assistance.

TABLE 1. PARTICLE SIZE DISTRIBUTION OF SORGHUM FLOUR OBTAINED BY A VILLAGE MILL AND UDY MILL

Retained on sieve[a]	Per cent flour particles	
	Village mill[b]	UDY mill[c]
355 μm	5.7	2.0
250 μm	16.4	11.7
180 μm	16.4	14.9
150 μm	9 6	10.4
Passed through 150 μm	50.3	60.2

[a]USA standard testing sieve (ASTM.E 11 specification)
[b]Values based on average from 3 cultivars ground in 3
[c]Values based on average from 52 cultivars

TABLE 2. DISTRIBUTION OF PARTICLE SIZE, STARCH DAMAGE AND PROTEIN CONTENT IN FLOUR FRACTIONS OF SORGHUM CULTIVARS (MEAN OF 52 CULTIVARS)

Particles retained on sieve	Flour fractions (%)			Starch damage in flour fractions (%)			Protein in flour fractions (%)		
μm	Range	Mean	SE±	Rang	Mean	SE±	Range	Mean	SE±
355	0.9- 3.7	2.0	0.10	6.3-15.5	9.8	0.28	8.4-19.1	12.4	0.28
250	8.3-18-6	11.7	0.30	7.0-21.9	12.3	0.44	10.1-17.6	13.0	0.28
180	9.4-23-6	14.9	0.42	7 9-25.4	15 1	0.51	9.5-18.0	12.8	0.24
150	6.3-26.4	10 4	0.58	8.7-29.5	18.1	0.64	9.1-15.9	12.0	0.22
<150	35.7-70.6	60.2	1.10	12.0-46.1	26.4	0.71	8.4-19.1	11.2	0.20
Whole flour				9.8-37.4	21.8	0.56	7.8-14.8	11,7	0.22

Grains were ground in UDY mill

TABLE 3. GRAIN CORNEOUSNESS (COR), PARTICLE SIZE INDEX (PSI), STARCH DAMAGE & ROTI QUALITY IN SORGHUM CULTIVARS.

Cultivar	COR	PSI	Starch damage (%)	Roti quality	
				Texture	General acceptability
SURAT 1	4	70.2	19.5	3.2	2.3
MALDANDI LOCAL	4	63.0	20.4	3.0	2.8
269	3	64.3	21.1	2.2	2.5
BP 53	4	68.0	21.9	3.0	2.5
VIDISHA 60-1	4	65.0	22.0	3.0	2.8
PJ 18R	3	64.4	22.1	2.4	2.0
NARALIGUTI	4	70.6	22.3	1.8	2.0
BILLORA VANI	4	69.6	23.9	2.4	2.4
PJ 31K	4	67.5	27.9	2.0	2.2
AISPURI	4	69.4	27.9	2.7	2.5
PJ 12K	4	35.7	28.3	2.3	2.7
PJ 1K	3	48.3	31.4	1.5	2.3
PJ 19R	3	36.1	33.9	1.3	2.3
PANDORI VANI	5	61.3	34.7	2.0	2.8
MEAN	3.8	61.0	25.5	2.3	2.4
SE±	0.16	3.21	1.36	0.16	0.07

Corneousness was measured on a scale of 1-5, where 1 is more corneous & 5 is floury.

Damaged starch content is given for the flour particles passed through 150 μm sieve.

Roti was made from whole grain flour; evaluated by a taste panel for texture and general acceptability on a scale of 1-4 where 4 is good and 1 is poor.

TABLE 4. GRAIN CORNEOUSNESS (Cor), PARTICLE SIZE INDEX (PSI), DAMAGED STARCH CONTENT (DSC), AND PORRIDGE QUALITY OF SORGHUM CULTIVARS

Cultivar	Cor	Starch damage (%)	PSI	Porridge score[a]
SURAT 1	4	19.5	70.2	3.7
BP 53	4	21.9	68.0	3.2
VIDISHA 60-1	4	22.0	65.0	3.2
NJ 1953	4	23.5	60.9	3.6
E 35	2	25.1	58.8	2.8
296	4	27.2	60.3	2.8
DHOLIO	4	27.8	60.9	3.2
PJ 31K	4	27.9	67.5	3.2
AISPURI	4	27.9	69.4	3.2
VANI VANI	4	33.6	66.8	1.2
PANDORI VANI	5	34.7	61.3	1.8
MEAN	3.9	26.5	65.5	2.9
SE ±	0.21	1.42	1.24	0.23

Grains were ground in UDY mill.

[a]Mean porridge score as evaluated for consistency by a taste panel of five members.

Score : 4 - Good, 1 - Poor.

TABLE 5. CORRELATION COEFFICIENTS BETWEEN VARIOUS CHARACTERS OF SORGHUM GRAIN (n=14 FOR ROTI, & 11 FOR PORRIDGE)

PSI vs Corneousness	0.34
PSI vs Starch damage	-0.62*
PSI vs Roti texture	0.54
PSI vs Roti acceptability	-0.16
PSI vs Porridge quality	-0.14
Starch damage vs Corneousness	0.07
Starch damage vs Roti texture	-0.72**
Starch damage vs Roti acceptability	0.10
Starch damage vs Porridge quality	-0.85**

** Significant at 1% level.

* Significant at 5% level.

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