Grits from Grain Sorghum Dry Milled on Roller Mills[1]

A. A. ABDELRAHMAN and E. P. FARRELL[2]

ABSTRACT

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Dry milling sorghum with a prebreak system produced grits with lower fat and ash contents than those in grits produced without a prebreak. As temper moisture increased, the yields of bran and fines (−30LW) increased and the quantity of grits decreased. The optimum tempering treatment for the production of grits with maximum yield and low fat content was 17% moisture and 8 hr of tempering.

Although sorghum is widely used for human food and its potential for other uses is great, sorghum milling technology is far from adequate. In developing countries, most grain is milled by grinding on stone mills or with a wooden mortar and pestle (Vogel and Graham 1979).

Modern dry-milling processes for sorghum use roller mills and pearlers. Hahn (1969) and Hoseney et al (1981) have thoroughly reviewed those methods. A major problem in sorghum dry milling is separating germ from endosperm; tempering the grain appears to facilitate the separation (Hahn 1969).

Griffith and Stickley (1977) invented a single-unit impact mill for producing refined sorghum grits. Tempered grain was ground in an impact mill, and sorghum particles were dried and sifted to remove the fine fraction (−30 mesh). Coarse particles were sifted to separate the stock into two fractions (+12 mesh and −12+30 mesh) and were then passed through aspirators to remove the germ and bran and produce refined grits.

Our objective was to determine the suitability of a simple system consisting of roller mills, sifters, and gravity separators for milling sorghum into refined endosperm fractions with low fat and ash. We wanted to develop a commercial dry-milling process to produce grits from sorghum.

MATERIALS AND METHODS

Materials

Commercial low-tannin sorghum, grown in Kansas in 1978, was cleaned on a Carter Dockage Tester and scoured with an experimental scourer. The light debris was removed with a model FC9 Kice Aspirator (Kice Metal Products Co., Wichita, KS). Test weight of the cleaned grain was 59.8 lb/bu; its 1,000-kernel weight was 24.9 g. The grain contained 9.1% protein (N × 6.25), 3.3% fat, 1.5% ash, and 12.4% moisture.

Milling Equipment

A pair of Allis Chalmers corrugated rolls (6 in. × 6 in.) with adjustable belt drive was used to break the kernels into small particles that then were separated on a Gyro Laboratory Sifter (serial No. 8325, Richmond Manufacturing Co., Lockport, NY) having a 2.1-in. throw run at 225 rpm. After sifting, a model V 135A gravity separator (Sutton, Steele and Steele, Inc., Dallas, TX) was used to separate particles. The gravity separator makes separations according to particle size, shape, and density. In this study the particle shape and size were controlled by sifting, and the separations achieved by the gravity separator were based on density. The separation is made by passing the material over a porous "deck" sloped in two directions, vibrating in a straight-line reciprocating motion, and through which air is discharged upwards into the material stream. The air stratifies the material according to the terminal velocity of each particle. Heavy endosperm sinks to the bottom and is conveyed to the high side and bran particles, being light in weight, flow to the low side.

Milling Procedure

The first milling system investigated consisted of three breaks and three sifters followed by two gravity tables (Fig. 1). A sample of 3,000 g, tempered to 17% moisture for 4 hr, was run through the system.

The second system had a prebreak to crack the kernels open before the first break. A prebreak creates more surface area, which fosters cleaner endosperm removal from the bran (Farrell[3]). To study the effect of a prebreak in contrast to that of a normal break on the end products of sorghum milling, we tempered a sorghum sample to 17% moisture for 4 hr, then passed it through the system shown in Fig. 2. The prebreak rolls had a fine corrugation (22 C) and a differential of 1:1.3.

To study the effect of different tempering conditions on the behavior of the sorghum during milling, we modified the prebreak milling system by adding two more breaks to grind the grits going to the first gravity separator (Fig. 3). Samples were tempered to four moisture levels (16, 17, 18, and 19%) and held for three time periods (2, 4, and 8 hr) before milling. Twelve combinations of temper moisture levels and holding times were tested. In each case, the samples were milled with a constant roll and feed setting. The percentages of total products in the fractions from each sample were determined. Each fraction was analyzed for moisture, fat, and ash (AOAC 1975).

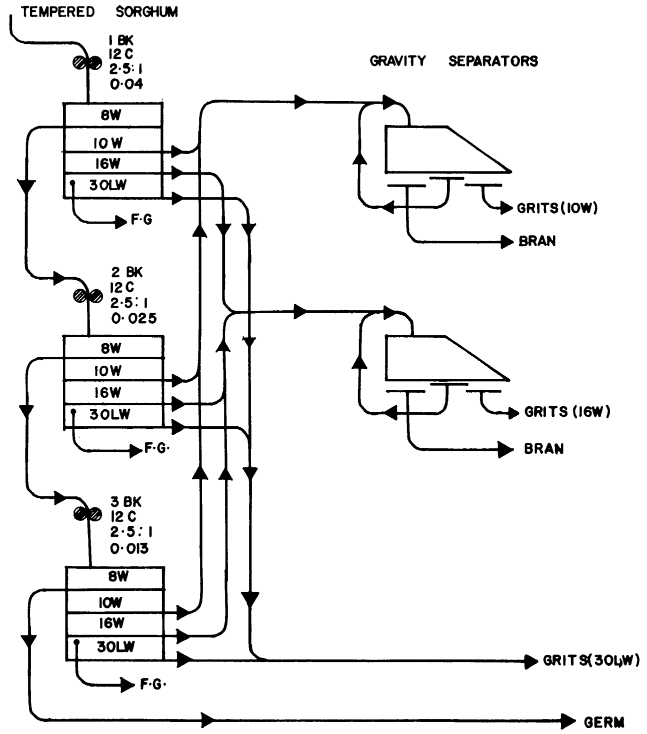

Fig. 1. Production of sorghum grits employing three breaks and three gravity separators.

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[1] Contribution 81-255-J, Department of Grain Science and Industry, Kansas State University, Manhattan 66506.

[2] Research assistant and professor, respectively.

[3] E. P. Farrell. 1980. Unpublished data.

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RESULTS AND DISCUSSION

Dry-Milling System

The data in Table I compare the prebreak system with the sorghum dry-milling system using three breaks. The prebreak system produced grits with lower fat. It tended to open rather than to crush the grain, and so produced less bran powder and gave more endosperm separation in subsequent breaks than did the three-break system.

The prebreak system still yielded coarse grits (+10W) with high fat content (Table I). When the modified system of a prebreak plus four breaks (Fig. 3) was used, a small fraction with high fat content (+10W) was separated, leaving grits (+30LW) with lower fat contents (Table II). This shows that the overs of the 10-wire sieve contained the germ. Apparently, the sorghum germ remained attached to the bran in the overs of the 10-wire sieve. Several authors have noted that the germ is firmly embedded in the kernel and is difficult to remove during dry and wet milling (Rooney and Clark 1968, Wall and Ross 1969).

TABLE I
Effect of Prebreak Milling System on Milling of Grain Sorghum

	Three Breaks			Prebreak Plus Two Breaks		
Sieve	Total Product[a] (%)	Fat[b] (%)	Ash[b] (%)	Total Product[a] (%)	Fat[b] (%)	Ash[b] (%)
Germ (+8W)	4.9	8.06	3.56	4.9	7.89	3.47
Grits						
+10W	35.2	2.13	0.92	28.7	2.15	0.94
+16W	22.0	1.30	0.48	23.2	1.09	0.48
+30LW	10.3	2.76	1.18	11.9	2.50	1.00
Fine grits (−30LW)	8.6	1.87	0.81	10.7	1.77	0.81
Bran						
+10W	10.2	7.73	3.10	9.5	8.67	3.47
+16W	6.8	4.57	1.81	2.8	5.09	1.92
Suction	2.0	5.2	2.29	2.3	5.55	2.49

[a] Percent based on total product.
[b] 14% moisture basis.

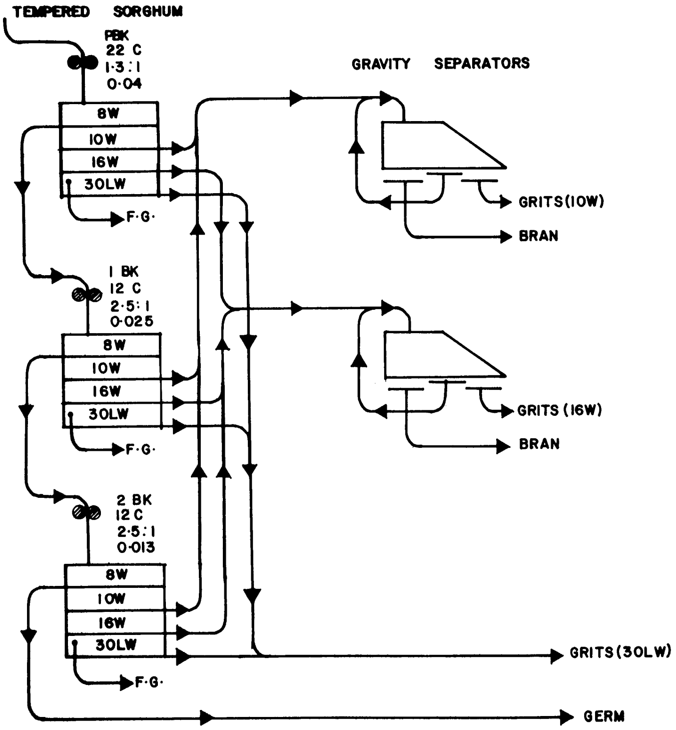

Fig. 2. Production of sorghum grits employing a prebreak, two breaks, and three gravity separators.

Effect of Tempering

The effect of different tempering conditions on the behavior of sorghum during milling was studied by comparing the total yield, fat, and ash contents of each fraction. For each sample, four fractions were obtained after grinding and sifting (Fig. 3): bran, germ, fines (−30LW), and grits (−10W + 30LW).

The effects of the interaction between temper moisture and time on total product yield, fat, and ash was tested by Tukey's test (Ostle and Mensing 1975). The test failed to show a significant effect of interaction between temper moisture and time on total product yield, fat, or ash. The main effects of temper moisture and time on each fraction also were studied by analysis of variance. The F-values for each effect are given in Table III.

Bran Separation. The amount of bran produced increased as the moisture content increased (Table IV). Fat and ash were affected

TABLE II
Effect of a Sorghum Milling System with Prebreak Plus Four Breaks

Sieve	Total Product (%)	Fat (%)	Ash (%)
Two breaks			
Bran (+8W)	4.4	8.3	3.82
Four breaks			
Germ (+10W)	7.6	14.30	5.87
Grits			
+16W	36.5	1.59	0.69
+30LW	17.1	1.19	0.48
Fine grits (−30LW)	17.0	1.86	0.77
Bran			
+16LW	7.1	5.11	2.12
+30LW	4.8	3.41	1.56
Suction	5.5	3.66	1.64

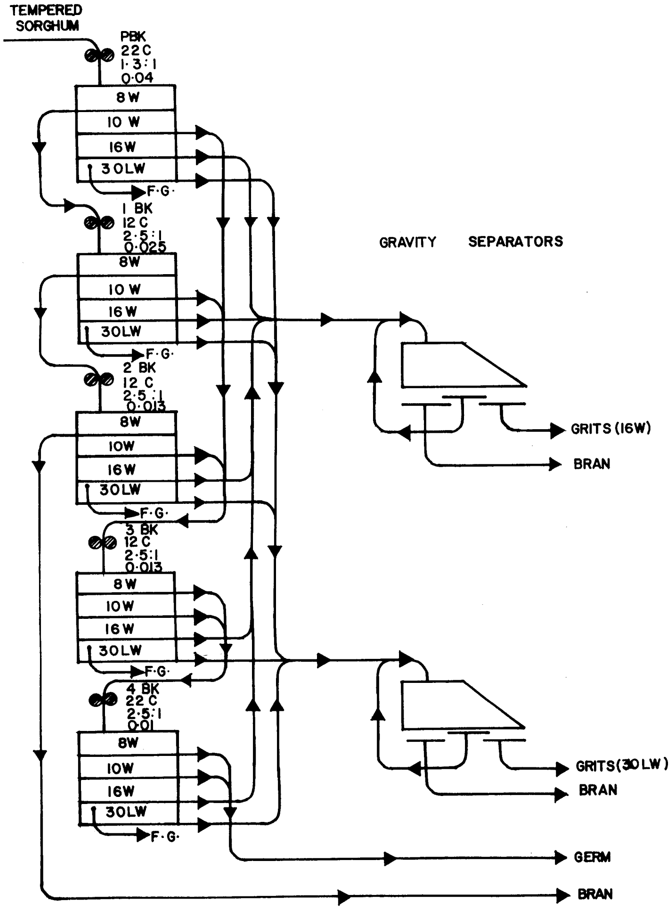

Fig. 3. Production of sorghum grits using a prebreak, four breaks, and two gravity separators.

less by moisture, except that at 19% both fat and ash decreased markedly. At the higher moisture level, some endosperm apparently remained attached to the bran and lowered its fat and ash contents. As tempering time increased, total production of bran decreased, but tempering time did not significantly affect either ash or fat content of the bran. As tempering time increases, moisture penetrates deeper into the kernel; the bran, left with less water, is less tough and breaks up more easily into particles that pass through the 8W sieve.

Our results indicate that the effect of moisture on sorghum bran is the same as that reported by Gillespie (1948). Moderate amounts of moisture make the bran tough and easy to separate, whereas excessive moisture makes the bran difficult to separate from the endosperm material.

Germ Separation. Level of tempering moisture significantly affected total germ yield, fat, and ash content of the germ (Table III). As the moisture level increased, production of germ increased (Table IV). However, at 19% moisture and 2 hr tempering, the quantity of germ produced was low. Some germ probably remained attached to the bran; the quantity of bran produced (Table IV) was much more than expected.

Fat and ash contents of the germ decreased as tempering moisture increased. Tempering time had no significant effect on the total germ yield or on fat and ash contents of the germ (Table III).

Fines Production. Temper moisture significantly affected the total production of fines (Table III). As moisture increased, production of fines increased (Table IV).

The fines are derived mainly from the floury endosperm, which is easily released upon grinding. As tempering moisture increases, the corneous endosperm becomes soft and more easily broken into fines. The increase in fines came from the corneous endosperm, not the bran; fat and ash decreased as the fines increased.

Grits Production. Both tempering moisture and temper time significantly affected total grits yield and the fat and ash contents of the grits (Table III). Increasing moisture decreased total grit production (Table IV), probably by increasing the friability of the grits (corneous endosperm) so they more easily reduced to fines.

As tempering time increased, grits yield slightly increased. Because fat and ash contents of the grits also increased, some bran may have been included with the grits.

Refinement of Grits on the Gravity Separator

The coarse and medium grits obtained from different tempering conditions were refined with a gravity separator (Fig. 3). Total yield, ash, and fat content of refined coarse grits after tempering for various times at 16% moisture are given in Table V. Data from the other tempering conditions were similar.

The separator operated at high efficiency to separate refined grits from bran. An average of 82% of the material from the separator was refined grits with low fat and ash. The remaining 18% was high in fat and ash. Our data on the gravity separator agree with findings of Anderson et al (1969), who reported that a gravity separator for sorghum grit separation gives results comparable to flotation in sodium nitrate solution.

SUMMARY AND CONCLUSIONS

Dry milling of sorghum with a prebreak system produced grits with lower fat and ash contents than those of grits produced without a prebreak. During dry milling with roller mills (prebreak plus four breaks) the oil-rich germ stays with the material

TABLE III
F-Values for the Main Effects of Temper Moisture and Time on Total Product Yield, Ash, and Fat Content of Bran, Germ, Fines, and Grits

		F-Value	
Fraction		Temper Moisture	Temper Time
Bran	Total Product	34.38[a]	9.12[a]
	Ash	2.52	2.41
	Fat	8.15[a]	1.99
Germ	Total Product	4.55[a]	0.39
	Ash	19.22[a]	1.89
	Fat	11.12[a]	2.69
Fines (−30LW)	Total Product	12.99[a]	2.81
	Ash	51.62[a]	10.50[a]
	Fat	56.06[a]	28.29[a]
Grits (−10W + 30LW)	Total Product	248.42[a]	14.97[a]
	Ash	55.27[a]	13.36[a]
	Fat	61.48[a]	14.55[a]

[a] Significant at $P<0.05$.

TABLE IV
Effects of Different Tempering Conditions on Separations

	Temper Time (hr)	Temper Moisture (%)			
		16	17	18	19
		Bran			
Yield	2	5.40	6.70	9.80	15.00
	4	3.80	5.50	9.40	10.30
	8	2.30	5.00	7.50	10.00
Fat[a]	2	8.27	8.16	8.20	7.93
	4	8.36	8.20	7.97	7.58
	8	8.50	8.20	8.55	7.77
Ash[a]	2	3.94	4.08	4.15	3.81
	4	4.04	3.96	3.79	3.69
	8	4.25	3.96	4.08	3.94
		Germ			
Yield	2	5.80	7.50	7.60	6.19
	4	5.80	6.90	7.40	8.70
	8	5.30	6.90	7.70	7.50
Fat[a]	2	14.01	12.72	12.72	12.73
	4	14.69	13.62	13.12	12.33
	8	14.77	14.52	13.00	12.76
Ash[a]	2	6.62	5.89	5.80	5.50
	4	6.52	6.00	5.81	5.72
	8	6.45	6.37	5.97	5.80
		Fines[b]			
Yield	2	12.80	13.50	14.00	14.20
	4	12.20	12.90	13.90	15.30
	8	13.00	13.90	14.20	16.40
Fat[a]	2	1.84	1.65	1.56	1.36
	4	1.64	1.54	1.45	1.26
	8	1.65	1.35	1.35	1.13
Ash[a]	2	0.76	0.69	0.62	0.61
	4	0.75	0.69	0.59	0.57
	8	0.73	0.60	0.57	0.54
		Grits[c]			
Yield	2	76.00	72.30	68.60	64.60
	4	78.20	74.70	69.30	65.70
	8	79.40	74.20	70.60	66.10
Fat[a]	2	2.37	2.17	1.90	1.73
	4	2.45	2.28	2.00	1.89
	8	2.65	2.28	2.07	2.07
Ash[a]	2	1.05	0.94	0.82	0.76
	4	1.11	1.03	0.90	0.81
	8	1.25	1.04	0.91	0.86

[a] On 14% moisture basis.
[b] −30LW.
[c] −10 W + 30LW.

TABLE V

Performance of Gravity Separator in Separating Coarse Grits (−10W, +16W) from Sorghum Tempered to 16% Moisture

	Grits				Bran			
Temper Time (hr)	System[a] Yield (%)	Yield[b] (%)	Ash[c] (%)	Fat[c] (%)	System[a] Yield (%)	Yield[b] (%)	Ash[c] (%)	Fat[c] (%)
2	82	42.6	0.70	1.77	18	9.5	2.32	5.31
4	81	44.2	0.79	1.77	19	10.2	2.40	5.77
8	83	44.6	0.78	1.78	17	9.4	2.30	5.28

[a] Percentage of total product obtained from gravity separator.

[b] Percentage of product of the overall system.

[c] Expressed on 14% moisture basis.

remaining over the 10-wire sieve.

Tempering conditions affected the behavior of sorghum during milling. An increase in temper moisture increased yields of bran and fines and reduced the grits yield. Thus tempering water affects the dry-milling performance of grain sorghum as it does that of wheat; it toughens the bran and makes the endosperm soft and friable. The optimum tempering treatment for the production of grits with maximum yield and low fat content was 17% moisture and 8 hr of tempering. The gravity separator was effective in separating grits from bran.

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