A Laboratory Method for Milling Small Samples of Sorghum Grain[1]

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ABSTRACT

A method for milling 100- to 200-g. samples of sorghum by a combination of abrasive milling, screening, and air flotation is described. The yield and standard deviation (n = 13) for the milling fractions from a yellow endosperm sorghum-grain sample were: coarse-grits, 51.0 ± 0.8%; fine-grits, 19.0 ± 0.8%; germ-rich grits, 4.7 ± 0.8%; germ, 1.5 ± 0.3%; bran, 3.3 ± 0.2%; and flour, 18.1 ± 0.6%. Ether extract of the coarse and fine grits was less than 0.5%, ash was less than 0.3%, and protein was decreased by 1 to 2% compared to the protein content of the grain. The method gave good reproducibility for the milling fractions from two other sorghum varieties. It may be useful for studying the milling properties of different types of sorghums when only small quantities of grain are available.

Few techniques are available for laboratory milling of sorghum grain samples, especially for routine study of various types of sorghum where large samples are not available. Weinecke and Montgomery (1) milled sorghum grain by using a brush-type mill which debranned and degermed the kernels by combined abrasive and tearing action. The bran was separated by air aspiration and the germ by flotation. This milling procedure required a relatively large sample and is slow for routine milling of sorghum samples. Normand et al. (2) described a mill which permitted controlled removal of successive layers of cereal grains by tangential abrasion. This method did not provide a means of obtaining germ and bran. The Buhler experimental wheat mill has been used to produce flour and various milled fractions from sorghum (3). However, this method gives only crude flour, bran and shorts fractions, and does not permit separation of germ. It requires a 5-lb. sample or larger, and reproducibility is poor.

Our laboratory research program is directed toward determining the relation between the chemical and physical attributes of sorghum and its processing properties. A laboratory method for dry-milling sorghum into grits was required. Grain with widely different characteristics must be studied. Large quantities of grain are not always available and numerous samples must be milled by a limited number of personnel. Therefore, none of the methods described in the literature is useful in our program.

This paper describes a laboratory procedure for milling 100- to 200-g. samples of sorghum into grits, flour, germ, and bran fractions. The procedure employed equipment that was available in our laboratory. Additional information on use of the method will be presented in succeeding papers.

MATERIAL AND METHODS

Sorghum Samples

Three varieties were employed in developing and testing the method: 1) Martin, a red pigmented variety considered to have a hard texture; 2) Tx-2536, a yellow endosperm variety; 3) Dekalb G-600, a commercial, yellow endosperm hybrid. All sorghum samples were grown under comparable conditions at the South Plains

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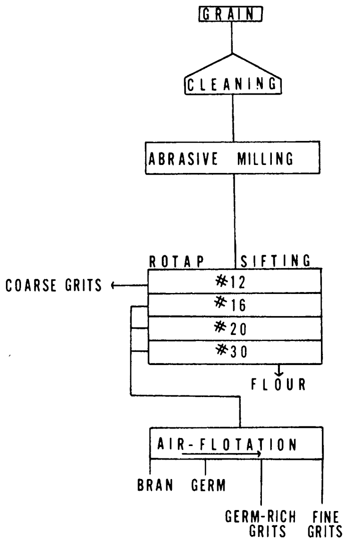

Fig. 1. Flow sheet for milling sorghum grain.

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Proximate Analysis

Petroleum ether extract, protein (N X 6.25), and ash were determined by accepted AACC procedures (4).

RESULTS AND DISCUSSION

Description of Method

The essential steps in the method are presented in Fig. 1. The milling is accomplished by placing 100 to 200 g. (usually 100 g.) into a Strong-Scott barley pearler which was modified by substituting a wire brush for the Carborundum wheel. The wire brush is 6 in. in diameter and 2 in. wide. The screen in the pearler is approximately 2.40-mm. or No. 8 U.S. standard-sieve mesh. The grain is subjected to the abrasive, tearing action of the brush for 1 to 2 min. Exact time depends upon the hardness of the grain determined in previous experiments. Samples with harder texture require additional milling time. The stock from the mill is sifted over a nest of Tyler screens for 5 min. with a Ro-tap sifter. The overs of the No. 12 screen are termed coarse grits. The overs of the Nos.16, 20, and 30 screens are combined and separated with air flotation in a model D South Dakota seed blower. The quantity of air flowing through the sample can be closely controlled, which permits removal of bran, germ, and germ-rich fractions successively by increasing the air flow. The remaining stock is the fine grits fraction. The germ-rich fraction contains germ and fine grits which are virtually inseparable by air flotation. The quantity depends on the variety. Large quantities of the germ-rich fraction may be further separated by use of a gravity table; however, further separation is impractical because of the small sample size.

Tempering of the grain to 16 to 18% moisture levels did not appreciably increase the separation of the grain into the various components. Tempered grain caused slowing of the procedure because it was necessary to dry the stock after abrasive milling to facilitate separation of the stock during sieving and air-flotation. Therefore, grain with 12 to 13% moisture was used. The increased time required for milling and separating tempered grain was judged a disadvantage not offset by the slightly increased grits yield obtained with tempered grain. The Nos. 16, 20, and 30 Tyler screens improve the reproducibility of the method. When the Nos. 16 and 20 screens were removed, the quantity of flour obtained was more variable.

Reproducibility of Method

Table I presents the mean, standard deviation, and range in yield of the fractions obtained by replicated milling of three sorghum-grain samples. The yellow endosperm hybrid, Dekalb G-600, gave a total yield of fine and coarse grits of 70.0%. Grain from Martin gave a total grits yield of 74.2%, whereas grain from Tx-2536 gave 70.6% total grits yield. In addition, some germ-rich grits were obtained from each variety of sorghum.

The range and standard deviations for the milling fractions obtained on grain from Martin were much greater than those of Tx-2536 and Dekalb G-600, possibly because of the lower number of replications.

TABLE I. MEAN MILLING YIELD, STANDARD DEVIATION, AND RANGE FOR MILLED FRACTIONS OBTAINED FROM THREE SORGHUM VARIETIES

Fractions	No. of Replicates		
	Martin 5	Dekalb G-600 13	Tx-2536 9
	%	%	%
Coarse grits			
$\bar{X}$	65.8	51.0	57.4
SD	1.1	0.8	0.4
R	64.0-66.5	49.8-51.8	56.7-58.1
Fine grits			
$\bar{X}$	8.4	19.0	13.2
SD	1.0	0.8	0.7
R	7.3-9.5	17.5-20.1	12.5-14.3
Germ-rich grits			
$\bar{X}$	2.1	4.7	5.0
SD	1.4	0.8	0.7
R	0.4-4.0	3.1-5.6	3.6-5.5
Germ			
$\bar{X}$	1.2	1.5	1.1
SD	0.4	0.3	0.2
R	0.6-1.2	1.0-1.9	0.9-1.3
Bran			
$\bar{X}$	4.6	3.3	4.5
SD	0.8	0.2	0.1
R	4.0-6.0	3.1-3.7	4.3-4.7
Flour			
$\bar{X}$	16.4	18.1	16.4
SD	1.0	0.6	0.4
R	15.5-17.8	17.3-18.6	15.9-17.2
Recovery			
$\bar{X}$	97.4	97.6	97.6
SD	0.6	0.4	0.5
R	96.2-98.3	96.1-98.1	97.1-98.1

The endosperm of sorghum comprises 80 to 84.6% of the kernel (average = 82.3%), according to Hubbard et al. (5). Using 82.3% as the quantity of endosperm present in the kernel, the recovery of endosperm as grits was 85.0, 90.6, and 85.6% for Dekalb G-600, Martin, and Tx-2536 , respectively. These figures do not include the germ-rich grits fraction which contained endosperm. The remaining endosperm was in the flour fraction. Recovery of germ and bran fractions was not quantitative, but the fractions were free from contamination. Much of the germ and bran portions of the kernel is in the flour.

A slight loss of material occurs during milling. Total recovery of all fractions averaged 97.4, 97.6, and 97.6% of the original grain sample for Martin, G-600, and Tx-2536, respectively. The material is lost mainly during abrasive grinding. Redesigning the abrasion mill would eliminate a large portion of this loss.

Chemical Composition of Milled Fractions

Table II presents ether extract, protein, and ash content for whole grain and milled fractions from Martin, Tx-2536, and G-600. Ether extract of the coarse and fine grits is less than 0.5% which indicates complete degermination of the grain. Ash content is less than 0.3%. Grits are light in color, which indicates complete bran removal. Grits from Tx-2536 and G-600 have a more acceptable appearance than those from Martin. The values in Table II were determined on composites of the milling replicates. Calculations showed that 95.0 and 95.7% of the total protein of the grain of Martin and G-600, respectively, was recovered in the milled fractions. Similar calculations for ether extract of Martin and G-600, respectively, showed that only 84.4 and 82.0% of the lipids originally present in the grain was recovered in the milled fractions. The lower recovery of ether extract might be explained by the loss of sample during milling. The materials lost during milling are small particles of germ, pericarp, and outer endosperm layers which would have a high content of ether extract.

The method appears to have good potential for studying the milling properties of sorghum grain where only small samples are available. Grits with acceptable color and ether extract levels are produced in high yields. The method is reproducible and can be used to obtain quantities of endosperm, bran, and germ for study. The grits can be reduced to flour by further milling techniques.

No information is available concerning the reliability of this method to consistently indicate differences in milling properties that are related to commercial

TABLE II. COMPOSITION OF MILLED FRACTIONS FROM MARTIN, TX-2536, AND G-600 SORGHUMS[a]

	Ether Extract			Protein			Ash		
Fractions	Martin %	Tx-2536 %	G-600 %	Martin %	Tx-2536 %	G-600 %	Martin %	Tx-2536 %	G-600 %
Whole grain	4.14	3.38	2.98	15.1	12.1	11.5	1.50	1.53	1.58
Coarse grits	0.37	0.54	0.45	14.1	11.5	10.6	0.25	0.30	0.22
Fine grits	0.44	0.45	0.44	14.7	10.6	10.0	0.35	0.40	0.28
Germ-rich grits	4.08	....	4.50	17.2	....	12.2	0.88	....	2.23
Germ	16.18	....	15.78	19.5	....	15.7	5.39	....	8.17
Bran	7.49	....	9.23	13.0	....	15.7	3.15	....	4.78
Flour	14.35	7.19	7.55	15.7	12.9	13.0	5.09	4.23	3.92

[a]Values are means of three analyses on composites of milled fractions of all replications.

milling performance of sorghum. This will be accomplished when a procedure for milling larger samples is devised or made available. Good laboratory milling techniques are needed for sorghum, and the cooperative effort of personnel interested in sorghum research will be required to develop an accepted method.

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