DEHULLING CEREAL GRAINS AND GRAIN LEGUMES FOR DEVELOPING COUNTRIES. II. CHEMICAL COMPOSITION OF MECHANICALLY AND TRADITIONALLY DEHULLED SORGHUM AND MILLET[1]

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Cereal Chem. 54(1): 174-178

ABSTRACT

The chemical composition of Nigerian sorghum and millet dehulled mechanically with a laboratory barley pearler and "Village Scale" abrasive- and attrition-type mills is compared with grains dehulled with the traditional mortar and pestle. Grains dehulled to progressively lower extraction levels were analyzed for protein, ash, oil, and crude fiber. Sorghum kernels were also manually dissected into pericarp, germ, and endosperm fractions and analyzed. Mechanically dehulled grains contained 31–51% less oil and ash and 9–18% less protein at 75% extraction than the whole grains. Traditionally dehulled grains contained 7–21% less oil and ash and 5–9% less protein at 75% extraction than the whole grains. Crude fiber was removed more efficiently with the barley pearler and the abrasive-type mill than with the attrition-type mill or the traditional method.

In developing countries such as Nigeria, grains bearing pigmented or very fibrous pericarps are dehulled and subsequently ground to flour in the traditional mortar and pestle fashion before being consumed. Efforts are being made to replace this tedious operation in small communities with "Village Scale" mills

[1]NRCC No. 15411.

incorporating a dehuller, grinder, sieving equipment, etc.

Carr (1) described the mortar and pestle methods used in southern Rhodesia to process maize, sorghum, and millet, and concluded there was a considerable loss of important nutrients associated with the process. However, nutrient losses are also associated with mechanical dehulling of such cereal grains. The effects on chemical composition of dehulling cereals with barley pearling-type equipment

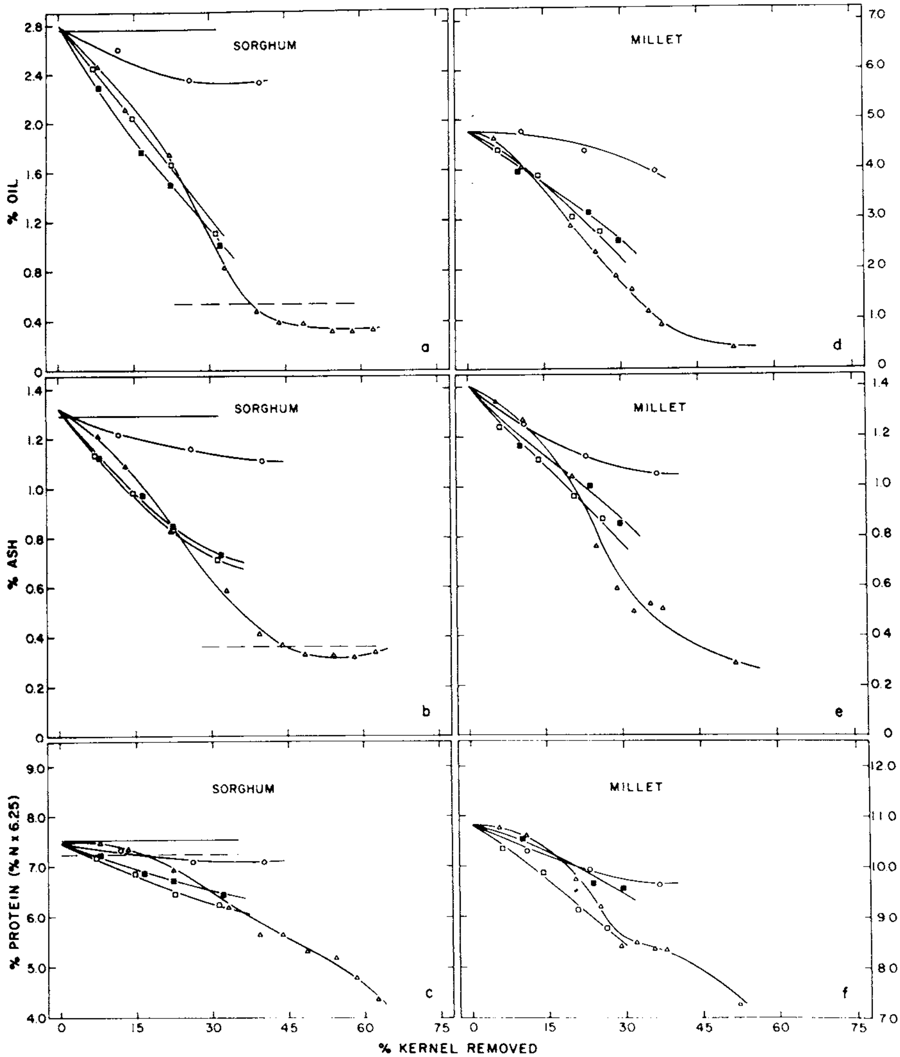

Fig. 1. Oil, ash, and protein content of sorghum and millet dehulled with the abrasive-type mill (□), a barley pearler (△), an attrition-type mill (■), and by the traditional method (O). Horizontal lines indicate composition of sorghum endosperm (- -) and sorghum endosperm plus germ (___).

(2–4), abrasive rice milling machinery (5,6), an attrition-type dehulling system (7), an experimental peeler (8), and a tangential abrasive device (9) have been reported.

The objective of this investigation was to quantify differences in chemical composition resulting from dehulling the same sample of sorghum and millet by a variety of dehulling methods. Mechanical methods include dehulling with: a new (10) carborundum stone-type dehuller named the George O. Hill Grain Thresher (abrasive-type mill); a sawtooth blade plate attrition-type dehuller named the Palyi Compact Mill (attrition-type mill); and a Strong-Scott laboratory barley pearler. The same grains were dehulled in the traditional mortar and pestle fashion and the sorghum grain was also manually dissected.

MATERIALS AND METHODS

Mechanical Dehulling

A vitreous red-branned sorghum (*Sorghum bicolor* (L.) Moench) and a green-branned millet (*Pennisetum typhoides*) were obtained from Maiduguri, Nigeria, and mechanically dehulled to successively lower extraction levels with the three dehullers as previously described (10). Twenty-gram samples of the dehulled grains were ground 2 min in a Chemical Rubber Co. micromill to prepare samples for analysis. Reflectance measurements on these flours have been reported (10).

Traditional Dehulling

Approximately 1-1/4 lb from the same batches of sorghum and millet were dehulled in a manner comparable to the traditional method used in Nigeria. The grain was thoroughly mixed with 20% by weight of water, allowed to stand 5 min, and pounded with a wooden pestle approximately 10–15 min. Subsequent air drying and winnowing removed the bran and other fine material. The amount removed was calculated on a dry weight basis and a sample of the dehulled grain was saved for analysis. The dehulled material was processed a second and third time to obtain lower extraction levels by adding approximately 15% by weight of water, pounding for 5 min, drying, and winnowing.

TABLE I
Proximate Constituents in Sorghum Components

Component	% by Weight	% Protein (% N × 6.25)	% Ash	% Oil	% Crude Fiber
Pericarp	4.90	6.31 (4.0)[a]	1.86 (7.1)	3.15 (5.7)	22.88 (53.4)
Germ	6.90	16.47 (14.5)	12.70 (68.2)	30.42 (76.9)	5.00 (16.4)
Endosperm	88.20	7.23 (81.5)	0.36 (24.7)	0.54 (17.5)	0.72 (30.2)
Whole sorghum	100.00	7.46 ...	1.32 ...	2.78 ...	2.38 ...

[a]Proportion of constituent in parentheses.

Manual Dissection

After soaking sorghum kernels in distilled water for 2 hr, all pericarp layers and the germ were removed under a magnifying glass using a small spatula. The components were vacuum-heat dried and weighed. The standard deviations of per cent pericarp and per cent germ obtained by dissecting four replicates of 10 kernels each were 0.11 and 0.27, respectively.

Millet kernels could not be dissected even after prolonged soaking in water.

Analytical Methods

Samples were analyzed for: protein (% N × 6.25) in a Hewlett-Packard 185 CHN analyzer; oil by the gravimetric method of Troeng (11), ash by the official AOAC method 13.006 (1960); and crude fiber by the micro-method described by Stringham *et al.* (12). The mean percentage standard deviation of duplicate analysis on 15 samples was 1.77, 3.35, 1.12, and 7.50% for protein, oil, ash, and crude fiber, respectively. Results are presented on a dry weight basis.

RESULTS AND DISCUSSION

The analysis and proportions of proximate constituents in the hand-dissected components of Nigerian sorghum are given in Table I. The sorghum germ contains 76.9 and 68.2% of the total oil and ash, respectively, and losses of these constituents during dehulling reflect losses of the germ. Sorghum pericarp contains 53.4% of the total crude fiber, and analysis of this constituent in dehulled grains is indicative of the degree of pericarp removal. The endosperm of the sorghum kernel contains 81.5% of the total protein.

Figure 1 indicates the oil, ash, and protein contents of sorghum and millet dehulled by the different dehulling methods. The three mechanical dehullers all decrease the quantity of oil and ash markedly, and of protein to a lesser degree. There are only small differences between the dehullers with respect to losses of oil, ash, and protein incurred in dehulling to the same extraction levels. Grains containing approximately the same amount of oil and ash as pure sorghum endosperm (broken horizontal lines in Fig. 1) can be obtained by removing 35–45% of the sorghum kernel with the barley pearler. At these low extraction levels, however, the protein content is also reduced.

Traditionally dehulled sorghum and millet contain higher oil and ash contents than mechanically dehulled grains (Fig. 1). The germ is firmly embedded in the sorghum endosperm and is not readily removed by pounding of the tempered kernels. Traditionally and mechanically dehulled grains do not differ as markedly in protein content as they do in ash or oil contents.

Crude fiber analysis on all dehulled sorghum and millet samples confirmed the order of dehulling efficiencies of the mechanical dehullers previously compared on the basis of efficiency of color removal (10). Crude fiber values at 75% extraction were 0.82, 0.94, 1.22, and 1.20 for sorghum, and 0.58, 0.72, 0.96, and 1.12 for millet in dehulling with the barley pearler, abrasive-type mill, attrition-type mill, and by the traditional method, respectively. The whole sorghum and millet had crude fiber contents of 2.38 and 1.96%, respectively.

Analysis of protein, ash, oil, and crude fiber indicates that the three mechanical dehullers tested all remove more of the nutritive constituents from sorghum and millet than does the traditional mortar and pestle method. Products from the mechanical dehullers, however, are produced more uniformly and at much higher throughputs than those produced traditionally. Mechanically dehulled products can be produced at low moisture contents, whereas the traditional process requires a large quantity of water and subsequent drying.

Acknowledgments

We wish to thank E. F. Lorer and B. D. Panchuk for technical assistance; the International Development Research Center for financial support of this project; and the Government of Nigeria for supplying the grains.

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[Received November 16, 1975. Accepted June 4, 1976]