Village-Scale Mechanical Dehulling of Cowpeas[1]

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ABSTRACT

Two methods of dehulling two varieties of Nigerian cowpeas were quantitatively tested. A reflectance spectroscopic technique was developed to measure the percent residual hull in brown cowpea flour. The Hill grain thresher, an abrasive type dehuller, effectively dehulled cowpeas at low Carborundum stone speeds. Brown or black-eyed cowpeas were dehulled at extraction levels of 73–86% and throughputs of 250–1,800 lb per hour. After a 10–12 min soak in water, cowpeas also were effectively dehulled with a rubber-matted barley deawner. Yields of 94–96% were obtained at throughputs of about 200 lb per hour. Moisture contents of the latter products were 20–30%, necessitating a drying step. The Hill grain thresher is a more versatile dehuller, but for special applications a barley deawner may be useful.

Cowpeas are grown extensively in West Africa, South America, India, and other tropical countries. In Nigeria, cowpeas are a principal source of dietary protein (Bliss 1975). For various reasons, cowpeas have been chosen as one of the main legumes of the grain-improvement program of the International Institute of Tropical Agriculture, Ibadan, Nigeria (Rachie 1975).

In West Africa the main method of dehulling cowpeas is with the traditional mortar and pestle. Either dry or sprinkled with water, cowpeas are stamped with the pestle in a mortar until the hulls are removed (Siegel and Fawcett 1976). Labor-intensive operations such as these are being mechanized and the technologies incorporated in "village scale" mills (anonymous 1976).

Black-eyed cowpeas previously were dehulled simply by coarse milling of the seed followed by air aspiration (Molina et al 1976). This method is not applicable to varieties of cowpeas with a testa layer that adheres tightly to the surface of the seed. The objective of this investigation was to examine quantitatively two methods for dehulling the black-eyed cowpea and a cowpea variety bearing a brown testa and a light-colored eye. The seeds were subjected to dry abrasive dehulling with the Hill grain thresher and also to wet-dehulling with a rubber-matted barley deawner.

MATERIALS AND METHODS

Brown cowpeas (*Vigna unguiculata* var. Red Dan Bornu) with a brown testa layer and light-colored eye and black-eyed cowpeas (*V. unguiculata* var. White Dan Bornu) with a white testa layer and black-colored eye were obtained from Maiduguri, Nigeria, in June 1974.

Hand-Dissection and Proximate Analysis

Cowpeas were soaked in distilled water for 10 min and the seed coats were removed manually. The embryos were reimmersed in H_2O for about 20 min. The cotyledons were split and separated from the hypocotyl and plumule, which were combined in a third fraction. The components were vacuum-dried at 60°C and weighed.

Samples were analyzed for protein (N × 6.25) in a Hewlett-Packard 185 CHN analyzer, oil by the gravimetric method of Troeng (1955), ash by AOAC Method 13.006 (1965), and crude fiber by the micromethod described by Stringham et al (1974). The latter is a micromodification of AACC Method 32-15 (1969). Results are reported on a dry weight basis.

Dehullers

The Hill grain thresher, described by Reichert and Youngs (1976), was operated on a batch basis. After pearling 40 lb of grain in the machine for 1 or 2 min, the grain was removed and the fines separated by passing over a 20-mesh screen. The grain also was passed through an Almaco air-blast seed cleaner that efficiently separated the eyes and a small quantity of other fine material. The extraction level was calculated and the grain was reintroduced into the machine. This procedure was repeated several times for both grains at various Carborundum stone speeds.

The rubber-matted barley deawner used (Fig. 1) was built at the Crop Development Center, University of Saskatchewan, Saskatoon. The middle roller rotates at approximately 63 rpm; the outside rollers rotate at 23 rpm. The kernels are simply introduced into the space above the middle roller. To test the barley deawner on brown and black-eyed cowpeas, 1-lb batches of each grain were soaked with 2 lb of distilled water for 2, 5, 8, and 12 min. Duplicate trials were conducted at each soaking time. After soaking, the excess water was poured off quickly and the cowpeas were left to drain for 1 min. The seeds were passed through the barley deawner in approximately 15–20 sec and spread to dry in a single layer. A sample was immediately taken for moisture determination. After air drying for two days, the seeds were again passed through the deawner to free any seed coat still adhering to the kernels. The seed coats were then separated from the dehulled kernels by means of the Almaco air-blast seed cleaner.

Product Quality Evaluation for Brown Cowpeas

Dry flour reflectance spectra were obtained on grains that were ground in a CRC micro-mill. Flours were packed as firmly as possible in glass reflectance cells with a spatula, and measurements were made with a Hitachi Perkin-Elmer spectrophotometer with a diffuse reflectance attachment (Reichert and Youngs, 1976).

Flour-water pastes for reflectance were prepared by thoroughly mixing 2.25 ml of distilled water and 2.5 g of the flour for 5 min. The creamy paste was placed in the glass cells with care that no air bubbles were present on the cell surface.

A calibration curve that correlated brown cowpea hull increments in cowpea flour with reflectance was prepared by measuring the reflectance (525 nm) of flour-water pastes incorporating 20, 40, 60, 80, and 100% of the seed coat of the original cowpea. The seed coat fraction was obtained from hand dissection and ground for 6 min in a Wig-L-Bug ball mill. Similarily, embryo material was ground for 2 min in a CRC micro-mill and fine ground for 2 min in the ball mill. Brown cowpea samples from dehulling tests and the embryos were ground similarly, and the reflectance measurement (525 nm) of the flour-water paste was taken to determine the percent of residual hull in the flour.

RESULTS AND DISCUSSION

Composition of Nigerian Cowpea

The proportions and proximate analyses of the anatomical components of hand-dissected Nigerian brown and black-eyed cowpeas are given in Table I. Hull contents were significantly lower and hull protein and ash contents higher in these seeds than in cowpeas of

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Indian origin dissected by Singh et al (1968). The Indian cowpea variety contained 10.64% hull, a hull protein content of 10.7%, and hull ash content of 3.17%. Black-eyed cowpeas of South American origin contain 11.43% seed coat (Molina et al 1976). Nigerian brown and black-eyed cowpeas contain only 3.65 and 4.96% seed coat, respectively. This small quantity of material markedly discolors flour from the whole grains.

Assay of Residual Seed Coat in Cowpea Flours

To assess the amount of seed coat on partially dehulled brown cowpeas, a reflectance spectroscopic technique was developed. Figure 2 illustrates the dry flour and flour-water paste reflectance scans of whole and hand-dehulled brown cowpea flour. Dry flour scans showed only a small difference between whole and hand-dehulled flours. When flour-water pastes were measured, however, the magnitude of the difference increased by a factor of approximately 5 at 525 nm and the absolute absorbances were markedly increased. Figure 3 shows the linear relationship (r = 0.997) between absorbance at 525 nm and the percent of the hull for flour-water pastes incorporating increasing amounts of hull obtained from hand-dissection of brown cowpeas. Measurements of flour-water pastes at 525 nm were used to quantitate the percent of residual hull in cowpea flours from dehulling tests.

Quality of partially dehulled black-eyed cowpeas was quantitated by measuring the weight percent of the cowpeas that still contained the blackeye.

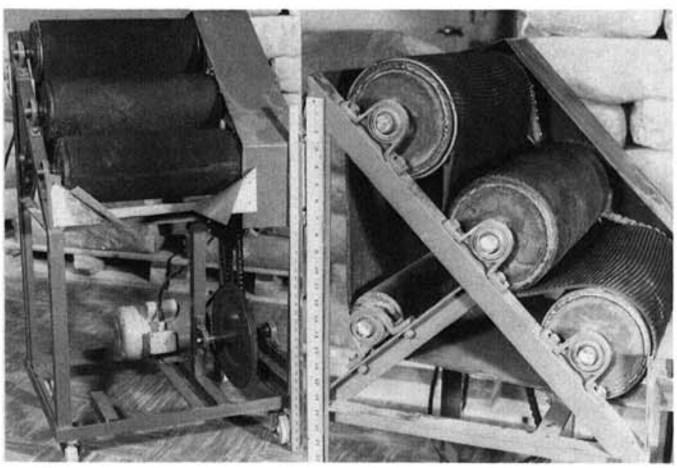

Fig. 1. Front and side views of rubber-matted barley deawner.

Evaluation of Dehullers

Figure 4 illustrates the effect of varying the stone speed in the Hill grain thresher on the efficiency of hull removal from brown cowpeas. Dehulling at 465 rpm was more efficient than dehulling at 770 or 1,050 rpm in terms of the percent hull removed for the amount of material sacrificed as hull fraction. Stone speeds in the Hill grain thresher in excess of 770 rpm were not practical in dehulling this grain. High stone speeds resulted in more splitting of the cotyledons, thus exposing more surface area of the seed to the abrasive action of the Carborundum stones. Sorghum or millet are effectively dehulled by abrasion at 1,050 rpm (Reichert and Youngs 1976) because these grains are much harder and much more resis-

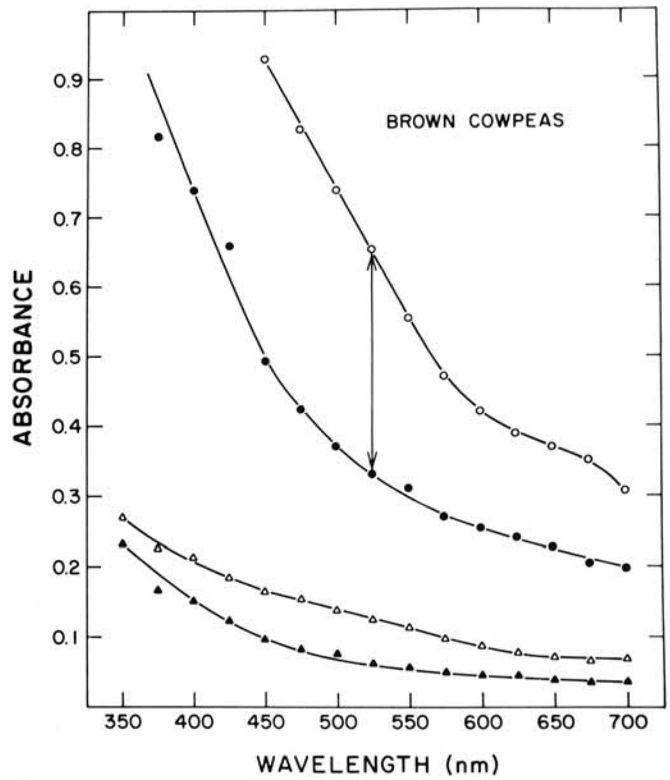

Fig. 2. Reflectance wavelength scans of brown cowpea flours prepared dry and as flour-water pastes. Dry flour reflectance of whole (△) and hand-dehulled (▲) brown cowpeas and reflectance of whole (○) and hand-dehulled (●) brown cowpea flour-water pastes.

TABLE I
Proximate Constituents in Brown and Black-Eyed Cowpea Components

Grain	Component	% by Weight	% Protein (N × 6.25)	% Ash	% Oil	% Crude Fiber
Brown cowpeas						
	Seed coat	3.65	18.73(2.59)[a]	5.39(5.48)	1.18(2.70)	24.71(39.42)
	Miniature plant structures[b]	1.69	46.18(2.96)	4.28(2.02)	9.95(10.56)	2.52(1.86)
	Cotyledons	94.62	26.33(94.45)	3.51(92.51)	1.46(86.72)	1.42(58.72)
	Whole cowpea	100	26.20	3.68	1.63	2.31
White cowpeas						
	Seed coat	4.96	13.70(2.65)	6.59(8.97)	0.51(1.75)	25.90(46.03)
	Miniature plant structures	1.44	45.54(2.55)	4.29(1.69)	8.06(8.05)	2.53(1.31)
	Cotyledons	93.60	26.02(94.80)	3.48(89.34)	1.39(90.22)	1.57(52.65)
	Whole cowpea	100	25.74	3.85	1.47	2.61

[a]Proportion of constituent in parentheses.

[b]Includes hypocotyl with the root tip and epicotyl.

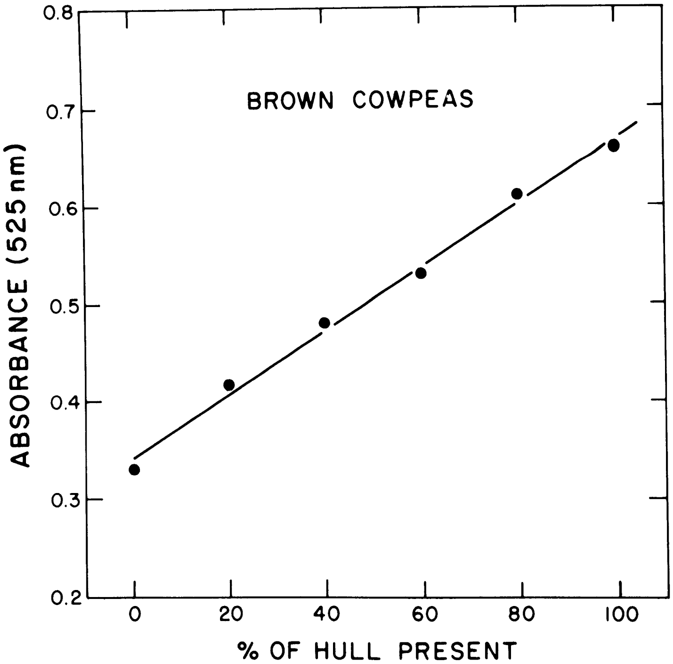

Fig. 3. Standard curve for the reflectance determination of the percent hull in brown cowpea flours.

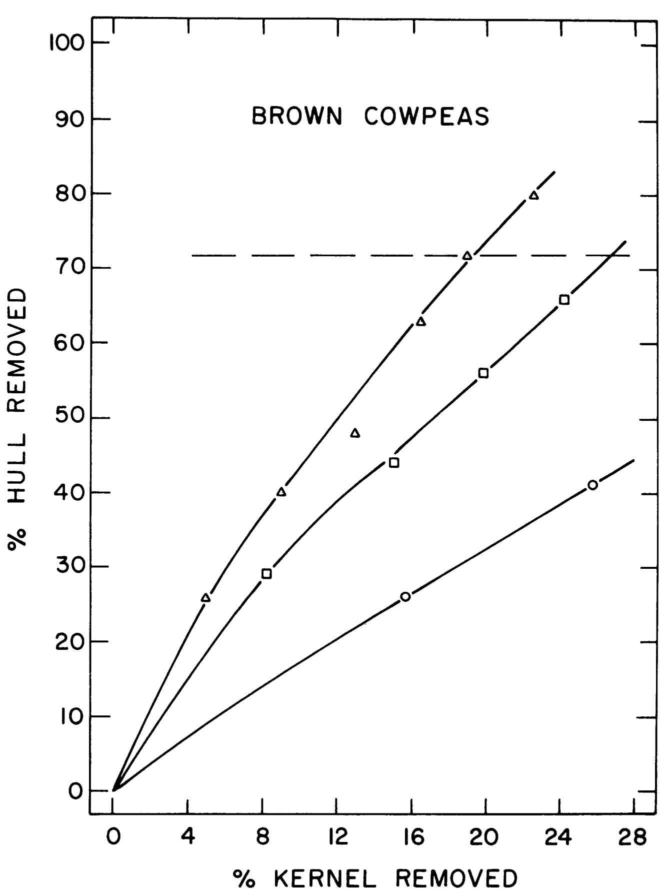

Fig. 4. Effect of stone speed in the Hill grain thresher on the efficiency of dehulling brown cowpeas. △, 465 rpm; □, 770 rpm; O, 1,050 rpm. Horizontal line represents a traditionally dehulled brown cowpea flour.

tant to breakage than cowpeas. The horizontal line in Fig. 4 represents a traditionally dehulled brown cowpea flour from Maiduguri, Nigeria. To attain this quality, it was necessary to remove approximately 19 and 27% as hull fraction at 465 and 770 rpm, respectively. At these stone speeds, throughputs of approximately 250 and 550 lb per hour would be expected.

Figure 5 shows the effect of dehulling black-eyed cowpeas at 465 and 770 rpm. Both stone speeds were capable of removing more than 90% of the black-eyes with the weight of hull fraction comprising only 14–17% of the material. Throughputs of approximately 600 and 1,800 lb per hour at 465 and 770 rpm, respectively, would be expected at these extraction levels. Effect of stone speed was less apparent than for brown cowpea.

TABLE II
Effect of Soaking Time on Product Quality in Dehulling Cowpeas with the Barley Deawner

Grain	Soaking Time (min)	% Moisture	Product Quality	Yield
Brown cowpeas			% Residual hull	
	2	21.4	38	96.1
	5	26.3	21	96.3
	8	29.3	15	96.3
	12	31.5	13	96.1
Black-eyed cowpeas		Wt % cowpeas with blackeyes		
	2	25.4	9.2	95.0
	5	28.6	6.4	95.5
	8	32.4	2.6	94.7
	12	35.0	3.4	94.5

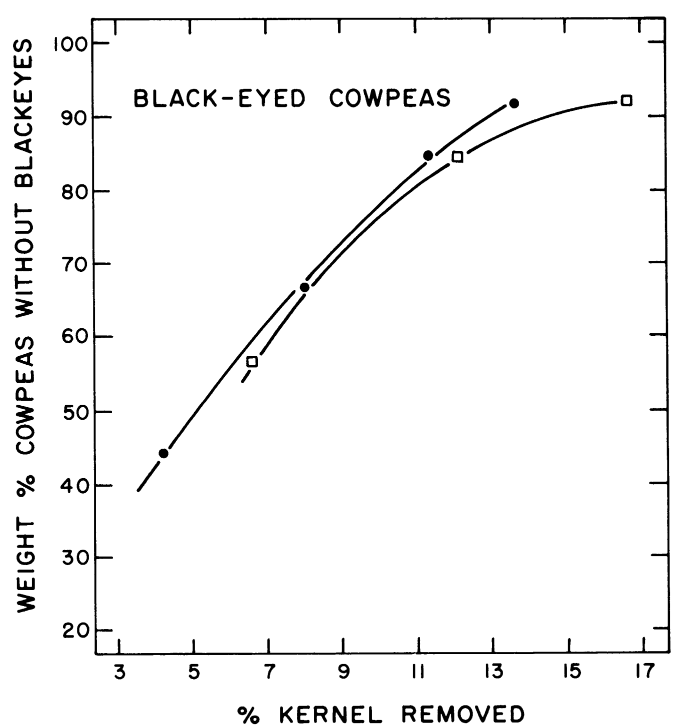

Fig. 5. Efficiency of removing the blackeyes from black-eyed cowpeas with the Hill grain thresher (origin = [0,0]); ●, 465 rpm; □, 770 rpm.

Table II illustrates the effect of soaking time on the efficiency of hull removal from brown and black-eyed cowpeas with a barley deawner. Cowpea hulls from both varieties absorbed water quickly and wrinkled. When the grains were soaked in water for 8 min and dehulled, only 13% of the brown cowpea hull and 3.4% by weight of white cowpeas with blackeyes remained. The yields were 94–96% for both varieties, indicating that this method of dehulling is very efficient. One disadvantage is that processed grains must be reduced in moisture from 25–35% to 10–15% to prevent spoilage. In a "village scale" operation, this would involve drying yards similar to those employed in wet-dehulling systems in India (Siegel and Fawcett 1976). If drying facilities were available, throughputs of about 200 lb per hour could be expected with the barley deawner. This machine could easily be scaled up.

Crude fiber content of the grains was the only proximate constituent that was significantly affected by dehulling cowpeas. For brown cowpeas, the fiber content was reduced to 1.85 and 1.40% in removing 9.10 and 16.46% of the kernel at 465 rpm with the Hill grain thresher. Similarly crude fiber was reduced to 1.72 and 1.54% in removing 8.02 and 13.69% of the black-eyed cowpea kernel.

CONCLUSIONS

Cowpeas are effectively dehulled by an abrasive method in a Hill grain thresher or by a wet method in a rubber-matted barley deawner. Although extraction levels are considerably lower using the dry process, the Hill grain thresher is more versatile and also is effective on cereal grains such as sorghum or millet. Wet dehulling in the barley deawner is applicable only to grains with seed coats that become soft and pull away from the embryo on wetting. Where a Hill grain thresher could not be readily installed, a small, hand-cranked barley deawner could be recommended for dehulling cowpeas or other seeds amenable to wet-dehulling.

ACKNOWLEDGMENT

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