



Design, construction and testing of a dehuller for African breadfruit (*Treculia africana*) seeds

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Abstract

The African breadfruit seed is a popular food resource in several parts of West Africa. It is presently being dehulled manually in the absence of a suitable mechanical device. A machine was designed in order to remove the drudgery involved in dehulling the seeds. The machine comprised of a roller which cracks the hull, an oscillating cam follower which removes the cracked hull through repeated shearing against a stationary wall, and an aspiration unit which sifts the hull from the endosperm. A prototype was constructed and tested. Throughput was 64 kg/h; yield, 75%; completely dehulled seeds, 85%; breakage, 1% and sifting efficiency was practically 100%. © 1999 Published by Elsevier Science Ltd. All rights reserved.

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1. Introduction

Dehulling is the removal of the outer pericarp and testa (hull) during processing of cereal grains, grain legumes, nuts and oilseeds. Besides nutritional and aesthetic enhancement (Deshpande, Sathe, Salunke & Cornforth, 1982), dehulling reduces the bulk density of the plant material, thereby facilitating better temperature management and control of other rate transfer processes in downstream processing.

The dehulling of the African breadfruit seed like that of many typical indigenous African seeds is carried out manually. In the traditional method of dehulling the African breadfruit seeds, a small quantity of the par-boiled seeds is spread on a clean flat and hard surface, and a roughly cylindrical object or a bottle is used to press and gently shear the seeds against the hard surface. The resultant mass, comprising the hulls and endosperm, is winnowed to obtain the endosperm (Ikegwuoha, 1998). This method, like all traditional

methods of dehulling, is beset with problems of low handling capacities and labour intensiveness. The drudgery involved in the dehulling, by traditional methods, has been highlighted as one of the major problems militating against the realization of the full potential of a good number of indigenous African seeds, as veritable staple foods, in spite of their widespread popularity and acceptance, and has therefore led to the development of a number of abrasive disk dehullers suitable for use in small-scale milling systems (Reichert & Youngs, 1976; Reichert, Oomah & Youngs, 1984; Basse & Schmidt, 1989). Many of these models were developed with sorghum (*sorghum vulgare*) and millet (*Panicum miliaceum*), and would therefore be applicable principally to these grains with tough and firmly adhering hulls, and possibly grains akin to them in physical characteristics.

In an earlier communication (Omobuwajo, Akande & Sanni, 1999), we highlighted the importance of the African breadfruit seed as a valuable food resource on account of its nutrient composition and popular acceptance. Further, we presented baseline data on the physical properties of the seeds, especially those which could be useful in the design of a dehuller. In this paper, we report on the development of the dehuller.

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2. Design and construction

2.1. Philosophy of design

The machine was conceived as a low-cost, easy-to-adjust, easy-to-dismantle and easy-to-fabricate device for removing the hull of the African breadfruit seed.

2.2. Design principles and theory

The seed is introduced through the feed hopper and decortication is achieved in three steps. In the first step, a cylindrical roller compresses the seed against a stationary cracking wall thereby subjecting the pliable endosperm to elastic deformation while the frangible hull is cracked.

In the second step, the cracked hull is detached from the endosperm by the repeated shearing action of an oscillating cam follower against a stationary shearing wall. The cam follower (oscillator) is mounted on helical springs. The springs generate the upward shearing force responsible for detaching the cracked hull and also returning the oscillator to its original position. In the last step, a fan exploits the differences in the suspension velocities of the hull and endosperm to separate the hull from the endosperm.

The clearance between the roller and the cracking wall, as well as that between the cam follower and the shearing wall are adjustable to suit the axial dimensions of the seed in order to ensure efficient cracking and detachment of the hull in a single pass.

The computation of design parameters and dimensioning were carried out in accordance with standard engineering practices.

2.3. Prototype machine

The overall dimensions of the prototype are $650 \times 500 \times 1000$ mm³ (Fig. 1). The machine comprises the feed hopper, and a motor to drive the cracking, shearing, and aspiration units.

The main frame consists of an angular flat rod, while the housing is made of galvanized flat steel sheet (18 gage). Many of the components were fastened with bolts and nuts to facilitate rapid dismantling for servicing and repairs. The machine parts are briefly described below while the specifications, which were determined after several trials, are given in Appendix A.

Feed hopper. The hopper is made of galvanized steel sheet and it is fitted with a feed-rate regulator.

Cracking unit. The cracking unit comprises of a cylindrical roller and a cracking wall, both made of hard wood and covered with an aluminium sheet (2 mm thick). The roller shaft is made of steel.

Shearing unit. The main features of the shearing unit are the two cams mounted on the roller shaft, the cam

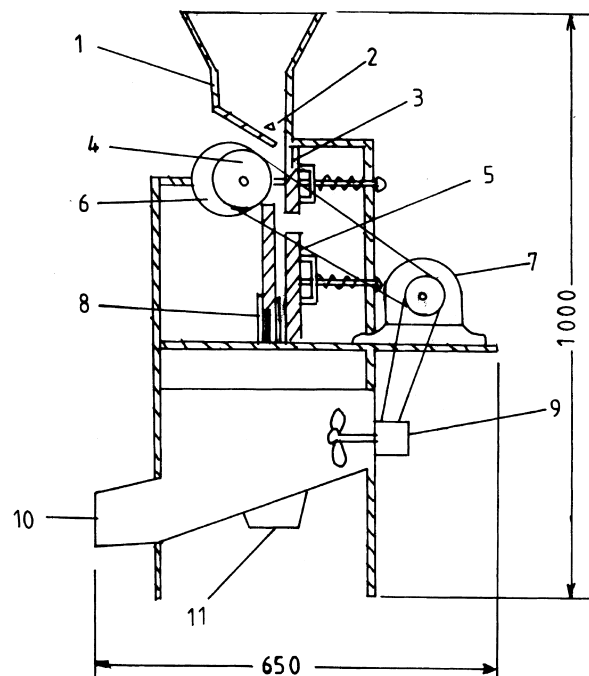


Fig. 1. Sectional view of the dehuller: (1) Feed hopper; (2) Feed rate regulator; (3) Adjustable cracking wall; (4) Roller; (5) Adjustable shearing wall; (6) Circular cam; (7) Electric motor; (8) Follower guide; (9) Fan; (10) Hull outlet chute; (11) Seeds outlet chute.

follower mounted on four helical springs, and the shearing wall. In addition, the cam follower is provided with a steel guide. The cams, cam follower, and stationary wall are all made of hard wood. The seed contacting surfaces of both the cam and follower are covered with aluminium sheet; the surface of the follower is slightly convex.

Aspiration unit. The aspiration unit comprises of a fan and a system of ducts.

Power unit. The dehuller is powered by a 1 hp electric motor.

3. Experimental testing

3.1. Breadfruit seeds

A batch of 200 kg of the African breadfruit seeds was purchased from the Bodija market in Ibadan, Nigeria.

3.2. Parboiling of seeds

The seeds were cleaned and divided into lots of approximately 20 kg each. The lots were parboiled as required. Parboiling entailed soaking the seeds in water maintained at 70°C for 10 min, draining the water and steaming in an autoclave at 121°C for 10 min, followed by drying in approximately 2.5 kg lots, at ambient room temperature ($30 \pm 2^\circ\text{C}$) to moisture contents varying

from 10% to 50%. Processed seeds were stored temporarily (before use) in a polythene bag to minimize moisture loss.

3.3. Moisture content determination

The seed was prepared for analysis by grinding about 20 g of manually dehulled seeds to pass a sieve with circular openings of 1 mm diameter and mixing it thoroughly. Two grams of the comminuted material was vacuum dried at 80°C to a final constant weight (AOAC, 1984). Reported value was the mean of three replications.

3.4. Testing

The one-factor-at-a-time method was employed in evaluating the effects of selected parameters on the performance of the prototype dehuller. Factors and levels investigated were seed moisture content, 10–50%; shaft speed, 80–150 rpm; and feed rate, 30–70 kg/h. Performance indices evaluated were throughput, yield, percentages of completely dehulled, partially dehulled, and unde-hulled seeds, breakage, and sifting efficiency.

Throughput was reported as the rate of handling 2 kg of the parboiled seed under choke feeding, while the yield was the weight of recovered product expressed as percentage of feed.

To determine the effectiveness of dehulling and also breakage, a 200 g sample of the product (dehulled seed) was taken and sorted to determine the number of seeds dehulled and unbroken (N_1), dehulled and broken (N_2), partially dehulled and unbroken (N_3), partially dehulled and broken (N_4), and unde-hulled seeds (N_5). Fractions of completely dehulled seeds ($(N_1 + N_2)/N_0$), partially dehulled seeds ($(N_3 + N_4)/N_0$), unde-hulled seeds N_5/N_0 , and broken seeds $(N_2 + N_4)/N_0$, were computed and expressed in percentages (Odigboh, 1979). Sifting efficiency is reported as mass fraction of detached hull in product stream.

All reported values of performance indices were means of five determinations.

4. Results and discussion

The results of the tests carried out to evaluate the performance of the prototype machine are shown in Table 1. The results show that the throughput and hence capacity of the machine was 64 kg/h when operated at a shaft speed of 150 rpm, under choke feeding, and at 40% seed moisture content. This capacity is low when compared with 145 kg/h reported for a melon sheller (Odigboh, 1979). Although the

Table 1
Performance indices of the prototype dehuller^a

Performance indices	Experimental value
Throughput (kg/h)	64.1 ± 1.7
Yield (%)	74.9 ± 2.1
Completely dehulled seeds (%)	84.6 ± 2.4
Partially dehulled seeds (%)	10.8 ± 0.4
Undehulled seeds (%)	4.5 ± 0.3
Breakage (%)	1.0 ± 0.2
Sifting efficiency (%)	99.4 ± 0.6

^a Shaft speed, 150 rpm; choke feeding; and seed moisture content, 40 ± 2%.

mechanism of dehulling, the feed materials, as well as other factors may be different in both cases, and the comparison should be made with caution, it is nevertheless necessary to improve the capacity since it is an important factor in the economic appraisal of machine operation.

The major reason for the difference in the capacities of the machines would appear to be the speed of operation. While the melon sheller was operated at a shaft speed of 2150 rpm, the prototype dehuller was operated at 150 rpm. There is therefore room for optimism that the capacity of the experimental dehuller will improve as soon as it becomes technically feasible to operate the machine at higher speeds.

The dehulling yield, that is, the amount of the feed recovered as product, which is a measure of the effective rate of dehulling was found to be 75%.

The percentage of completely dehulled seeds was roughly 85%, partially dehulled seeds 11%, and unde-hulled seeds 5%. These values are in the same range as reported for the melon sheller.

The breakage recorded for the dehuller was quite low, a mere 1% while higher values of 6–24% were reported for the sheller. Although the low breakage is commendable, higher breakage may be expected at higher speeds of operation.

5. Conclusions

A machine has been developed for dehulling African breadfruit seeds. The tests carried out on the machine indicate a fairly satisfactory performance. The effects of some physical parameters on the performance of the machine were also observed. It should be possible to improve the performance of the machine, especially with respect to throughput and percentage of completely dehulled seeds, with further modification and testing.

Appendix A. Specifications of the dehuller

Type	Small capacity, electrically operated continuous type
Overall dimensions, mm	650 × 500 × 1000
<i>Feed hopper:</i>	
Top, mm	300 × 150
Base, mm	270 × 120
Height, mm	70
Emptying angle, °	35–40
<i>Cracking unit:</i>	
Roller diameter, mm	100
Roller length, mm	310
Roller shaft diameter, mm	30
Stationary wall, mm	300 × 150 × 30
<i>Shearing unit:</i>	
Circular cam diameter, mm	80
Cam offset, mm	40
Cam thickness, mm	25
Cam follower, mm	350 × 110 × 30
Follower guide mm	360 × 120 × 3
<i>Aspiration unit:</i>	
Air velocity, m/s	3.5
<i>Power unit (Electric motor):</i>	
Power rating, HP	1
Working speed, rpm	150

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