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Development of a coconut dehusking lever

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A tool of second class lever mechanism type for aiding manual dehusking of coconut was developed. The dehusker is based on the physical and mechanical properties of coconut. The machine, on testing indicated that a manual effort (force) of 107 to 157 N on the handle of the lever is required to dehusk the Nigerian tall coconut variety having sphericity of 75 - 81%. A female worker (1.57 m height, 46 kg weight) was able to dehusk with a machete, a vertical tool and the new dehusking lever an average of 35, 12 and 47 nuts/h, respectively.

Keywords: Coconut processing, Dehusking, Dehusking-lever

Coconut (*Cocos nucifera* L) is a tropical perennial, fibrous drupe having largest seed in the plant kingdom and cultivated in the tropic and sub tropics of the equator (Godin and Spensley 1969). It is mainly cultivated in small holdings with about 96% of world production in small farms (Rognon and Van Vuure 2001). Though coconut plays an important role in Nigerian society, its potential is neglected. The coconut fruit has an outside smooth skin (exocarp), which at maturity dries to grayish brown colour. The endocarp consists of meat and coconut water. The mesocarp is white and tough in young coconut, enclosing the kernel (endosperm) and shell (endocarp) (Child 1974). It can be distinctly triangular to nearly globular. The fibre classified as a miscellanies fibre along with piassava (Vaughan 1970) is composed of a number of reddish brown, strong elastic filaments of different lengths which tapers towards the posterior and anterior ends of coconut giving it an elliptical appearance (Kirby 1963). The average matured coconut weighs 680.4 g and measures about 34.1 cm long and 16.4 cm wide. The whole matured coconut yield of the husk, shell, coconut meat and water are about 42, 15, 29 and 14%, respectively during processing (Badmus et al 2000). On an average, 1000 nuts of coconut yield 136 l of coconut water (Hutagulang 1976). The nut water consists of 2% (w/v) carbohydrates and other substances which induce rapid growth of beneficial microorganisms (Diokno-Palo 1972).

The hard brown reddish shell protecting the meat is largely considered waste in traditional coconut processing or used as fossil fuel in drying kilns. However, value added products such as pyrolysate has been reported and the antimicrobial and termicidal properties confirmed (Badmus 1999, Badmus and Adeyemi 2000). The very first step in coconut processing is the practice of dehusking, which is removal of husk of coconut with either machete or a vertical chisel type dehusking tool to obtain coconut meat, coconut water and shell which are important raw materials in the production of coconut milk, copra, oil, cake, carbon, pyrolysate, and coir fibre. The existing coconut dehusking methods are the use of machete or vertical chisel.

In the first method, a sharp machete is used to shear the coconut at the posterior and anterior ends length wise, which is followed by hitting the sides of the coconut with the blunt edge of the machete until the husk is removed. Where there is no need for preserving the length of the husk, the machete is used to shear up the coconut along both ends and the blunt edge of the machete is used to hit the husk until it is removed. In this manner the husk is sheared to pieces. The second method involves holding a coconut at a height and bringing it down against a pointed iron stake (chisel) inserted into the ground or on a concrete base. Repeated twisted pushes of the nut against the pointed edge of the rod remove the husk. This method requires great skill and a skilled worker can deal with 2000 nuts on a normal day's work (Child 1974).

The tedious process of dehusking has remained largely male dominated due to the enormous manual labour involved. There has been no appropriate dehusking technology hence, the preference for the use of machete and the vertical chisel type-dehusking tool. This operation is skill dependent but there are not many skilled workers available for this task. As such the much priced long fiber, which is about 50% by weight of the coconut, gets damaged as it is sheared during this process. A study was undertaken to develop an efficient coconut dehusking device that can be used by any worker irrespective of gender and at the same time the quality of the fibre is also preserved.

Materials and methods

Design of the dehusker: The traditional practices were observed with a view to developing a suitable dehusking tool. Tall variety coconuts obtained from the Plant Breeding Division of NIFOR were discretely divided into 3 sizes, namely small, medium and large on visual observation. A Chartered Standard for describing shapes of fruits and vegetables (Mohsenin 1978) was used in determining the shapes of the coconut for dehusking.

The major (a), intermediate (b), minor (c) axis were measured (Fig. 1) along with the depth of the husk at the middle (x), anterior (s) and posterior (o) ends.

Descriptive analysis of these values was obtained and the sphericity of the coconut calculated (Mohsenin 1978):

$$\frac{\text{Geometric mean dia}}{\text{Major diameter}} = \frac{(abc)^{1/3}}{a}$$

A hydraulic press was used to determine the pressure (force) required to dehusk coconut longitudinally. Points of husk failure on the coconut and the values obtained were used in estimating dehusking jaw geometry, lever length, mechanical advantage and the points where

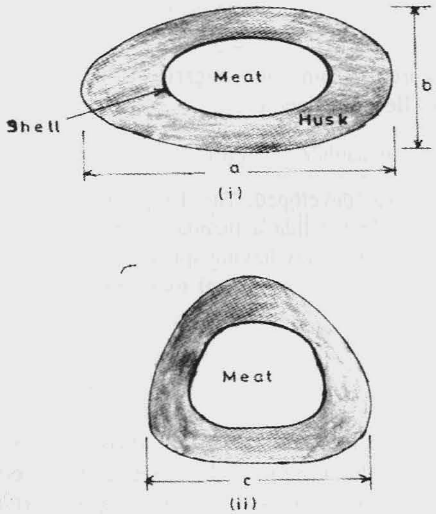

Fig. 1. Longitudinal (i) and transverse (ii) sections of coconut.

the removal of the husk will be most effective without cracking the shells of coconut. Based on the aforementioned physical and mechanical properties, the coconut-dehusking lever (Fig. 2) was designed.

Fabrication of dehusking lever: The coconut dehusking lever designed (Fig. 2) was fabricated using mild steel at the Research Engineering Division of the Nigerian Institute for Oil Palm Research, Benin City.

Testing: The dehusking lever was tested using tall variety of coconut obtained from the Plant Breeding Division, NIFOR. A female worker (1.57 m height, 48 kg weight) was employed to carry out this task by placing the discretely divided coconut (namely small, medium and large sizes) on the dehusking platform and manually apply force with the dehusking lever on each coconut. Five coconuts in each group were dehusked and the time taken for the work was recorded for each set of coconut dehusked. A calibrated spring balance scale was used to determine the force needed to achieve removal of the husk by the lever arm. A machete and a vertical chisel tool available at the Research Engineering Division for previous dehusking operations were used as control for comparison.

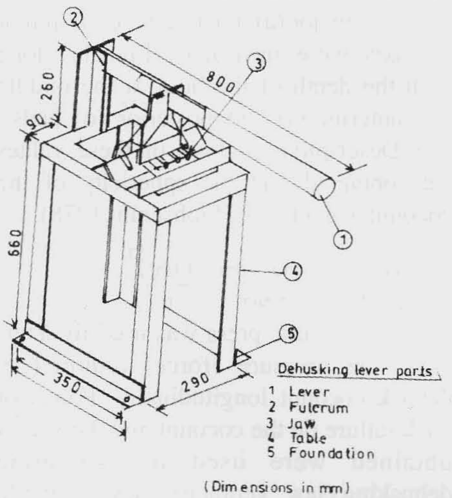

Fig. 2. Hand - operated dehusking lever

Coconut was placed on the dehusking platform beneath the piercing jaw frame. The effort arm, when raised, positions the piercing jaw on the coconut periphery. The effort arm was pushed against the coconut, thus the swing motion of the jaw about the fulcrum teared the husk. Using a calibrated spring scale attached to the lever arm, the scale was used to pull down the arm until piercing and tearing was achieved.

Results and discussion

Physical properties of coconut: Table 1 shows the average husk depth (x) from a longitudinal view; depth (y) and depth (v) from a transverse view for small, medium and big coconuts. Table 2 shows the values of posterior (o), anterior (s) and husk depths along the major, intermediate, and minor axis for the small, medium and big coconuts. The longitudinal and transverse sections (Fig. 1) established were elliptical and trianguloidal using the Chartered Standard for describing shapes of fruits and vegetables (Mohsenin 1978). Average sphericities of 81, 75 and 79% were obtained for the small, medium and large coconuts, respectively.

Component parts of the dehusking machine: The dehusking lever (Fig. 2) designed and fabricated using mild steel material consists of a stand, a lever arm with fulcrum at one end. The lever carries four piercing chisel type of jaw hinged between the fulcrum and the handle of the effort arm above the dehusking platform. The coconut to be dehusked rests on the platform of the dehusking lever. The hinge of the piercing jaw frame is connected to the fulcrum point such that a swing mo-

Table 1 Axial dimensions and coconut husk thickness (mm) of tall coconut type selected for dehusking

Coconut type		Axial dimension, mm							
		a	b	c	x	y	v	o	s
Small	S_1	199	135	147	35	46	30	31	30
	S_2	233	155	155	25	31	23	31	24
	S_3	205	150	156	35	54	29	35	46
Medium	M1	174	15	121	18	31	20	24	35
	M2	153	123	120	13	21	13	19	30
	M3	167	123	123	14	32	10	29	35
Large	L_1	198	125	125	22	39	12	30	35
	L_2	200	125	133	23	32	24	34	50
	L_3	195	126	129	20	25	21	36	29

a=Major axis, b=Minor axis, c=Intermediate axis, x=Middle husk depth, s=Anterior husk depth, o=Posterior husk depth, v=Side husk depth, y=Side husk depth

Table 2. Coconut dimensions used in designing the piercing jaw

Axial dimension	Axial dimension, mm		
	Small	Medium	Large
Sphericity, %	81	75	79
Major axis, a	212.3±18.10	164.7±10.70	198.0±2.50
Intermediate axis, b	146.7±10.40	120.3±4.60	125.6±6.00
Minor axis, c	152.7±4.90	121.3±1.50	129.0±4.10
Posterior husk thickness, o	32.3±2.30	24.0±5.00	33.3±3.10
Anterior husk thickness, s	33.3±11.40	33.3±2.90	37.3±1.80
Side husk thickness, v	27.3±3.80	14.3±5.10	19.0±6.20
Middle husk thickness, x	31.7±5.80	15.0±2.60	21.7±1.50
Side husk thickness, y	43.6±11.10	28.0±6.10	32.0±7.00

Table 3. Applied minimum (Min) and maximum (Max) force on the handle of manual dehusker reading from calibrated spring scale during dehusking

Coconut size	Min, N	Max, N
Small	100.5	150.6
Medium	110.6	159.6
Large	112.3	160.2
Mean	107.8	156.8

tion of the jaw describes a circular path as it pierces the husk of each coconut, thus tearing out the husk.

Piercing jaw dimension design is based on the above values. The average values for the anterior, posterior and sides of the coconut were used in designing the piercing depth of the jaw so as to handle small, medium and large coconuts. On account of calculated sphericities, the piercing jaw is designed to be elliptical and able to achieve even distribution of forces during dehusking.

Force requirement and efficiency of dehusking: A nominal force of 107.8 to 156.8 N as noted (Table 3) in the calibrated spring scale is needed to puncture and tear off the husk from the coconut. This is similar to the observation when the coconut was pressed under the hydraulic press. The husk length was not affected. During the trial run one female worker using the dehusking lever on an average can dehusk 70, 47 and 24 nuts/h on small, medium and large coconut, repectively, average 47 nuts as compared to 46, 27 and 33 nuts/h, respectively, for machete and 15, 21 and 0 nuts/h, respectively for chisel. None of the coconuts were damaged during dehusking. This dehusking lever has been used successfully at the Agricultural Research Engineering Division, NIFOR.

Conclusion

The coconut dehusker developed is an improvement of the existing machete and vertical chisel for dehusking coconut. The use of this device is less hazardous when compared to other two methods. In addition, the quality of the coconut fibre is retained so that it could be used for preparing fibre coir, footmat, rope and other value added products.

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