Design and Development of Chironji (Buchanania Lanzan) Decorticator

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***Abstract*: *Chironji* decorticator was designed, constructed and tested to evaluate its performance. The *chironji* decorticator was fabricated and tested by decortications of *chironji* seeds. A study was under taken to obtain design and development of *chironji (Buchanania lanzan)* decorticator and its performance analysis and cost economics. The machine comprises of hopper, cylindrical housing, emery black stones, lower frame, electric motor, driving systems, sieves, reciprocating grader, gap adjustment screw, starter, grader stand etc. The drawings were prepared with using the CAD software. The selection of materials and fabrication was done following the standard manufacturing processes. The machine was tested by decortications of *chironji* seeds (sample weight = 10 kg) in the laboratory as well as in the field. The laboratory tests showed that the hulling efficiency of *chironji* decorticator is higher after 7th pass 80 % followed by 78.78 %, 75.44 %, 68.06 %, 56.01 %, 39.38 % and 21.2 % for passes 6th, 5th, 4th, 3rd, 2nd and 1st respectively. The unit price of the experimental prototype was Rs. 65000/-.**

Keywords: Chironji Decorticator, Chironji Nuts, Chironji Kernels, Black Emery Stone, Sieve/Grader, Hulling Efficiency.

I. INTRODUCTION

Chironji (*Buchanania lanzan*) is common tree in dry deciduous forests. It is endemic to tropical dry deciduous forest of India [9]. *Chironji* (*Buchanania lanzan*), belongs to family Anacardiaceae. It is a medium sized tree, with straight, cylindrical trunk, up to 10-15 m height and tomentose branches. The fruit fetches a much lower price for the collectors than the kernel and hence, collectors usually grind the seed to obtain the kernel, 5 kg of fruit can yield almost 1 kg of *chironji*. Each tree can produce 3-4 kg of *chironji* which is sold for a price of around Rs. 100-125 per kg to the village traders. Thus, a typical farmer owning 5 trees can about Rs.1500 by selling *chironji* every year. Prices for *chironji* in the national market were around Rs. 700-1200 per kg. [3]

The presence of hard seed coat is one of the shelling problems in decortications of nuts, its small size let's to damage the seed at the time of decortications and spoil the seeds which reduce its economical value and also deteriorate the shelf life of it which leads to low storage stability [1]. Traditional processing method *chironji* is very cumbersome, time consuming and labour extensive. There is very less recovery of whole kernel nearly 20 % only rest is either broken or mashed. There is excessive loss due to crude methodology adopted for the processing, which leads not only to huge economical loss but also loss of nutrition also. In addition to these, since the method involves huge labour the processing cost becomes higher. [4]

II. MATERIALS AND METHODS

The study was conducted in Swami Vivekananda College of Agricultural Engineering and Technology and Research Station, Faculty of Agricultural Engineering, IGKV, Raipur (CG) situated at 21° 14° 02' N latitude and 81° 43° 11' longitude. The operational field meant for the study was selected from the demonstration / research field of the faculty.

Traditional Method of Char Processing

The skin of the harvested green nuts turns black on storage which has to be removed before shelling. The nuts are usually soaked overnight in water and rubbed with pulms for small scale processing and with the jute sack for large scale processing. The water containing fine skin is decanted. The nuts are washed fresh water to dried in sun for 2 to 3 days and for further processing i.e., shelling.

Indigenous Technique for *Chironji* Nut Processing

Hand operated disk huller similar to the burr plates are also use. These disks were made of either stone or backed clay or sun dried clay. The bottom disk is generally fixed on the ground and the top one is rotated by hand. A steel or wooden axle projecting from the centre of the bottom disk serves as a guide for the top disc. The efficiency was low and it causes more broken and powder. [4] The *chironji* seed was fed through the top disk.

Fig: 1 Indigenous techniques of *chironji* decortications

Design and development of machine

The machine comprises of hopper, cylindrical housing, emery black stones, lower frame, electric motor, driving systems, sieves, reciprocating grader, gap adjustment screw, starter, grader stand etc. Many parts of the machine were designed as per standard procedures and some pre fabricated parts like belts, pulley, bearing, bearing housing etc were also used as per availability in the market.

Hopper

The hopper were design in square shape which was made of 20 gauge mild steel sheet in which the dimension of section A (upper side) was 380 mm × 380 mm and section B (lower side) dimension were 110 mm × 110 mm that's allow to feed the *chironji* seeds into the decortications unit were the total height of hopper was 500 mm.Overall capacity of the hopper was 15 kg and the discharge slope angle was 60° which was allow to smooth flow of *chironji* seeds from the hopper to the shelling unit shown in Fig.2

Cylindrical Housing

The cylindrical housing were made of 18 gauge mild steel sheet which was circular shape with the diameter of 530 mm and the height of 210 mm. In which emery black stone and longitudinal ribs operates which rotates inside a concave. When the fabrication of cylindrical housing to maintain the 50 mm distance between cylindrical housing and around the stone disc because when the seeds are spread from the stone disc after impact .Then the seeds were stoke to the cylindrical housing wall and thus the break down the crack seeds and thus the overall resultant kernels separate from the sell shown in Fig.3

Lower Frame

The lower frame which was in the shape of rectangular it was made of 50 × 5 mm angle with the height of the frame was 910 mm and width was 630 mm. The size of 35 × 5 mm angles were used for supportive base for the machine components i.e. shaft, bearing, motor and pulley etc. and their length is 630 mm.

Grader

The main purpose of grader was separates the kernels from hulls and to separate the kernels of different sizes. The overall size of the sieve/grader was 1000 × 610mm. The shelled or splitted kernels will pass through grader. The grader was having 4 screens of various sizes and screens were moving by oscillating motion driven by shaft. Here shelled produce as per its opening size.

Emery Black Stone

The black emery stone was purchased from local market. We have design of ribs in inner portion of the disc to increase friction between *chironji* seeds and disc surfaces were the centrifugal force are acting in the decortications unit. It was consist of an iron ribbed cylinder mounted on rotating shaft on ball bearing was fitted in concentric cylinder housing. The inner ribbed cylinder has helical ribs up to one-fourth of its length and four to six number of straight ribs for rest of the length. The ribbed cylindrical disc was rotated at a speed of 240 rpm.

Electric Motors

The electric motor was used to transmit power or rotational motion to the shelling disc through its protruding shaft with the aid of a key that fastened them together. The power rating of the electric motor is 1hp single phase or 1440 rpm. The electric motor was bought already made from the market.

Bearing Housings

A ball bearing housing and hanger was designed to stabilize the rotary shaft and reduce vibration, thereby preventing collision of the rotating shelling disc with the stationery wall of the shelling drum in turns to reduce the amount of crushed *chironji* seeds. The bearing block was purchased from local market as per requirement of the machine design.

Shaft

In the machine three different sizes of shafts were taken. The shaft S_1 was fixed in the back side of the machine with the help of ball bearing. It was a main shaft to taking power by the help of v-belt from the electric motor and thus transmitted powers another two shaft S_2 and S_3 respectively with the help of v-belt and flat belt.

Pulley

Velocity ratio of the two pulleys of a belt drive may be defined as the revolution per minute of follower divided by the revolution per minute of the driver.

$$\text{Velocity ratio} = \frac{\text{diameter of follower}}{\text{diameter of driver}} = \frac{D_2}{D_1} = \frac{N_2}{N_1} \quad (1)$$

Where,

D_1 = diameter of the driver;
D_2 = diameter of the follower;
N_1 = rpm of the driver; and
N_2 = rpm of the follower.

Belt Drive

In the belt drive, the grip between the pulley and the belt obtained due to friction was utilized to transmit power between two parallel shafts which either rotate in the same or opposite directions.

Power Transmission System

The power was transmitted from 1 hp single phase electric motor (1440 rated rpm). The step pulleys (50.8, 63.5, and 76.2 mm) were mounted on the motor shaft. The vertical shaft fixed in the rear side of the machine with different sizes of pulleys (i.e. 101.6, 127, and 88.9 mm, respectively) were also mounted on this shaft.

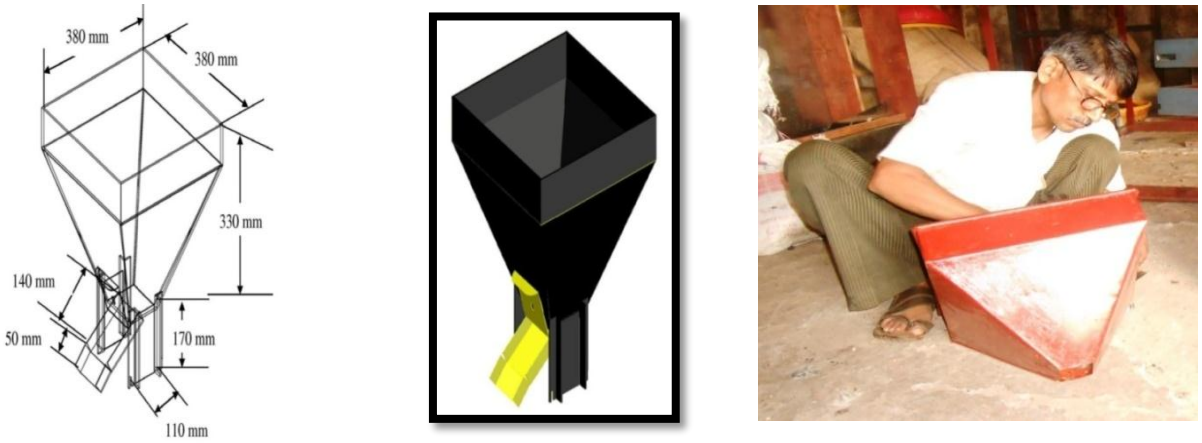


Fig : 2 Isometric view and fabrication of hopper

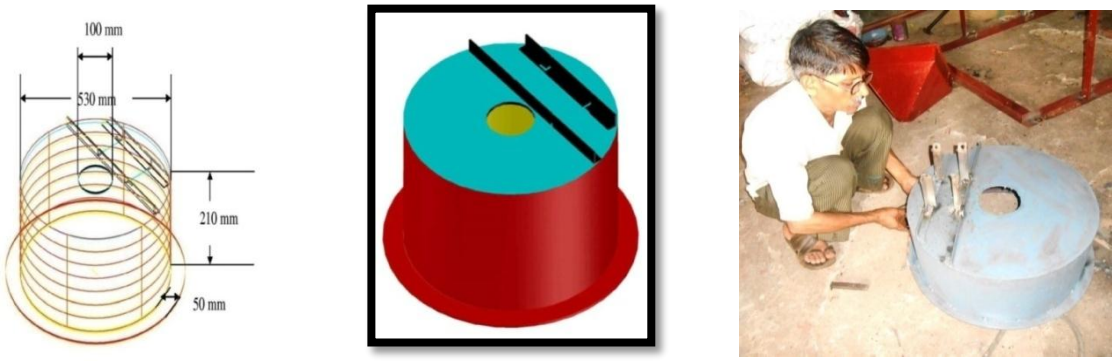


Fig : 3 Isometric view and fabrication of cylindrical housing

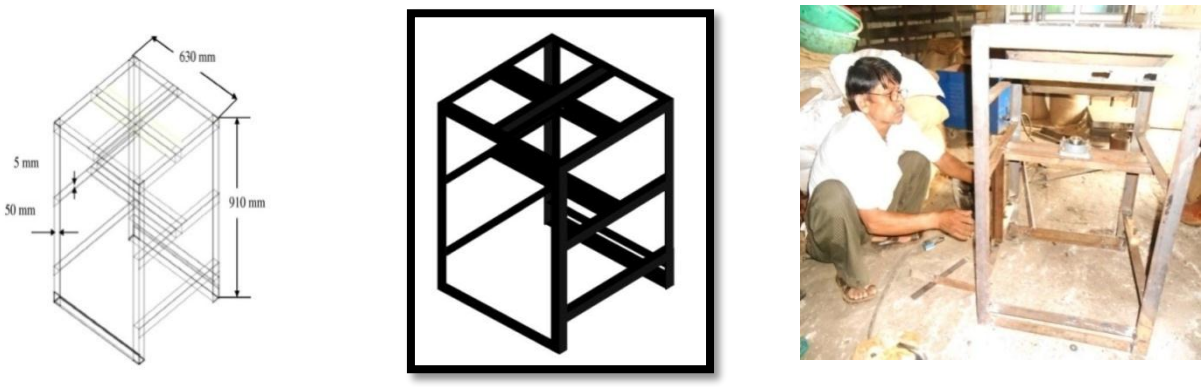


Fig : 4 Isometric view and fabrication of lower frame

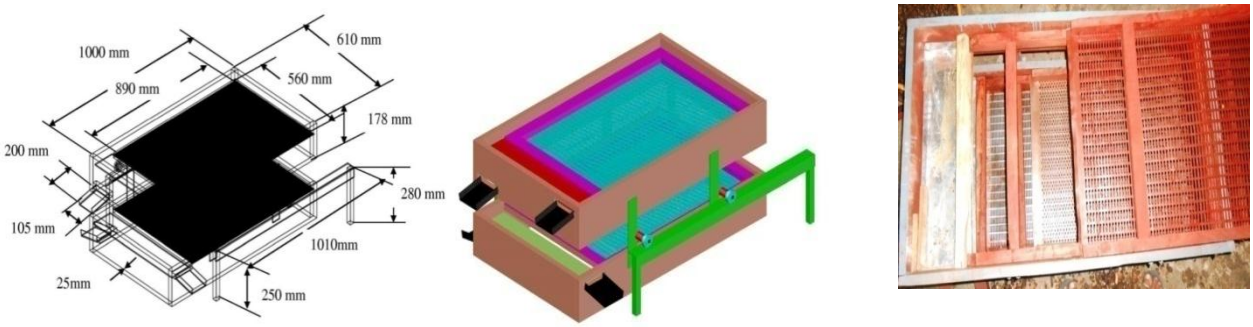


Fig : 5 Isometric view and fabrication of sieve/grader

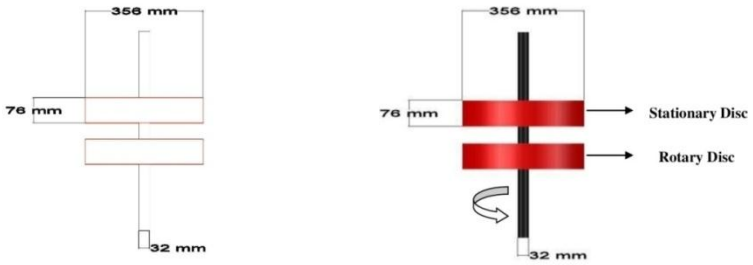
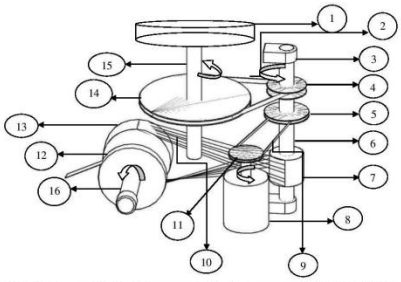


Fig. 6 Isometric view of emery black stone

Fig: 7 Different sizes of pulley are used



1. Black Emery stone	2.V-belt B_1	3. Bearing Housing	4.Pulley(P_1)=101.6mm	5.Pulley (P_2)=127mm
6. Shaft (S_1) = 720 rpm	7. Pulley(P_3) = 88.9mm	8. Motor Single Phase 1440 rpm	9. V-belt B_2	10. Cross Belt B_3
11. Step Pulley (P_4) = 50.8, 63.5, 76.2 mm	12. Crank Shaft	13.Pulley (P_5) = 152mm	14. Pulley (P_6) = 304.8mm	15. Shaft (S_2) = 240 rpm
16. Shaft (S_3) = 420 rpm				

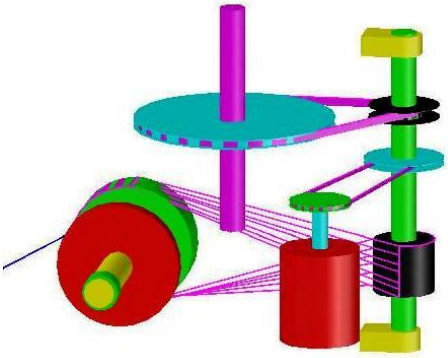


Fig. 8 Isometric view of power transmission of machine

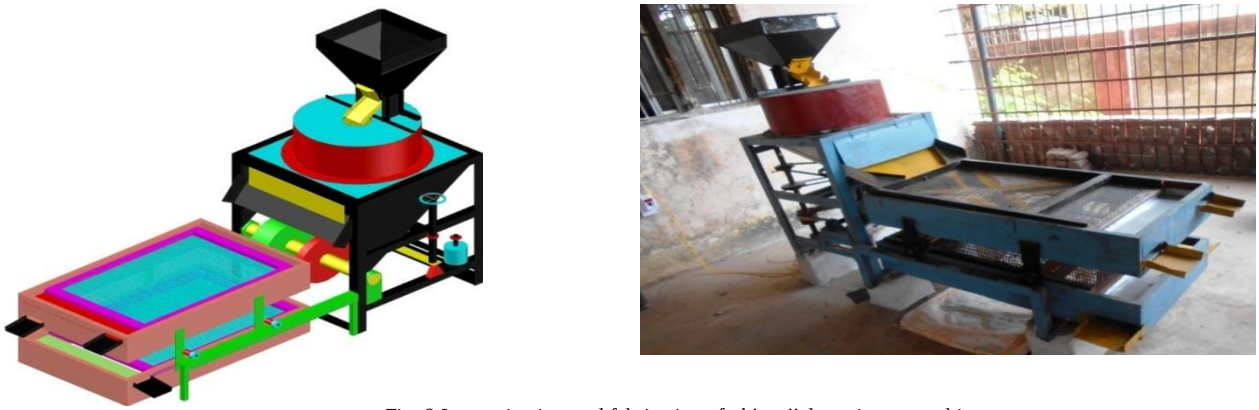


Fig: 9 Isometric view and fabrication of *chironji* decorticator machine.

Studies on Milling Efficiency

The *chironji* seed was taken for the decortications as per the basis of laboratory test an unknown moisture contents. The samples were subjected to decortications /shelling in decorticator. Feed rate were keeping constant during decortications process, were adjusted by setting the metering mechanism of decorticator fitted at the bottom of the feed hopper. A sample size corresponding to 10 kg of *chironji* seeds fed to the decorticator has fixed operating parameters. The following milling parameters were calculated using the formula given below [2].

III. RESULTS AND DISCUSIONS

The sample of 10 kg *chironji* seeds was taken for the decortications in *chironji* decorticator. The speed and feed rate was kept constant for the machine for entire duration of decortications process. The 10 kg sample was fed to the hopper and its metering device was opened for the feeding of seeds into the decorticator for decortications process. After decortications the seeds were found at different fractions i.e. unhulled seeds, whole kernels, broken kernels, husk and dust. These all fractions were separated by the help of sieve/grader. The sieve/grader was attached with decorticator therefore the all fractions are collected from the different outlet of the sieve/grader and thus the first pass is accomplished. After first pass analysis and reweight of the all fractions. The seven passes were required for the complete decortications of 10 kg *chironji* seeds and similarly previous analysis is necessary for remaining all passes. The sample weight and time requirement are gradually reduced after each pass. The whole *chironji* kernels, broken, husk and dust/mealy waste of kernels was yield 14.22 % 14.41 %, 82.41 % and 9.28 % respectively is shown in Table 1

From the Table 1 the hulling efficiency of *chironji* decorticator was highest after 7^{th} pass 80 % followed by 78.78 %, 75.44 %, 68.06 %, 56.01 %, 39.38 % and 21.2 % for passes 6^{th}, 5^{th}, 4^{th}, 3^{rd}, 2^{nd} and 1^{st} respectively. The coefficient of hulling was increased after each pass but the coefficient of wholeness of kernel was reduced after each pass. The hulling efficiency was increased after each pass significantly.

The 10 cm clearance was maintained between stone discs during decortications of *chironji* seeds. The disc was revolved constant 240 rpm speed an entire duration of decortications process. Throughout the capacity of machine 80 kg/h was yield. The individual hulling efficiency was found to be after each pass and overall hulling efficiency was yield due to the mixing of one pass to another to each other respectively is shown in Table 3.

Table 1 Fractions of hulled 10 kg *chironji* seeds sample in seven passes

Sample Fractions	1st pass (kg)	2nd Pass (kg)	3rd Pass (kg)	4th pass (kg)	5th pass (kg)	6th pass (kg)	7th Pass (kg)	Total weight (kg)
Whole *Chironji* Seeds	10.000	7.500	5.300	3.300	1.800	0.800	0.300	0.00
Chironji Kernel	0.386	0.315	0.294	0.225	0.130	0.050	0.022	1.422
Broken	0.039	0.038	0.035	0.033	0.031	0.019	0.010	0.205
Husk	2.045	1.819	1.646	1.209	0.823	0.422	0.277	8.241
Dust/Mealy Waste of kernels	0.030	0.028	0.025	0.021	0.016	0.009	0.003	0.132
Total								10.00

Table 2 Hulling efficiency of chironji seeds

S.N.	Coefficient of hulling $Eh = 100\left(1-\frac{n_2}{n_1}\right)$	Coefficient of wholeness of kernel $Ewk = \frac{k_2-k_1}{(k_2-k_1)+(d_2-d_1)+(m_2-m_1)}$	Hulling efficiency $\eta\ (\%) = E_h \times E_{wk}$
1	25.0	0.846	21.20
2	47.0	0.838	39.38
3	67.0	0.836	56.01
4	82.0	0.830	68.06
5	92.0	0.820	75.44
6	97.0	0.812	78.76
7	100.0	0.808	80.80

Table 3 Comparison between individual hulling efficiency and overall hulling efficiency

S.N.	Shelling disc (rpm)	Clearance between stone disc (m)	Capacity (Kg/h)	Decortications efficiency, %							
					1st pass	2nd pass	3rd pass	4th pass	5th pass	6th pass	7th pass
1.	240	0.10	80	Efficiency	25.0	29.3	37.7	45.5	55.5	62.5	100.0
			Overall efficiency		25.0	47.0	67.0	82.0	92.0	97.0	100.0

VI. CONCLUSION

1. A *chironji* decorticator machine was designed and developed successfully.
2. Over all capacity of machine was found to be 80 kg/h. The machine hulling efficiency was found to be 80% in 7th pass.
3. The decortications efficiency of developed machine was found to be 80 % with 14.41% broken kernels and 9.28% dust/mealy waste which was under acceptable limits of the industry.

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