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Modification and performance evaluation of the NCAM motorized coconut dehusking machine

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Abstract

NCAM motorized coconut dehusking machine was tested for its performance. The objective of the test is to optimize the dehusking performance of the machine. Different sizes of coconut fruits were fed into the machine and the time taken for each fruit to be dehusked was noted. A total number of 60 matured Badagry coconuts from Lagos State, Nigeria were dehusked with the machine. The performance evaluation shows that the efficiency of the machine was **90.1%** while the average capacity is **122** coconuts per hour. The percentage number of distorted and broken coconuts was 10% and 0% respectively. Hence, the machine is suitable and recommended for small, medium and large scale coconut processors.

Keywords: Coconut; Dehusking; Evaluation; Motorized; Efficiency

1. Introduction

Coconut (*Cocos nucifera L.)* is an important fruit that supports the livelihood of the majority of coastal people in Nigeria and the sustainability of their environment. Coconut is named Tree of Life because all parts of the coconut palm are useful, and the trees have a comparatively high yield (up to 75 fruits per year); it, therefore, has significant economic value. However, the level of poverty continues to increase despite the many products that accrue from the crop [1]. Despite the advantages of the crop, coconut farmers in Nigeria experienced a low standard of living because of inadequate access to new technologies that will improve production. To unlock this potential, Nigeria Government established the National Coconut Producer Processors and Marketers Association of Nigeria (NACOPPMAN) and the Coconut Research Institute of Nigeria (CORIN) in 2018 with the major aim of improving the productivity of the Coconut sub-sector through several Research and Development Activities [2].

In 2019, 62 Million tonnes of coconuts are produced worldwide. However, Nigeria is ranked 19th in the World Coconut producing countries among the countries with the highest volume of coconut production like the Philippines with 1.2 million tonnes, Indonesia with 885,000 tonnes, and India with 390,000 tonnes, with a combined 76 percent share of global production.

Every part of the coconut palm has its marketable value. The coconut stem can be used for building material, coconut leaves can be turned into brooms, coconut fibre can be turned into a cushion, coconut shell can be used as charcoal for energy source and Coconut husk fibers are used to make ropes, mats, runners, brushes and brooms, also turned to produce fireproof boards [3]. The predominant use of coconut husks is in direct combustion to make charcoal; otherwise, husks are simply thrown away. It was reported that coconut husk can be transformed into a value-added fuel

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source that can replace wood and other traditional fuel sources. In terms of the availability and costs of coconut husks, they have good potential for use in power plants [4].

The mechanization level of coconut production in Nigeria is very low due to inadequate access to modern technologies. The first stage of coconut production after harvesting is de-husking process which involved the removal of husk from the coconut by tearing principle. Sujaykumar et al., 2017 investigated that, the binding force between fibre in the husk is greater than that between the husk and the shell; therefore, piercing takes place between the husk and the shell interface. The force between the husk and the shell interface cannot be easily overcome through the manual method of separation. Coconut De-husking with traditional hand tools like cutlass or a spike required skilled workers and involves training. But such skilled workers are very minimal.

The defect of the above methods of the coconut dehusking process, demands mechanized coconut dehusker to improve productivity, working rate, and safety [5]. Thus, an indigenous motorized coconut dehusking machine was developed at National Centre for Agricultural Mechanization (NCAM) and evaluated. As part of efforts to curb problems associated with dehusking processes, many researchers have developed and evaluated some Coconut de-husking machines, a few of them are mentioned here:

Ghosal et al developed a powered-operated coconut dehusking and evaluated three varieties of coconut namely, Sakhigopal, Guamal, and Hazari. The sakhigopal variety has the highest dehusking efficiency of (92.45%), however, there is less difference in all the three varieties. The dehusking capacity of 330nuts/hr was noticed with Sakhigopal followed by Guamal and Hazari (324 nuts/hr varieties [6].

Patil et al. developed a low-cost, medium-speed coconut dehusking at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Its parts consisted of a main frame, electric motor, gearbox, cam and follower, lifter, holding mechanism, and splitting mechanism, etc. The parameters used to determine its performance are time, output capacity, dehusking efficiency, and operating cost. The report obtained from the performance evaluation of the duhusker with the average time required to dehusk one coconut was 30.6 s and the output capacity of the machine was 118 nuts/h, which was far better off using manual dehusker. Therefore, the machine can dehusk any shape and size of coconut without nut breakage [7].

Ogunjirin et al. fabricated an indigenous motorized dehusking machine using locally sourced materials at National Centre for Agricultural Mechanization (NCAM). The machine was tested for efficiency by loading a mature coconut fruit through the hopper into the dehusking chamber. The average time utilized by the machine to fully dehusk a coconut was 10 seconds. This operation was repeated for different shapes and sizes of coconut and the result proved that it can effectively dehusk any variety of coconut. The aimed objective of this work is to carry out a performance evaluation on the coconut dehusking fabricated in NCAM for possible improvement [8].

2. Material and methods

2.1. Description of the Machine

The NCAM motorized coconut dehusking machine consists of the following essential parts; the frame, hopper, dehusking unit, coconut outlet chute, husk outlet chute, spur gears, reduction gear, and diesel engine prime mover (plate 1).

The hopper is a spherical hollowed cylinder with a diameter of 232mm and a height of 25mm and made from a 2mm mild steel sheet. the hopper is attached at the top of the dehusking unit cover. Inside the dehusking drum are spikes welded along the circumference of the cylinder pipe at a measured distance from one another for easy penetration and tearing of the husk during de-husking. The spike is designed from a 12 mm diameter, cut into smaller pieces, a sharp edge is formed based on the average thickness of the coconut husk aids the opposite rotation of the two spike drums. It is a simple gear with inner 30 mm diameters and outer 148 mm diameters. It is the best to use to transmit rotary motion between shafts that rotate in opposite directions. Reduction gears are incorporated with a belt pulley arrangement and driven by a 5 hp diesel engine to produce the required torque.

Figure 1 Pictorial View of the NCAM coconut dehusking machine

2.2. Working Principle of the Machine

The coconut fruits are fed into the hopper and by gravity, it moves down to the dehusking unit. In the dehusking unit, the two spikes roller rotate in opposite directions, the rolling spikes grip the husk by shearing force and tear the husk from the nut. After the separation, the nuts comes out at the coconut chute outlet while the husk dropped by gravitational force through the hush outlet chute.

2.3. Design Considerations

The coconut dehusking machine was fabricated based on the certain criteria for optimal performance. The physicochemical properties of the coconut fruit were considered during the modeling of the machine. The availability of constructional materials was also considered for the construction of the machine to repair and maintain the machine for further use. Gender-friendliness and safety precautions were taken into consideration during the design of the machine.

2.4. Performance Testing and Data Analysis

The evaluation of the performance of the NCAM motorized coconut dehusking machine was carried out at the Engineering and Scientific Services Workshop of the National Centre for Agricultural Mechanization (NCAM) Ilorin, Nigeria where the coconut dehusking was fabricated. The coconut sourced from Badagry, Lagos State, Nigeria was used for the evaluation. The specific purpose of this evaluation is to optimize the optimal dehusking efficiency and capacity of the machine. This was determined by twenty experimental runs. Number of nuts (N_{ns}) during the experiment their relevant de-husking timer was recorded. The number of nuts with a full length of fiber (N_{ff}) together with numbers of distorted fibre (N_{df}) also recorded. The de-husking time was measured using a digital stopwatch (Timex, Netherland) and The rotational speed of the machine was determined using a digital tachometer (Stimpo Instruments USA) to measure the time taken to de-husk a coconut. Thereafter, the efficiencies, (ϵ) and capacity (C) of the machine were mathematically calculated as follows:

$$\in (\%) == \frac{N_{ff}}{N_{ns}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$\mathrm{C}\left(\frac{nuts}{hr}\right) = \frac{N_{ns}}{t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2 \text{ [9]}$$

2.5. Effect of Modification on the Efficiency of the Machine

The power transmission parts of the original machine are V-belt and pulley. This brought about slippage of the belt on the pulley thereby not fully transmitting the total torque developed by the reduction gear. However, with the introduction of sprocket and chain mechanism, the slippage was reduced to bearest minimum. This allows the machine to dehusk better than when it was operated with belt and pulley mechanism.

Figure 2 Different sizes of undehusk coconuts

Figure 3 Coconut dehusking machine during the performance test

Figure 4 Husks after coconut dehusking

Figure 5 Fully dehusked coconut fruits

3. Results and discussion

The performance test results carried out on the motorized coconut dehusking machine are presented in table 1

Table 1 Coconut Dehusking Efficiencies and Capacity

S/no	No. of coconut de-husked N_{ns}	No. of broken nuts	No. of dehusked nuts with full fibre,N_{ff}	No of dehusked with distorted fibre, N_{df}	TIME, t (seconds)	Efficiency, ε(%)	Capacity, C (nuts/hr)
1	3	0	3	0	95	100	113.7
2	3	0	3	0	84	100	128.6
3	3	0	2	1	90	67	120
4	3	0	3	0	86	100	126
5	3	0	3	0	94	100	115
6	3	0	2	1	91	67	119
7	3	0	3	0	96	100	112.5
8	3	0	3	0	88	100	122.7
9	3	0	2	1	90	67	120
10	3	0	3	0	90	100	120
11	3	0	3	0	87	100	124.1
12	3	0	2	1	85	67	127.1
13	3	0	3	0	86	100	125.6
14	3	0	3	0	84	100	128.6
15	3	0	2	1	56	67	128.6
16	3	0	3	0	83	100	130.1
17	3	0	3	0	84	100	128.6
18	3	0	2	1	85	67	127.1
19	3	0	3	0	95	100	113.6
20	3	0	3	0	98	100	110.2
Tot/Ave	**60**	**0**	**54**	**6**	**1,747** **87.35**	**90.1**	**2,441.1** **122.1**

It is observed that the machine has the capacity to dehusk the commonly available coconut of different varieties in term of thickness and hardness effectively. The machine can normally dehusk about

160 to 190 coconuts per hour despite, time require to dehusk is linked with the age of coconut. Graph 1. Shows time taken to dehusk, different aged coconut.

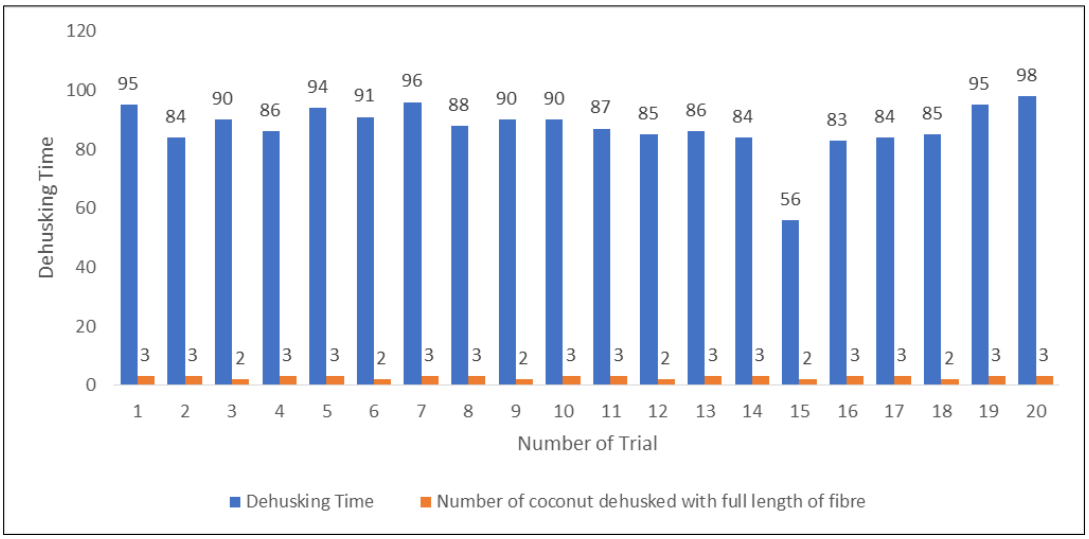

Figure 1 Time v/s Number of Coconut Dehusked

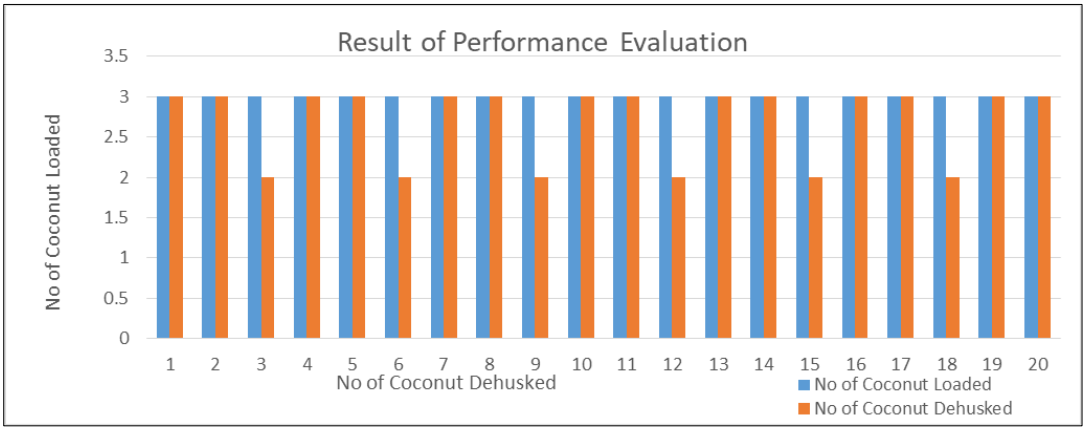

Figure 2 Number of nuts dehusked v/s Number of coconut loaded

The results of the performance evaluation figure 1 and figure 2 shows that the machine performed above 90% efficiency in all the number of trial as expected. It can be deduced from table 1 that the capacity of the developed machine ranges between 120 and 195 nuts per hour depending on the operator, however, on average an operator can de husk 122 nuts per hour with this machine. Meanwhile, the percentage number of distorted and broken coconuts was 10% and 0%. Hence this machine is recommended for farmers.

4. Conclusion

The performance evaluation of the NCAM coconut dehusking machine shows that the modification on the existing NCAM coconut dehusking machine dehusked perfectly. If further improvement is made in the affordability of this machine to the farmers, the production of coconut production in Nigeria will be ranked closely among the world coconut-producing countries.

Compliance with ethical standards

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Disclosure of conflict of interest

We hereby declared there is no conflict of interest on this research work.

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