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Performance Evaluation of a Palm Fruit Debuncher

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ABSTRACT : A palm fruit debuncher that was designed and fabricated at the Department of Agricultural and Bio-Environmental Engineering Technology, The Federal Polytechnic, Ado-Ekiti was evaluated for the stripping of bunches. Faults were identified and modified after the machine was tested under load and no load. Studies were conducted on the effect of machine speed (550rpm, 730rpm and 1095rpm) and the quantity of feed (5kg, 10kg and 15kg) on the machine stripping capacity, efficiency and percentage of damaged fruits. The performance of the palm fruit stripper was evaluated at different levels of machine and crop variables. Machine speed and quantity of feed statistically affected the machine performance at 5% significance level using SPSS. The performance was found to be influenced by all studied variables, however, the machine gave the best stripping efficiency of 94.7% at 550rpm for unsteam bunches and 100% at 730rpm for steam bunches; stripping capacity of 150kg/hr at 1095rpm for both steam and unsteam bunches. The machine gave the lowest percentage of damaged fruits of 18.8% at 1095rpm for unsteam bunches while the lowest percentage of damaged fruits was produced for steam bunches was 0% at 550rpm.

KEYWORDS: Palm Fruit, Debuncher, Stripping efficiency, stripping capacity

I. INTRODUCTION

The oil palm (*Elaeisguineensis*) is a popular tree crop in West Africa where every part of it has economic value, that is why it is being described as the prince of the plant kingdom[1]. As such, it plays a very important role in the agricultural and economic sectors of those countries where oil palm is being cultivated. [2][3]revealed that 338 billion pounds were generated from the cultivation of oil palm thus amounting to about twice the level of production of any other fruit crop, making oil palm by far the world's number one fruit crop. About 80 percent of palm oil produced is used in food products while the remaining percentage is used as feedstock for other non-food applications, thus, palm oil and palm kernel oil have a wide range of applications [4]. The by-products of oil palm fruit processing such as empty bunches and fibres can further be processed as raw materials for potash fertilizer, fibre, pulps and paper manufacture [5][6].

The technology of palm oil production has advanced in recent years with new modern innovation to produce palm oil and palm kernel oil of superior quality [7], results from various survey showed that 80 percent of Nigerians oil palm produce exist in smallholder plantations and wild groove [8], and thus the nation's oil palm industry can be classified as subsistence where traditional method predominate way of oil palm processing because there are very few large estate plantations that make large mills and imported mills relatively expensive and unaffordable by most farmers[9].

[8]states that processing the fruit without delay or fermentation yielded the highest oil extraction of 87 percent and best quality oil with a free fatty acid (FFA) of 2.31 percent. Hence, fresh fruit bunches should be processed as soon as possible to prevent a swift rise in free fatty acid which normally affects the quality of crude palm oil.

A palm fruit debuncher has been designed and fabricated in the Department of Agricultural and Bio-environmental Engineering, The Federal Polytechnic, Ado-Ekiti. This research work is aimed at carrying out performance evaluation of the machine to investigate its throughput, efficiency, ease of operation, ease of maintenance and affordability to both small and medium scale palm oil processors.

II. MATERIALS AND METHODS

Machine Description

The Palm Fruit Debuncher has been fabricated and it consists of four basic units viz: the feeding unit, the stripping unit, the drive mechanism, and the discharge outlets. The various component parts of the machine include:

(i) **Hopper**

The hopper is constructed in the form of a truncated pyramid and it is situated at the top-right edge of the drum. The hopper is made from mild steel plate with a dimension of 400mm × 400mm × 300mm of 3mm thickness. It was marked out and developed into shape by bending machine while the welding machine was used to join the edges together.

(ii) **Frame**

The frame is the component which supports the major parts of the machine in order to maintain stability with little or no vibration of the part during operation of the machine. It was made from mild steel angle iron of 5mm thickness. The frame dimension was taken to be of length 1200mm, breadth 600mm and height 900mm. The dimensions were marked out and cut using the hacksaw to their respective sizes. The frame was welded together with a welding machine and holes were drilled to allow the component parts to be joined to the frame.

(iii) **Debunching Unit**

The cylindrical drum and the spikes form the debunching unit of the machine. The drum was made from mild steel sheet and 3mm thickness with dimension 1100mm × 840mm. This was marked out and cut from the mild steel sheet and then folded by the rolling machine to form a cylindrical shape of the upper and lower part. The spikes which do the stripping of the bunches were made from mild steel iron rod. 50 pieces of length 120mm were cut from the iron rod and welded unto a shaft of diameter 16mm which was also made from mild steel iron rod.

(iv) **Screen**

The screen forms the lower section of the threshing cylinder perforated to allow the palm fruit to pass through to the discharge outlet. It was made from mild steel sheet of 3mm thickness. The perforation was done with the aid of electric burning, chisel, and hammer using a dimension of 40mm × 40mm for each hole.

(v) **Discharge Unit**

The discharge unit is the outlet through which the stripped fruits are collected. It is made from mild steel plate of 3mm thickness with dimensions 50mm × 50mm. The dimensions were marked out and cut using a hacksaw and welded together and attached beneath the stripping unit.

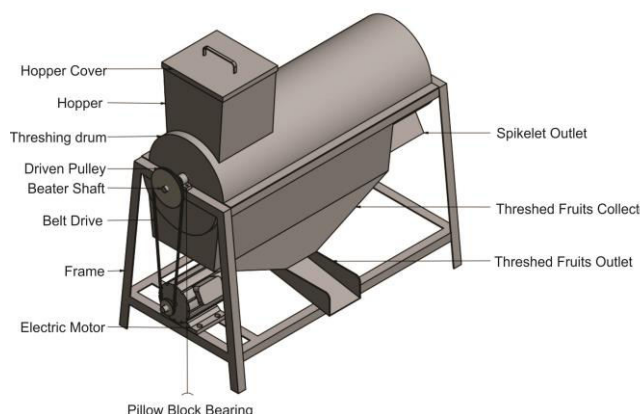


Fig 2.1 a: Isometric view of palm fruit debuncher



Fig 2.1 b: Fabricated palm fruit debuncher

Operation of the Machine

The palm fruit debuncher as shown above is connected to an electric motor of 5hp (kW) with the aid of belt and pulley arrangement, the driver pulley diameter is 60mm while the driven pulley diameter is 190mm, thereby reducing the speed from 1480rpm to 550rpm, the driven pulley is connected to the shaft carrying the spike, the shaft is held by two pillow block bearings for realignment of shaft in case of misalignment of shaft. Debunching is achieved by the beating of the spike on the palm fruit bunch which is fed into the machine through the hopper. The removed seed drops to the seed outlet through the screen which is then collected through the discharge outlet.

Performance Test

To evaluate the performance of the machine, 180kg of palm fruits bunches were purchased and divided into two batches A and B of 90kg each. Batch A was unsteamed while batch B was steamed for a period of one hour. The palm fruit bunches are fed into the machine through the hopper to the debunching unit where the shaft beaters arranged in an auger like form. As the shaft rotates through the power transmitted from the electric motor via belt and pulley mechanism, the bunch is thrown up against the housing while the spikes strip the fruits from the bunches. The stripped fruits were then collected at the discharge outlet beneath the machine.

In all the test, different quantity of feed - 5kg, 10kg, and 15kg, were fed into the machine at different speeds of 550, 730 and 1095 rpm. The speed was achieved by using different pulley diameter. The test was carried out for the steam and unsteam bunches. After each operation, the stripped fruits, unstripped fruits, damaged and undamaged fruits and the bunches from the outlet were carefully sorted out, weighed and recorded.

The following performance tests were carried out on the machine:

Stripping Capacity

The stripping capacity of the machine is the maximum rate at which the machine can process a certain quantity of bunches.

Stripping capacity, $C_t = \frac{W_b}{T_a}$, kg/hr where W_b = weight of bunches stripped in kg; T_a = Average time of stripping in hr

Stripping Efficiency

Stripping efficiency is the effectiveness of the machine in stripping the palm fruits which is expressed as:

Stripping efficiency, $E_s = \frac{W_f}{W_t} \times 100\%$ where W_f = total weight of stripped fruits; W_t = total weight of bunches stripped

Percentage of damaged fruits

This is the percentage at which the machine can produce fruits that are not damaged and it can be expressed as:

Percentage of damaged fruits = $\frac{W_{ud}}{W_f} \times 100\%$ where W_{ud} = Weight of undamaged fruits; W_f = weight of fruit stripped

III. EXPERIMENTAL RESULTS**Performance Results of the Machine****Performance results for varying quantity of feed for un-steam bunches**

The results of the performance test carried out using different quantities of feed with the machine operating at a different speed for un-steam bunches are presented below:

Table 3.1: Performance results for varying quantity of feed at speed 550rpm for un-steam bunches

Q (kg)	T_s (min)	W_u (kg)	W_d (kg)	W_{ufs} (kg)	W_b (kg)	W_{fs} (kg)	S_c (kg/hr)	S_e (%)	P_{df} (%)
5	3	1.4	0.4	0.1	3.1	1.8	100	94.7	22.3
10	7	2.1	0.5	0.2	7.2	2.6	85.7	92.9	19.3
15	9	1.9	0.7	1.3	11.1	2.6	100	66.7	26.9

Table 3.2: Performance results for varying quantity of feed at speed 730rpm for un-steam bunches

Q (kg)	T_s (min)	W_u (kg)	W_d (kg)	W_{ufs} (kg)	W_b (kg)	W_{fs} (kg)	S_c (kg/hr)	S_e (%)	P_{df} (%)
5	4	1.8	0.6	0.4	2.2	2.4	75	85.7	25
10	6	3.4	0.9	0.5	5.2	4.3	100	89.6	20.9
15	7	2.8	0.8	0.4	11	3.6	129	90.0	22.3

Table 3.3: Performance results for varying quantity of feed at speed 1095rpm for un-steam bunches

Q (kg)	T _s (min)	W _u (kg)	W _d (kg)	W _{ufs} (kg)	W _b (kg)	W _{fs} (kg)	S _c (kg/hr)	S _e (%)	P _{df} (%)
5	2	1.3	0.3	0.2	3.2	1.6	150	88.9	18.8
10	4	2.1	0.5	0.4	7	2.6	150	86.7	19.3
15	7	2.6	0.7	0.7	11	3.3	129	82.5	21.3

Where Q = Quantity of Feed (kg); T_s = Time of Stripping (min); W_u = Weight of undamaged fruit; W_d = Weight of damaged fruit; W_{ufs} = Weight of unstripped fruit; W_b = Weight of bunch; W_{fs} = Weight of stripped fruit; S_c = Stripping capacity; S_e = Stripping efficiency; P_{df} = Percentage of Damaged Fruits

Performance results for varying quantity of feed for steam bunches

The results of the performance test carried out using different quantities of feed with the machine operating at a different speed for steam bunches are presented below:

Table 3.4: Performance results for varying quantity of feed at speed 550rpm for steam bunches

Q (kg)	T _s (min)	W _u (kg)	W _d (kg)	W _{ufs} (kg)	W _b (kg)	W _{fs} (kg)	S _c (kg/hr)	S _e (%)	P _{df} (%)
5	4	0.8	0.2	0.1	3.9	1	75	90.9	20
10	8	3.4	0	0	6.6	3.4	75	100.0	0
15	10	2.9	0.6	0.4	11.1	3.5	90	89.7	17.2

Table 3.5: Performance results for varying quantity of feed at speed 730rpm for steam bunches

Q (kg)	T _s (min)	W _u (kg)	W _d (kg)	W _{ufs} (kg)	W _b (kg)	W _{fs} (kg)	S _c (kg/hr)	S _e (%)	P _{df} (%)
5	3	0.7	0.2	0.1	4	0.9	100	90.0	22.3
10	5	3.2	0.3	0.3	6.2	3.5	120	92.1	8.6
15	8	3	0.4	0	11.6	3.4	113	100.0	11.8

Table 3.6: Performance results for varying quantity of feed at speed 1095rpm for steam bunches

Q (kg)	T _s (min)	W _u (kg)	W _d (kg)	W _{ufs} (kg)	W _b (kg)	W _{fs} (kg)	S _c (kg/hr)	S _e (%)	P _{df} (%)
5	2	0.8	0.1	0.2	3.9	0.9	150	81.8	11.2
10	4	2.7	0.3	0.1	6.9	3	150	96.8	10
15	7	3.1	0.4	0.3	11.2	3.5	120	92.1	11.5

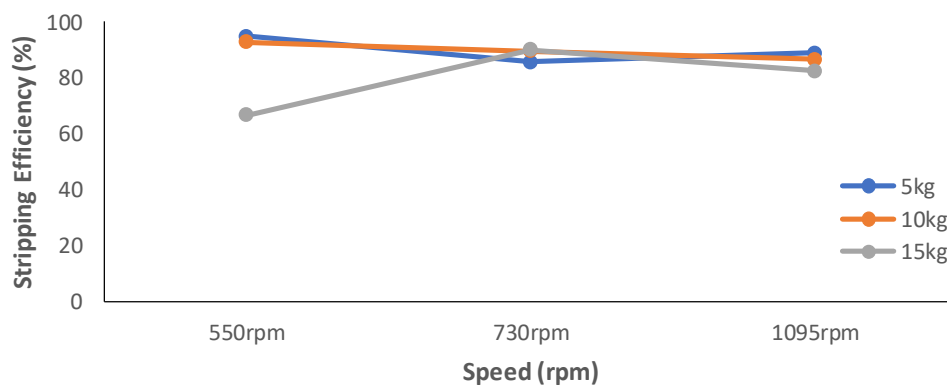


Fig 3.1: Graph showing effects of speed on stripping efficiency for unsteamed

From fig 3.1 above, the highest stripping efficiency was obtained when the machine is working at a speed of 550rpm at the 5kg quantity of feed.

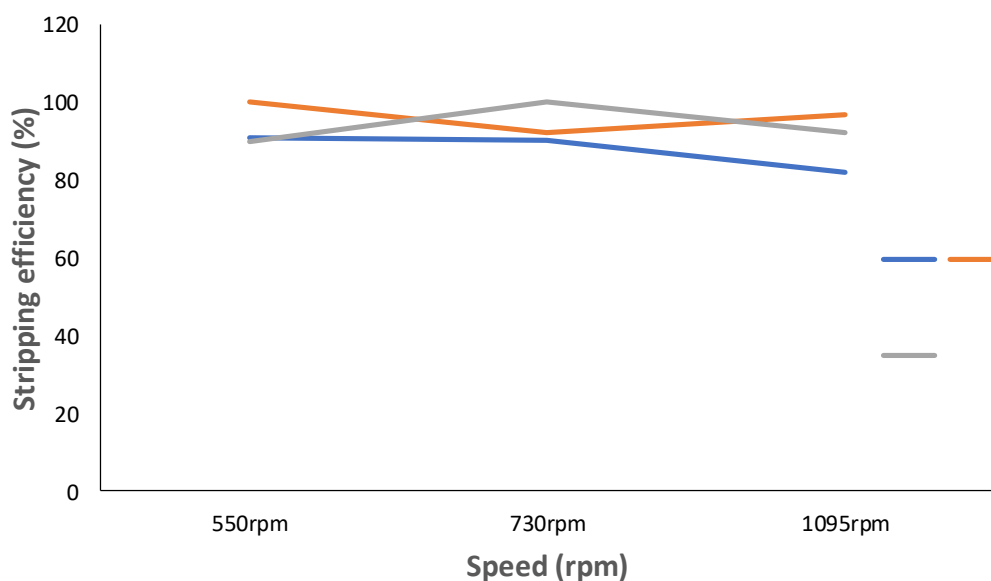


Fig 3.2: Graph showing effect of speed on stripping efficiency for steam bunches

From fig 3.2 above, the optimum stripping efficiency was obtained when the machine was working at the speed of 730rpm for the 15kg quantity of feed.

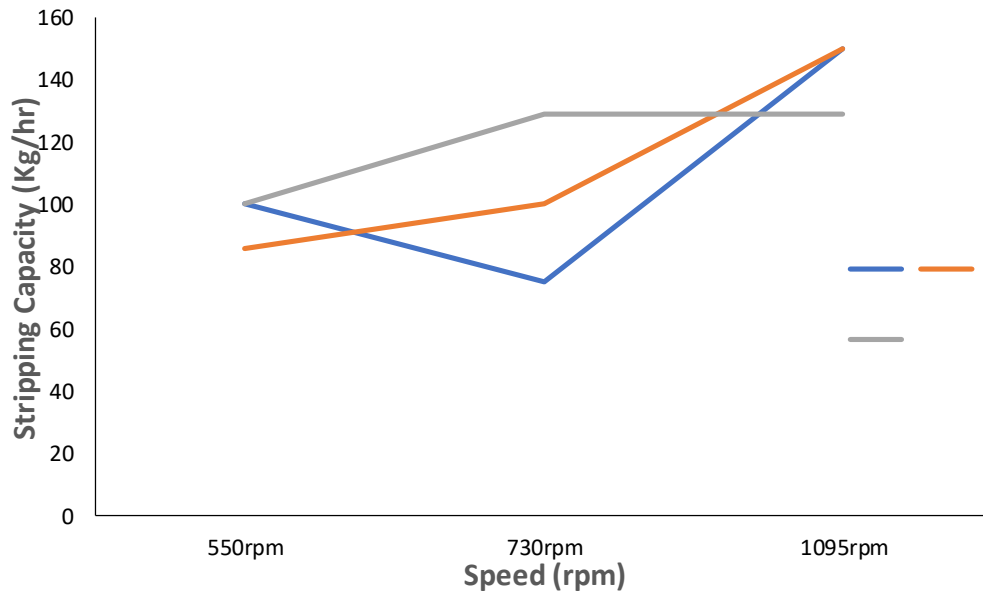


Fig. 3.3: Graph showing effect of speed on stripping capacity for unsteam bunches

From fig 3.3 above, the highest stripping capacity was obtained at speed 1095rpm which increase with decreasing quantity of feed.

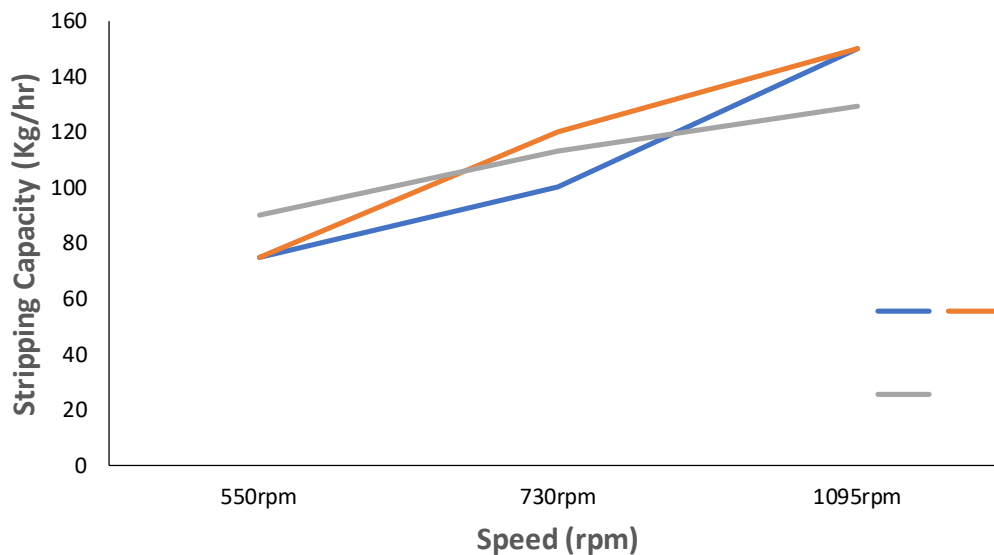


Fig. 3.4: Graph showing effect of speed on stripping capacity for steam bunches

From fig 3.4 above, the highest stripping capacity was obtained when the machine was operating at speed 1095rpm which increases with a decrease in the quantity of feed.

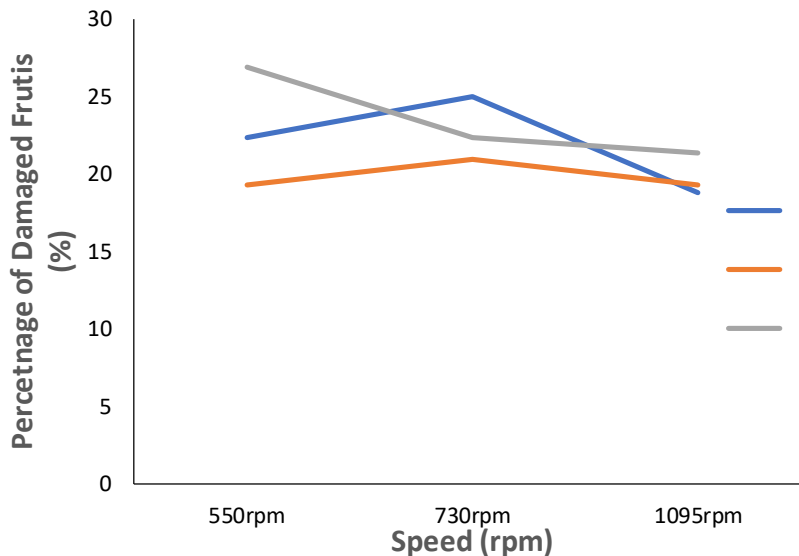


Fig 3.5: Graph showing effects of speed on percentage of damaged fruit for unsteam bunches

From fig 3.5 above, the machine produces the lowest percentage of damaged fruit when it is operating at a speed of 1095rpm with the 5kg quantity of feed.

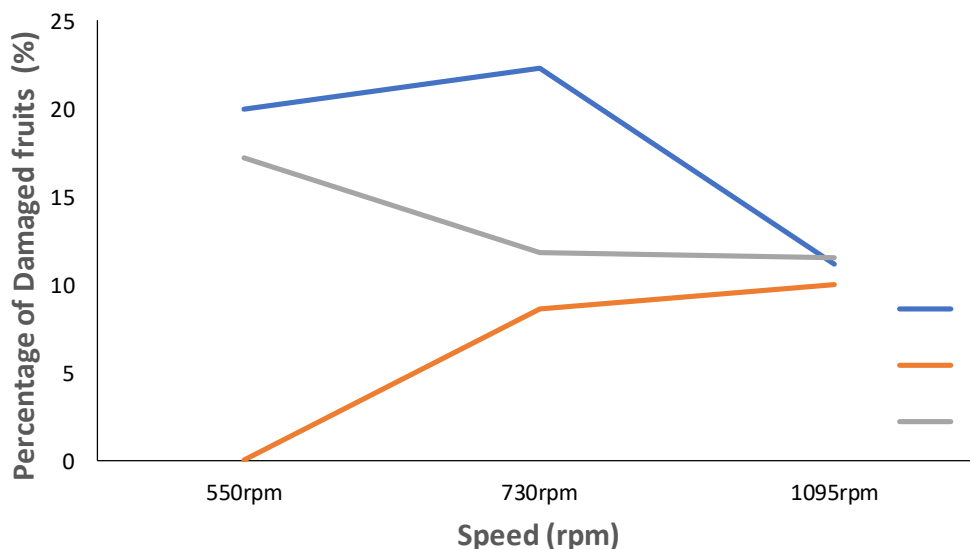


Fig 3.6: Graph showing effect of speed on percentage of damaged fruits for steam bunches

From fig 3.6 above, the machine produces the lowest percentage of damaged fruits when it is operating at a speed of 550rpm with the 10kg quantity of feed.

IV. CONCLUSION

An existing palm fruit debuncher was modified and performance data was determined. Based on the performance test results, it was observed that machine speed statistically affected the performance parameters of the machine at a 5% level of significance. The machine gave its best performance of stripping efficiency of 94.7% when operating at 550rpm for unsteambunches and stripping efficiency of 100% when operating at 730rpm for steam bunches. Optimum stripping capacity of 150kg/hr was obtained at 1095rpm for both steam and unsteam bunches. The

machine produced the lowest percentage of damaged fruits of the performance of 18.8% at 1095rpm for unsteam bunches while the lowest percentage of damaged fruits was produced for steam bunches was 0% at 550rpm.

Therefore, by using the optimum results for machine performance, this machine can help solve the problems and difficulties involved in palm fruit bunch stripping for small and medium-scale farmers.

REFERENCES

- [1] I. O. Elijah, C. I. Sylvester, A. E. Dorcas, and I. E. Cletus, "Small-Scale Palm Oil Processing Business in Nigeria; A Feasibility Study," *Greener J. Bus. Manag. Stud.*, vol. 4, no. 3, pp. 070–082, 2014, doi: 10.15580/gjbms.2014.3.012714071.
- [2] A. K. Aremu and O. A. Alade, "Development of a Palm Fruit Bunch Chopper and Spikelet Stripper," *Int. J. Eng. ...*, vol. 6, no. 2, pp. 47–53, 2017, [Online]. Available: https://www.researchgate.net/profile/Ademola_Aremu/publication/316547751_Development_of_a_Palm_Fruit_Bunch_Chopper_and_Spikelet_Stripper/links/59032cbfa6fdccd580cf66ba/Development-of-a-Palm-Fruit-Bunch-Chopper-and-Spikelet-Stripper.pdf.
- [3] H. U. Nwalieji and H. U. Ojike, "Characteristics of small-scale palm oil production enterprise in Anambra State," *J. Agric. Ext.*, vol. 22, no. 1, pp. 22–34, 2018, doi: 10.4314/jae.v22i1.3.
- [4] T. B. Onifade *et al.*, "Modification of a Locally Made Palm Fruit (*Elaeis Guineensis*) Stripping Machine," *Innov. Syst. Des. Eng.*, vol. 7, no. 4, pp. 29–38, 2016.
- [5] F. U. Asoiro, "Development of Motorized Oil Palm Fruit Rotary Digester," vol. 32, no. 3, pp. 455–462, 2013.
- [6] M. Oshiobugie, E. V. Atumah, A. Nnabuiife, G. O. Ariavie, and E. G. Sadjere, "Design of a Palm Bunch Stripping Machine Suitable for use in Benin City , Edo State , Nigeria," vol. 7, no. 5, pp. 413–417, 2017.
- [7] M. A. Dandan, W. M. Aiman Wan Yahaya, S. Samion, and M. N. Musa, "A comprehensive review on palm oil and the challenges using vegetable oil as lubricant base-stock," *J. Adv. Res. Fluid Mech. Therm. Sci.*, vol. 52, no. 2, pp. 182–197, 2018.
- [8] G. A. Badmus, O. K. Owolarafe, A. S. Osunleke, S. O. Ajadi, and O. A. Ajayi, "Mathematical modelling of digester-screw press process for expression of oil from oil palm fruit," *Ife J. Sci.*, vol. 21, no. 3, p. 193, 2020, doi: 10.4314/ijjs.v21i3.16.
- [9] R. Ghazali, M. Yusof, and S. Ahmad, "Non-Food Applications of Palm-Based Products – Market Opportunities and Environmental Benefits," *Palm Oil Dev.*, vol. 44, no. February, pp. 8–14, 1999.



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