Design, Fabrication and Evaluation of Palm Nut-Pulp Separator

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Abstract
A palm nut-pulp separator consisting of a cake breaker, auger separator, hopper, 3HP electric motor, nut and pulp discharging chutes was designed, fabricated and evaluated. The results of its performance test indicated 90.05% and 419.92kg/h as the efficiency and throughput of the separator respectively. The results of the comparative analysis of introducing this machine in semi-mechanized small scale palm fruit processing showed significant differences in the amount of palm oil extracted and palm oil loss to pressed fibre in the existing semi-mechanized methods and this new technique. Also the results indicated no significant difference (at α = 0.05) in the oil loss to palm nuts between the two processes irrespective of the type of fruit processed. The average quantity of palm oil extracted is greater while oil loss to fibre is low when the mechanized process with palm nut-pulp separation was used and also this new technique eliminated nut breakage and second pressing operation. All materials used for fabrication were sourced locally, and the estimated cost of producing this machine is one hundred and twenty seven thousand, one hundred and sixty naira (N127,160.00).

Keywords: pressing, screw press, nut breakage, palm oil loss, nut-pulp separation, separator

INTRODUCTION
The two main parts of an oil palm fruit are the pericarp (pulp) and nut. The fruit pulp from which the palm oil is extracted surrounds the nut, whose shell encloses the seed (palm kernel) from which another oil, the palm kernel oil is obtained (Hartley, 1988; Purseglove, 1995). Although, the three main varieties of the oil palm (Elaeis guineensis) distinguished by their fruits characteristics are dura, pisifera and tenera, successful processing of the fruits into these important oils is only possible with dura and tenera fruits due to shellless nature of pisifera (NIFOR, 1975; Hartley, 1988).

Extraction of palm oil and kernel from this fruits is practiced using two major variant methods, the traditional and mechanical methods. The traditional technique is the oldest method used before the advent of machinery and it is still used by rural dwellers for palm fruit processing (FAO, 2005). FAO (2005) further wrote that all machines and equipment used for palm oil and kernel extraction were developed from the observation of the traditional process. However, the sequence of units operation involved in the traditional processing of oil palm fruits into palm oil and kernel differs from that of the mechanical method; while the native technique separates digested palm fruits mash into palm nuts and pulp before hand squeezing (pressing) of the pulp for palm oil extraction, the digested mash is pressed without nut-pulp separation in the mechanized techniques (Kenneth and Kriemhild, 2000; Nwankwojike et al, 2011). Thus, existing experimental records such as Muthurajah (2002), FAO (2005) and Norilia (2008) indicated that the mechanized process is facing with the problem of nut breakage during pressing and undesired loss of palm oil to pressed fibre (due to attempts to reduce the nut breakage) especially when pressing is used for palm oil extraction.

The merits of pressing as the means of palm oil extraction in modern factories have been acknowledged (Muthurajah, 2002; FAO, 2005). According to Norilia (2008), broken nuts is usually as high as 10% and 15% with 9% and 10% oil loss to pressed fibre when screw press and auto-hydraulic press were used for palm oil extraction respectively. Muthurajah (2002), indicated 9 to 22% nut breakage depending on the type of fruit being processed with 8% oil content in the pressed fibre while an average oil loss to fibre of 10.7% with a screw press was recorded by Stephen and Emmanuel (2009). Also FAO (2005), indicated that in a small scale mechanized process where the breakage was not checked, 2-3% palm oil content of the pressed fibre was achieved but this has negative effects on the
bleachability and oxidation conservation of the extracted palm oil. Based on the experimental records of Muthurajah (2002), Nwankwojike et al (2011), reasoned that the quality of the palm oil extracted in this process was affected due to some small kernels crushed during pressing released their palm kernel oil into the palm oil. Muthurajah (2002), revealed that as pressing pressure increases during pressing of digested palm fruit mash, the nuts break and its crushed pieces fill the empty spaces created between the nuts as the palm oil is been expelled out of the cake to permit reasonable deoiling of the pressed fibre.

Production of high quality palm oil and kernel and effective recovery of these products (0% loss) during their extraction from oil palm fruits are the primary objectives of mechanizing oil palm fruits processing, apart from reducing tedium and drudgery. Also it is only the fruit pulp that contains the palm oil extracted during pressing. For this reason some operators of small scale processing equipment imitates the local method by sorting the palm nuts out from the digested pulp manually immediately after mechanical digestion before pressing of the pulp. The manual separation of digested palm fruit cake into pulp and nuts after mechanical digestion is in practice among some small scale palm fruit processors in rural communities of Nigeria, Ghana and other West African nations (FAO, 2005). Although, this measure eliminate practically all nut breakage associated with pressing and improves de-oiling of pressed fibre as desired, the practice yields palm oil of high FFA due to undesired delay in this manual process which exposes the digested palm fruit mash to microbial attack (Akor, 1977). But according to Akor (1977) and RMRDC (2004), neither companies nor individuals desire palm oil with high FFA. Thus, to reduce time, undesired exposure of the digested palm fruit cake and drudgery involved in this palm nut-pulp separation process.

Nwankwojike et al (2011) proposed for units operation sequence modification in the mechanized palm fruits processing to include palm nut-pulp separating machine between the digester and press as shown in Figure 1. Since this proposed units operation sequence modification is in accord with Akor (1977) which called for modification in some palm fruit processing machines produced by Stork Armsterdam and other foreign companies to suit our conditions as we know them, this work aimed to develop and evaluate a palm nut-pulp separating machine.

**MATERIALS AND METHODS**

**Design Considerations**

The palm nut-pulp separating machine was designed and developed based on the following considerations:

i. The availability of materials locally to reduce cost of production and also materials were selected for the various components of this machine based on the type of force that will be acting on them, the work they are expected to perform and the environmental condition in which they will function.

ii. The fibrous oil rich digested pulp can pass through narrow slits (dimension<3mm) but palm nuts cannot, and also that the cake from the digestion process is fairly compacted which must be thoroughly slacked before effective separation of the pulp and nuts will be possible.

iii. It is desired that the nuts and their kernels should not sustain injury during cake breaking, therefore the internal walls of the machine were lined with score pads.

iv. The hopper is a wide open type and it’s inclined at an angle greater than the angle of repose of the digested mash (46.01°) with steel by more than 10° for effective loading and fall of the mash into the machine by gravity.

v. The discharging chute was also inclined at angle an angle greater than the angle of repose of the digested pulp (47.91°) with steel by more than 10° for effective discharge.

![Figure 1: Flow diagram of palm oil and kernel extraction by the proposed mechanized method with a palm nut-pulp separation step.](image-url)
Description of the Palm Nut-Pulp Separator

The major components of the palm nut-pulp separating machine are the frame, hopper, cake breaking unit, separating unit, electric motor, palm nut and pulp discharging chutes (Figure 2). The frame, made from 2.5mm thick angle iron is the main supporting structure upon which other components of this machine were mounted. The feed hopper, through which the digested palm fruit mash is fed to the machine is a rectangular frustum made from mild steel sheet of 3mm thickness with a top opening of 1000mm x 500mm and a height of 500mm. The hopper slants with an inclination of 60° from the left end of the separator into the upper chamber through a 300mm square aperture at right hand side of the top cover for easy flow of the digested mash into the upper chamber of the machine.

Figure 2: Isometric view of the palm nut-pulp separator with identified part

The cake breaking and separating units are housed in the upper chamber and lower chamber of the separator respectively. The cake breaking unit consists of a 30mm diameter mild steel shaft of length 1430mm, cake breaker membrane of 1290mm in length made of 85mm diameter mild steel pipe and fifty-six pieces of 16 mm diameter mild steel rods (beaters) with a length of 40mm each. The beaters were welded vertically to the membrane in four rows at spacing of 86mm from one another. The space between the rows is 66.77mm. The rotary motion of beaters slackens the fairly compacted digested palm fruit mash as it falls from the hopper through it into the right end of the lower chamber, thereby detaching the entangled palm nuts from the pulp for effective separation. The internal walls of the machine were lined with score pad to ensure that the nuts neither break nor sustain internal injury as they hit the walls during cake breaking.

The actual separation of the slacked mash from the upper chamber takes place in the separating unit at the lower chamber. The separating unit consists of a pair of adjustable blade, a shaft of 1530mm length made from a 30mm mild steel rod and an auger membrane of length 1290mm made from a 85mm diameter mild steel pipe upon which a metal of 2mm thickness was scrolled and welded (given an auger flight of 4.2mm with the weld) in a spiral form with a pitch of 129mm. The lower chamber was constructed with an adjustable narrow slit at the bottom which extends through its length from right to left. The slit is 2.5mm wide from the right to a length of 1000mm and 50mm wide from this point to the remaining part of the chamber. The 2.5mm opening allows the pulp only to be discharged through it while the nuts carried to the end discharges through the 50mm-slit as the auger conveys the loosened cake from right to the left hand side of the chamber. The discharge chute, made from a mild steel sheet of 3mm thickness was folded below and across the whole length of the lower chamber with a width of 45mm and a declination of 60° projection for effective discharging of the separated pulp and nuts. The chute was demarcated into two along its length according to 2.5mm and 50mm slits forming the pulp and palm nut discharging chutes respectively.

Design Analysis

Volume and Weight Capacity: The effective volume, V of this separator that can be occupied by the digested palm fruit mash depends on the part of
...machine was determined as 0.0375m using following relation:

\[ V_f = 0.75 \left[ \frac{lw}{3} - \left( \frac{\pi r_m^2 l_m + n \pi r_b^2 l_b}{2} \right) \right] \]

where \( n \) is the total number of the beaters. The weight capacity of the separator was estimated as 390.21N using density, mass and volume relationship given as:

\[ W_m = V_m \rho_m g \]

where: \( \rho_m \) = Bulk density of digested palm fruit cake, 1060 kg/m³ (Muthurajah, 2002)  
\( g \) = Acceleration due to gravity, 9.81m/s²

**Selection of pulleys and belts:** The machine requires four pulleys for its drives, one mounted on the electric motor shaft, one each at both ends of the auger shaft and the remaining one mounted at left end of the cake breaker shaft. Due to its availability, cost and performance; cast iron pulleys were selected. The diameters of the selected driving and driven pulleys for the motor/auger drive are 100mm and 200mm respectively while those of the auger/cake breaker drive are respectively 100mm. The centre distances, \( C \) between the adjacent pulleys were determined using Equation 3 as 250mm and 200mm for the motor/auger and auger/cake breaker drives respectively (Sharma and Aggarwal, 2006)

\[ C = \frac{D_1 + D_2}{2} + D_1 \]

Where \( D_1 \) and \( D_2 \) are diameters of driving and driven pulleys. The lengths of the V-belts required were initially computed as 981mm and 714mm for the motor/auger and auger/cake breaker drives respectively using Equation 4:

\[ L = 2C + 1.57(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4C} \]

Since each of the drives transmits less than 3.5kW, V-belt of type “A” is required for both drives (Khurmi and Gupta, 2005; Sharma and Aggarwal, 2006). Based on IS: 2494-1974 standards, 1026 mm and 747mm standard pitch length V-belts were selected for the motor/auger and auger/cake breaker drives respectively. Consequently, Equation 4 was further used to determine the exact centre distances between the adjacent pulleys as 255.01mm and 198.50mm for the motor/auger and auger/cake breaker drives respectively.

**Determination of shaft diameters:** The diameters, \( d \) of the auger shaft and cake breaker shaft of this machine were determined using maximum stress relations given as:

\[ d = \left[ \frac{16}{\pi \tau} \left( \sqrt{(K_b M_b)^2 + (K_t M_t)^2} \right) \right]^{1/3} \]

where:
\( \tau = \) Allowable stress for steel shaft with provision for key ways = 42N/mm²  
\( M_b = \) Maximum bending moment on the shafts, N-mm  
\( M_t = \) Maximum twisting moment on the shafts, N-mm  
\( k_b = \) Combined shock and fatigue factor for bending  
\( k_t = \) Combined shock and fatigue factor for twisting.

Bending and twisting moments occur on shafts as a result of applied loads and belt tensions. The maximum twisting moment on each of the shafts was determined using the relationship given by Khurmi and Gupta (2005), as:

\[ M_t = \left( T_i - T_c \right) \frac{D_2}{2} \]

The bending moments (B.M.) on each of the shafts were determined using the standard procedures as follows;  
The belts tight side tension, \( T_i \) was determined as 163.79N and 168.52N for the motor/auger and auger/cake breaker drives respectively using the following equations given by Khurmi and Gupta (2005), as:

\[ T_i = T_{max} - T_c \]

\[ T_{max} = ca \]

\[ T_c = m v^2 \]

Where \( T_c \) and \( T_{max} \) are the centrifugal and maximum tension of the belts. The coefficient of friction, \( \mu \) between the pulleys and the belts, mass per unit length, \( m \) maximum safe stress, \( \sigma \) and cross sectional area, \( a \) of the belts were obtained from standard tables as 0.3, 0.108kg/m², 2.1N/mm² and 81mm² respectively (IS: 2494-1974-Khurmi and Gupta, 2005; Sharma and Aggarwal, 2006). The belt speeds, \( v \) for the motor/auger and auger/cake breaker drives were computed as 7.64m/s and 3.82m/s respectively from the following relations

\[ v = \frac{N_1 \pi D_2}{60} \]
\[
\frac{N_1}{N_2} = \frac{D_2}{D_1}
\]

Where the speeds of the primary (electric motor) driver pulley, \( N_1 = 1460 \text{rpm} \)
\( N_2 \) = the speed of driven pulleys

Consequently, the tension on slack side of each belt, \( T_j \) was determined using Equation 12 as 13.08N and 9.29N for the motor/auger and auger/cake breaker drives respectively.

\[
2.3 \log \frac{T_j}{D_j} = \mu \theta \cos ec \beta
\]

The groove angle \( (2\beta) \) of each of the pulleys is 38° (thus, \( \beta = 19° \)) while the angles of lap, \( \theta \) were determined as 2.74rad. and 3.14rad. for the motor/auger and the auger/cake breaker drives using Equation 13 given by Khurmi and Gupta (2005) as;

\[
\theta = 180 - 2 \left[ \sin^{-1} \left( \frac{D_2 - D_1}{2C} \right) \right]
\]

The applied loads and belt tensions on the cake breaker shaft are shown in Figure 3.

**Figure 3:** The cake breaker shaft showing forces acting on it

- \( W_c \) is the weight of the cake breaker = 29.43N
- \( W_{cp} \) is the weight of the auger/cake breaker shafts driven pulley = 16.73N.
- \( T_1 \) is the auger/cake breaker drive belts tight side tension = 168.52N.
- \( T_2 \) is the auger/cake breaker drive belts slack side tension = 9.29N.

The reactions, \( R_A \) and \( R_C \) were determined by taking moment about \( A \):

\[
\sum M_A = 0:
\]

\[
R_c (1290) = 194.54 (1430) + 419.64 (645)
\]

\[
\therefore R_C = 425.47N
\]

Also \( \sum F_y = 0 \):

\[
419.64 + 194.54 = 425.47 + R_A
\]

\[
\therefore R_A = 188.71N
\]

Thus, the bending moments on this shaft were computed using Figure 3 as follows:

- \( B.M. \) at \( A \) and \( D = 0\text{N-mm} \)
- \( B.M. \) at \( B = 121714.25\text{N-mm} \)
- \( B.M. \) at \( C = 27235.60\text{N-mm} \)

Thus, the maximum bending moment on the cake breaker shaft is 121714.25N-mm. Since feeding of the fairly compacted digested palm fruit cake from hopper into the upper chamber of the machine is partially sudden, \( K_h = 1.5 \) and \( K_c = 1.5 \). The maximum twisting moments on this shaft was also computed from Equation 6 as 7961.50N-mm. Thus, the shaft diameter was calculated as 28.31mm using Equation 5. Hence, a standard 30mm diameter solid shaft was selected for the operation of the cake breaking unit.

The auger shaft and the forces acting on it, is as shown in Figure 4.

**Figure 4:** The auger shaft showing forces acting on it

Where:

- \( W_a \) is the auger weight = 20.52N
- \( W_{ap} \) is weight of the motor/auger shafts driven pulley = 17.13N
- \( W_{cp} \) is the weight of the auger/cake breaker shafts driving pulley = 16.73N.
- \( T_3 \) is the auger/cake breaker belts tight side tension = 163.79N
- \( T_4 \) is the auger/cake breaker belts tight side tension = 13.08N.

The reactions of the bearings, \( R_B \) and \( R_D \) were determined by taking moment about \( B \):

\[
\sum M_B = 0:
\]

\[
161.81(1430) + R_B(1290) + 194(150) = 410.73(645)
\]

\[
\therefore R_D = 4.25N
\]

Also \( \sum F_y = 0 \):

\[
410.73 + 194 = 161.08 + 4.25 + R_B
\]

\[
\therefore R_B = 439.40N
\]

Thus, the resultant bending moments on this shaft are as follows:

- \( B.M. \) at \( A \) and \( E = 0\text{N-mm} \)
- \( B.M. \) at \( B = 29094\text{N-mm} \)
- \( B.M. \) at \( C = 129189.05\text{N-mm} \)
- \( B.M. \) at \( D = 22551.20\text{N-mm} \)

Therefore, the maximum bending moment on the auger shaft is 129189.05N-mm. The maximum twisting moment this shaft was also determined from
Equation 6 as 15071N-mm. Since the feeding of the slacked digested palm fruit cake fro into the auger separator is gradual and steady, $K_r = 1.5$, $K_s = 1.0$ (Khurmi and Gupta, 2005) and also the shaft diameter determined using Equation 5 is 28.71mm. Consequently, a standard 30mm diameter solid shaft was selected as auger shaft.

**Selection of Prime Move (Electric Motor):** The power required for the operation of this machine is the total sum of the power required to drive its units and the power required to overcome the drives friction. The power, $P$ required in the cake breaking and separating units were determined as 0.61kW and 1.15kW respectively using Equation 14.

$$P = (T_i - T_f)\omega$$

Taking care of 10% possible power loss due to friction, the total power required to drive the developed palm nut-pulp separating machine was computed as 1.94kW (2.60HP). Therefore a 3HP electric motor was selected for the operation of this machine.

**EXPERIMENTAL PROCEDURE**

The developed separator was evaluated using two different sets of experimental design. Dura and tenera fruits used were procured from Onyeije Oil Palm Plantation, Amawom in Ikwuano, and Abia State Small Holders Oil Palm Management Unit at Akoli-Imenyi, all in Abia State of Nigeria. In the first experimental plan, the throughput, $TP$ (kg/h) and efficiency, $\eta$ (%) of the machine were studied using six experimental runs. Dura fruits were used in the first three trials while the last three involved tenera fruits. In each of the trials, a stop watch was used to monitor the time of separating 20kg of mechanically digested palm fruit mash using the developed separator, after which the outputs (separated pulp and nuts) were weighed and recorded as per each run. Thereafter, the throughput, $TP$ (kg/h) and efficiency, $\eta$ (%) of the machine were determined from the data obtained using the following relations;

$$TP \ (kg/h) = \frac{m_o}{t}$$  

$$\eta \ (%) = \frac{m_o \times 100}{m_1}$$

where: $m_o$ = Total mass of the pulp and nuts separated (kg)  
$m_1$ = Mass of digested palm fruit cake input (kg)  
$t$ = Time taken for the separation (s)

A completely randomized design involving thirty batches of tests was used in the second experimental plan which involves comparative evaluation between the existing mechanized palm fruit processing method and the mechanized palm fruit processing with the palm nut-pulp separator. Dura fruits were used in the first fifteen trials while tenera fruits were used for the second fifteen runs. A freshly prepared 40kg of digested palm fruit mash from the same source was used in each batch of the tests. Each test involved dividing the digested fruit mash into two immediately after mechanical digestion using a horizontal digester, whilst one part (20kg) of the mash was separated into pulp and nuts using the palm nut-pulp separator before pressing of the separated pulp for palm oil extraction the remaining mash was pressed to extract palm oil without undergoing nut-pulp separation process. This is to ensure that fruits processed in the two methods as per each batch of the trails were of the same quality for effective comparison. Pressing was performed for 10minutes in both processes using manual screw press. The palm oil extracted from each of two mechanized processes was then clarified, weighed and recorded.

In addition, oil losses to palm nuts and residual fibre from both processes were also analyzed at Central Laboratory of National Root Crops Research Institute, Umudike, using solvent extraction gravimetric method. Five hundred grammes (500g) of nuts and one hundred grammes (100g) of fibre samples from each test were wrapped separately in whatman No. 1 filter paper. Each wrapped sample was then placed in a soxhlet reflux flask before mounting of the flask on a weighed oil extraction flask containing 250ml of n-hexane solvent. Thereafter, the extraction flask was heated after connecting the upper end of the reflux flask to a condenser, thus the solvent vaporized and condensed into the reflux flask to soak the wrapped sample until the flask was filled up and siphoned over, thereby carrying the extracted (refluxed) oil down into a boiling flask. Cycle of vapourization, condensation, extraction and siphon were repeated for fourteen times in each case before removing the defatted sample carefully with a pair of forceps as the solvent condensed back into the reflux flask while leaving the oil extract in the boiling flask. The boiling flask with its content was then placed in an oven at 900 for 30minutes, cooled in a dessicator and reweighed. The weight of oil loss to the nuts and fibre samples, $W_o$ analyzed was computed from the difference between the weight of the flask and the oil extract, $W_2$ and that of the empty flask, $W_1$ (= 21.44g) as expressed in equation 17.

$$W_o = W_2 - W_1$$

Data obtained were comparatively analyzed using Analysis of Variance (ANOVA) and Turkeys test methods.

**RESULTS AND DISCUSSION**

The results of the performance test (Table 1) show that the machine performed above 90% efficiency as expected. The results also indicated 419.92kg/h as the average throughput of the developed separator and that were no significant differences (at $\alpha = 0.05$) in
the efficiency and throughput of this machine when dura and tenera were processed.

Table 1: Results of Performance Test of the Palm Nut-Pulp Separator

<table>
<thead>
<tr>
<th>S/NO.</th>
<th>Mass of separated nut output (kg)</th>
<th>Mass separated pulp output (kg)</th>
<th>Total output, (m_s), (kg)</th>
<th>Time taken (t) (s)</th>
<th>Efficiency, (\eta) (%)</th>
<th>Throughput, (TP) (kg/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.96</td>
<td>10.14</td>
<td>18.10</td>
<td>156.00</td>
<td>90.05</td>
<td>417.69</td>
</tr>
<tr>
<td>2</td>
<td>8.00</td>
<td>10.09</td>
<td>18.09</td>
<td>155.00</td>
<td>90.05</td>
<td>420.15</td>
</tr>
<tr>
<td>3</td>
<td>8.74</td>
<td>9.36</td>
<td>18.10</td>
<td>155.20</td>
<td>90.05</td>
<td>419.85</td>
</tr>
<tr>
<td>4</td>
<td>4.57</td>
<td>13.55</td>
<td>18.12</td>
<td>155.00</td>
<td>90.06</td>
<td>420.85</td>
</tr>
<tr>
<td>5</td>
<td>4.35</td>
<td>13.77</td>
<td>18.12</td>
<td>155.10</td>
<td>90.06</td>
<td>420.58</td>
</tr>
<tr>
<td>6</td>
<td>5.00</td>
<td>13.10</td>
<td>18.10</td>
<td>155.00</td>
<td>90.05</td>
<td>420.38</td>
</tr>
<tr>
<td>Average</td>
<td>6.44</td>
<td>11.65</td>
<td>18.09</td>
<td>156.00</td>
<td>90.05</td>
<td>419.92</td>
</tr>
</tbody>
</table>

The results of the comparative evaluation of the introduction of the palm nut-pulp separating machine in the semi-mechanized small scale palm fruit processing is shown in Table 2. The analysis of variance results of this data (Table 2) revealed that the quantities of palm oil extracted and palm oil loss to pressed fibre in the two processes were significantly different (at \(\alpha = 0.05\)). This result also indicated that there were no significant differences (at \(\alpha = 0.05\)) in the average oil loss to nuts between the two mechanized processes irrespective of the type of fruit been processed. It is also obvious from Table 2, that the average quantity of palm oil extracted is greater while oil loss to fibre is low with the mechanized process with palm nut-pulp separation. Table 2 further showed that nut breakage during pressing was observed in the existing semi-mechanized method only. ANOVA results indicated that there were significant differences in the quantity of broken nuts associated between dura and tenera processing.

Therefore the palm nut-pulp separating machine improved palm oil and kernel extraction as well as revenue generation in the sector. It also reduced drudgery and eliminates nut breakage, excessive loss of palm oil to pressed fibre, nut-fibre separation and second pressing operations in mechanized palm fruit processing. Therefore, adoption of this innovation will boost efficient production and recovery of quality palm oil and kernel in Nigeria and other part of the world where palm trees are cultivated because it solved the major problem of nut breakage and excessive loss of palm oil to pressed fibre facing the present day mechanized palm fruit processing. The estimated cost of producing the palm nut-pulp separating machine is one hundred and twenty seven thousand, one hundred and sixty naira (₦127,160.00) and it is easy to operate.

CONCLUSIONS AND RECOMMENDATIONS

Separation of digested palm fruit mash into palm nut and pulp before pressing of the pulp in mechanized palm fruits processing improved palm oil and kernel extraction in both quantity and quality, and also eliminates drudgery, nut breakage, excessive loss of palm oil to pressed fibre, nut-fibre separation and second pressing operations. Thus, the innovation of palm nut-pulp separating machine entails a new guide to the designers/manufactures of palm fruit processing machineries. It is recommended that manufacturers should mass produce this machine to reduce cost of production through the benefit of bulk purchase of its production materials, modify the existing palm oil production mills to incorporate palm nut – pulp separator between the digester and press, and also effect the same in all future mill designs.

ACKNOWLEDGEMENTS

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REFERENCES


Table 2: Comparative Evaluation of the Existing Mechanized Palm Fruit Processing Method and the Proposed Mechanized Palm Fruit Processing with Palm Nut-Pulp Separation Unit Operation

<table>
<thead>
<tr>
<th>S/NO</th>
<th>Existing Mechanized Technique</th>
<th>Proposed Mechanized Technique with palm nut-pulp separation step</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(without the proposed palm nut-pulp separation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Palm oil extracted (kg)</td>
<td>Oil loss to Fibre (g)</td>
</tr>
<tr>
<td></td>
<td>W2</td>
<td>W2- W1</td>
</tr>
<tr>
<td>W1</td>
<td>W1</td>
<td>W1</td>
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