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DEVELOPMENT OF AN IMPROVED NCAM WET COWPEA DEHULLER

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Abstract.

The process of dehulling cowpea is tedious and time consuming. The removal of cotyledon from the hull is commonly done manually. A few machines which operate under the batch process have been developed by some researchers. These machines are found to consume much time and human effort during operation. As a result of this, prompted the need to develop a continuous mechanism for the dehulling process of cowpea. The improved wet cowpea dehuller was developed at the National Centre for Agricultural Mechanization (NCAM), Ilorin. The test performance carried out on the cowpea dehulling machine indicated that the continuous mechanism for dehulling was a success which led to higher output and ease of operation. The highest and lowest dehulling efficiencies obtained for the developed cowpea dehulling machine during testing was 92.11% and 87.86%, respectively. The cleaning efficiency obtained for the developed cowpea dehulling machine was 88.43%; while the average output capacity obtained for the developed cowpea dehulling machine was 66kg/h.

Keywords: *Cowpea seed, dehuller, performance, development*

1. Introduction

Cowpea (*Vigna sinensis unguiculata*) is an important food item in most West African countries especially Nigeria due to its high protein and fat contents.Dehulled cowpea is required in the preparation of some meals such as fried beans cake commonly known as akara and boiled cake commonly known as moimoi. Dehulling refers to the removal of the seed coat (hull) from the seed, resulting in the separation of the cotyledons from the hulls, which is mostly done manually in Nigeria by first soaking the seeds in a bowl of water, slightly pounding the soaked seeds using mortar and pestle or rubbing the soaked seeds between the palms of hands so as to loosen the hull from the seeds and separating the hull from the cotyledon. The pounding with mortar and pestle or rubbing between the hands will depend on the quantity of cowpea seed to be dehulled. Some researchers have developed some machines to facilitate the ease of dehulling cowpea (Babatunde, 1995 and Olowonibi, 1999).

Ologunagba et al. (2013) developed a hydrocyclone for the separation of hulls from the cotyledons of dehulled legume seeds at 10, 20 and 30mm under flow orifice diameters. Test results showed that the separator gave its best work performance at 20mm underflow orifice diameter with separation efficiencies of 67.01, 65.80, 38.63 and 64.92% for common bean, cowpea, locust bean and soybean, respectively. The use of the hydro-cyclone for separation of hulls from cotyledons of dehulled grain legumes was therefore feasible. However, replaceable nozzles and mechanically adjustable orifices were reported necessary for animproved performance.

Olaoye and Olotu (2015) developed a hydro-separating cowpea dehuller which had an isolated separator for separating the dehulled cowpea. The test performance carried out on the dehuller showed that it obtained 95.06% as the highest dehulling efficiency and 70.98% as the lowest dehulling efficiency. The cleaning efficiency of dehuller was 70.21%; the feed rate of the machine was 157.02 kg/h while the output capacity of the machine was calculated to be 18.63 kg/h/batch. Butthe operation was performed in batch process which required much time and human effort to aid the operation.

Kamaldeen et al. (2017) conducted a performance evaluation on a wet cowpea dehulling machine using factorial experiment in a completely randomized design (CRD) involving operational speed, soaking time and cowpea variety each at 3, 3 and 2 levels,respectively. The results indicated that speed, soaking time and cowpea variety had significant effect on dehulling efficiency and output capacity while soaking time and operational speed had significant effect on mechanical damage. Its optimum performance was at 120rpm and11 minutes soaking times.

However, most of the machines earlier developed operate by batch process. As a way to improve the dehulling process of cowpea, this study aims at developing a machine that would dehull cowpea under the continuous process of operating principle.

2.0 Materials and Methods

2.1 Design consideration

In the design of the improved cowpea dehulling machine the following were taken into consideration:-

i. Availability of construction materials: materials of adequate strength and stability sourced locally were used for the fabrication of the dehulling machine.
ii. Cost: low cost materials that give adequate strength and stability were used for the fabrication of the dehulling machine.

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iii. Physical and mechanical properties of cowpea: relevant geometric mean diameter of the cowpea was considered for the design of the dehulling machine.

iv. Basic considerations were given to the design of the size, speed and capacity of the dehulling machine.

2.2 Description and operation of NCAM developed wet cowpea dehuller

The machine as shown in Figs 1,2 and 3 consist of a 2hp electric motor, hopper which is made from 2mm galvanized sheet, a dehulling section which comprises of a shaft which passes through a pipe with series of punches and wounded round by a 10mm pipe rod as the auger, cleaning unit which is made of 2mm galvanized sheet. The wet cowpea is introduced into the hopper, which flows to the dehulling unit consisting of a screw shaft that aids the conveying of the soaked cowpea and simultaneously dehulling the cowpea by the principle of abrasion as it moves along the length of the auger. The screw conveyor discharges dehulled cowpea seeds into the cleaning unit.The cleaning sectionwhich is connected by a gear like teeth to the end of the dehulling section comprises of a decanter which is incorporated with a special rubber brush attached to it cleans and energized the water with the aid of an agitator. Hence this process allowsthe cotyledon which are heavier to settle down the separating chamber while the hulls float out with the flowing water. The hulls are collected by a chaff/water collector. The continuous flow of water from the tank to the separating chambers through the connector makes the operation a continuous operation for dehulling larger quantity of cowpea.

Figure 1.Isometric view of NCAM developed wet cowpea dehuller

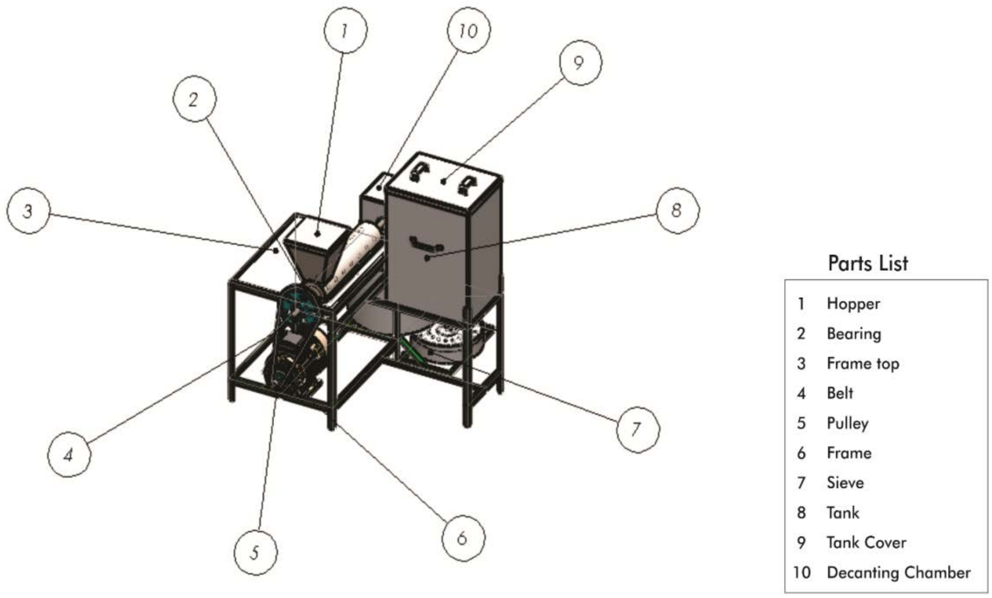

Figure 2; detailed view of the developed NCAM wet cowpea dehuller

2.3 Design calculations

All the various parts and components of the motorized cowpea dehulling machine were designed using various appropriate equations.

1. Hopper design

The volumetric capacity of the hopper was calculated using the expression given as:

$$V\ (m^3) = \frac{M}{\rho} \quad 1$$

where,

M = mass of cowpea (kg)

ρ= bulk density of cowpea (kg/m^3)

The height of the hopper was design using the equation given by Balami et al. (2014) as;**.**

$$V = \frac{1}{3}\left(A_1 + A_2 + \sqrt[2]{A_1 A_2}\right) \times H \quad 2$$

where,

V=volume of the hopper (m^3)

A_1, A_2=areas of top and bottom base of the hopper (m^2)

H=depth of hopper (mm).

2. Dehulling unit

The volumetric capacity of the dehuller was based on the volume occupied by the cowpea seed and the size of the auger to be placed inside the cover. Hence, the volume and the diameter of the auger was calculated using the expression given by Olaoye (2011) as:

$$V=\frac{\pi D^2 L}{4} \quad 3$$

where,

V =volumetric capacity of the auger cover (m^3)

D = diameter of the auger cover (m)

L =length of the auger (m)

3. ***Pulley design***

The diameter of the pulley of the shaft was calculated to be 320 mm using the expression given by Khurmi and Gupta (2005) as:

$$N_1 D_1 = N_2 D_2 \quad 4$$

We have two operating shafts namely; screw conveyor (auger) shaft and agitator shaft which was selected based on the appropriate power requirement for rotation of screw conveyor, the agitator andthe output capacity of a screw conveyor (Olaoye and Olotu,2015).

4. Belt design

The belt speed, v (m/s) and its total belt length, L (m), were calculated using the expression given by Khurmi and Gupta (2005), respectively as:

$$V=\frac{\pi N D}{60} \quad 5$$

V= 5m/s

$$L = \frac{\pi}{2}(D_1 + D_2) + 2C + \frac{(D_1+D_2)^2}{4C} \quad 6$$

$$C = \frac{D_1+D_2}{2} + 0.05 \quad 7$$

5. Torque transmitted by the shaft

The torque transmitted by each shaft was calculated using the equation as:

$$T = \frac{P60}{2\pi N} \quad 8$$

where,

T = the torque transmitted by the shaft (Nm)

P = power required (Kw)

N =the required speed (rev/mins)

6. Shaft design

The combine twisting moments and bending moments were used to determine the shaft diameter by using the expression given by Khurmi and Gupta (2005) as:

$$T_e = ((K_B \times M)^2 + (K_T \times T)^2)^{0.5} = \pi \times S_S \times \frac{d^3}{16} \quad 9$$

where,

T_e = equivalent twisting moment (Nm)

M = resultant bending moment (Nm)

T = Torque transmitted by the gear shaft (Nm),

s = Allowable shear stress with keyway = 45N/mm^2 as given by Khurmi and Gupta (2005)

d = diameter of the shaft in mm

K_B= combined shock and fatigue factor applied to bending moment = 2.0 for minor shock

K_T= combined shock and fatigue factor applied to torsional moment =1.5 for minor shock

2.4 Performance test procedure

A preliminary evaluation was carried out on the NCAM developedwet cowpea dehuller using a 2hp electric motor as the source of power with a recommended optimum speed of 350rpm and a soaking time of 10 minutes (Olotu et al., 2013).Two commonly available cowpea varieties namely; *Yarihausa* and *Oloyin*, were used for the test.

2.5 Performance evaluation parameters

The performance indices used for this experiment were in accordance with the standard test code for groundnut sheller, (NIS, 1997; Babatunde, 1995).

i. **Feed Rate; F_R (kg/h): -** This is the quantity of soaked cowpea seeds that is feed into the dehuller perunit time. It determined the rate at which the soaked cowpea seeds are feed into the auger from the hopper. It is expressed as:

$$F_R = W_1/T_I \quad 10$$

where;

W_1=weight of the input recorded (kg)

T_I= time taking for feeding recorded (mins)

ii. **Dehulling efficiency; D_E (%): -** This indicates the quantity of soaked cowpea seeds that is being dehulled by the machine and it's expressed in percentage. This shows how effective and efficient the machine is in dehulling the sample. It is expressed as:

$D_E = W_D / W_S$ (%) 11

Where;

$W_{D=}$ weight of the dehulled cowpea (kg)

$W_{S=}$ weight of both the dehulled and undehulled cowpea (kg)

iii. **Cleaning Efficiency; C_E (%):-** This indicates the quantity of hull (chaff) that is being removed from the dehulled seeds insidethe separating chamber, it is expressed in percentage. It determines how efficient the machine is able to remove hull from thecotyledon. Its expressed as:

$C_E = W_{SH} / W_{RS}$ (%) 12

Where;

$W_{SH=}$ weight of the hull inside the collector (kg)

$W_{RS=}$ weight of hull remaining the cleaning chamber (kg).

iv. **Output capacity Oc (kg/hr):-** This is the quantity of dehulled cowpea seeds per unit time of operation. Its expressed as:

$O_C = W_2 / T_2$ 13

Where;

$W_{2=}$ weight of the output (kg) and

$T_{2=}$ time taking for the operation (minutes)

Figure 3.NCAM developed wet cowpea dehuller and the incorporated brush for separation cleaning of the dehulled cowpea.

3. Results and Discussion

Tables 1 and 2 shows the results of the preliminary evaluation that was carried out on NCAM developed wet cowpea dehuller as shown in fig 3 and fig 4, using two varieties of cowpea, namely Oloyin and Yarihausa, showed that the machine effectively and efficiently delivered desirable and favorable results

The test was run on three replicate to ascertain a clearer outcome. The average values gotten from the operations for the dehulling efficiency, cleaning efficiency and the output capacity using oloyin cowpea on three replicates for 1.00kg were 89.87%, 85.18% and 63.38kg/hr respectively and for 2.00kg were 90.60%, 86.80% and 65.35kg/hr respectively. Also The average values gotten from the operations for the dehulling efficiency, cleaning efficiency and the output capacity using yari hausa cowpea on three replicates for 1.00kg were 90.77%, 86.08% and 64.08kg/hr respectively and for 2.00kg were 90.58%, 86.14% and 63.78kg/hr respectively.

From the overall test results the highest dehulling efficiency obtained was 92.11%, while 87.86% was the lowest dehulling efficiency obtained for the machine using both varieties of cowpea at three replicates each Also, the results indicated that the cleaning efficiency of dehuller ranged averagely from 85% to 88%. The output capacity of the machine was calculated to be between the average ranges of 58 kg/h to 66kg/h. These results as compared to Kamaldeen (2017), Ologungba (2013) and Olotu (2015) showed that the dehuller showed a much higher range of dehulling and cleaning efficiency alongside its output capacity and was capable of effectively dehulling the cowpea seeds and separating the hull from the cotyledon efficiently.

Table 1. Test Results using Oloyin Cowpea Variety

Replicates	Initial weight of cowpea (kg)	Dehulling Efficiency (%)	Cleaning efficiency (%)	Output capacity (kg/h)
1	1.00	90.45	85.04	63.34
2	1.00	87.86	84.32	61.61
3	1.00	91.30	86.20	65.21
1	2.00	92.11	85.44	65.32
2	2.00	90.23	88.43	66.54
3	2.00	89.52	86.55	64.21

Table 2. Test Results using Yarihausa Cowpea Variety

Replicates	Initial weight of cowpea (kg)	Dehulling Efficiency (%)	Cleaning efficiency (%)	Output capacity (kg/h)
1	1.00	91.40	85.85	60.11
2	1.00	90.06	85.30	58.32
3	1.00	90.33	87.10	63.81
1	2.00	91.21	86.40	64.91
2	2.00	89.30	86.87	62.43
3	2.00	91.25	85.15	64.00

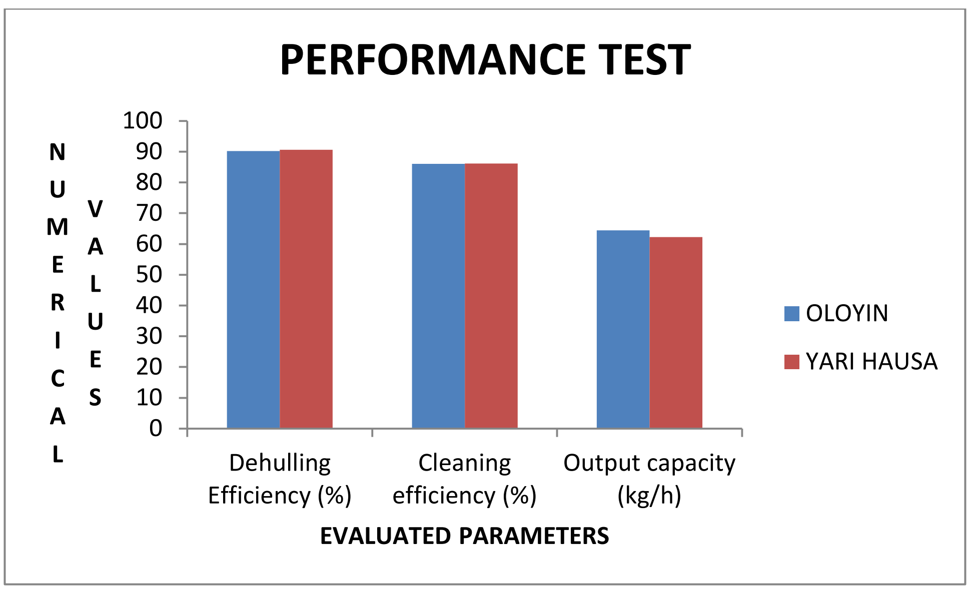

Fig 4; graphical comparism using the dehuller to run two varieties parameters

4. Conclusion and Recommendation

The wet cowpea dehuller was developed and tested. The dehuller was developed using locally sourced materials with adequate strength and stability.A performance test carried out on the cowpea dehulling machine using two available variety of cowpea seeds. Results obtained during test showed that the highest dehulling efficiency obtained for the machine was 92.11% and highest cleaning efficiency obtained was 88.43%. The results from the evaluation indicated a satisfactory performance of the NCAM developed wet cowpea dehuller. The dehuller was able to handle larger quantity of cowpea product due to its continuous operational design consideration, thus, making it suitable for use by the small and medium scale processing industries in Nigeria.

It is recommended that further comprehensive performance evaluation be carried out on the dehuller to determine the effects of cowpea varieties and feed rates on its various performance indices.

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