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Performance Evaluation of a Motorized Groundnut Sheller

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Abstract: *Performance evaluation of a motorized groundnut Sheller was carried out to determine the efficiency of the machine, mechanical loss, and weight of shelled and unshelled groundnut and chaff weight in kilogram (kg). Two varieties of groundnut were used "Dan Kaduna" and "Dan Dakar". A 7kg of unshelled groundnut was bought and both of the varieties are divided into five portions, the weight of each portion were measured with weighing machine, and the result was recorded in a tabular form. The nut of the first portion was 2.5kg, and it was shelled at 50 seconds, the second portion also has the weight of 2.5kg, but it was shelled at 54 seconds. The third, fourth and fifth sets were recorded following the same procedure. The weight of the chaff was also measured in kilogram (kg). However, mechanical loss on both varieties of groundnut was calculated by subtracting the weight of shelled groundnut from the weight of unshelled groundnut (kg).The machine efficiency was determined by dividing the output by the input multiplied by 100% which gave us 67%. Finally, some recommendations were made: future researchers needs to carryout researches using a sieve of smaller diameter, the use of at least three (3) different varieties of groundnut be used and Government should provide an instrument like tachometer for universities and polytechnics to make things easier in determining the exact machine efficiency, due to high cost of the instrument.*

Key words: *Shelling, Motorized, Evaluation and Groundnut.*

1. Introduction

Groundnut (*Arachis hypogea*) is the sixth most important oil crop in the world (Ikechukwu *et al.*, 2004). The major groundnut producing countries include India, Burma, China, Nigeria, Senegal, Sudan, and United state of America. With a world average yield of 1.4 metric tons per hectare (ha) (Madhusudhana, 2013). Shell of groundnut is a fundamental process as it allows the kernel and hulls to be available for use. It constitutes about 38% post harvest cost. (Butts *et al.*, 2009). Traditional shelling method has been found to be inefficient, laborious, time consuming and result in low output (Gitau *et al.*, 2013). Hence there is need for motorized shellers. Abubakar and Abdulkadir, (2012) categorized factors that affect groundnut shellers into three types, first are machine base that include a cylinder speed, concave clearance and fan speed. Next are crop factors such as; moisture contents, size and orientation. Last are operational based factors like feed rate, Operators skills and experience performance of groundnut are evaluated by some measurable dependent variables. The most often used parameter includes throughput, shelling, efficiency, winnowing, or cleaning efficiency and mechanical charge.

Studies to determine optimum operating condition for shellers have been done using different design of experiment and varied result have been obtained (Gamal *et al*., 2009). Investigated the effect of moisture content on groundnut maximum stress, deformation and toughens. (Helmy *et al*., 2007) modified a rotary shellers into a reciprocating one and determined optimum shelling speed and feed rate of 1.4m/s and 160kg/hr respectively. Adedeji and Ajuebor, (2002) determined the best shelling speed. Concave clearance and feed rate for a motorized groundnut Sheller and evaluated the influence of moisture content, impeller fungal Bambara groundnut Shellers. There has been limited research work on comprehensive groundnut Sheller performance that involves the combined influence of four or more factors and levels lead to large number of experiment, using one factor at a time method when dealing with several variable fails to consider any possible factor interactions, hence it is less efficient than other method based on statistical approach to design (Ballal *et al*., 2012).

Groundnut shelling is a fundamental process in post harvest management. Motorized shelling experience less than 100% shelling efficiency and vary level of kernel damage. From the research, throughput per unit power consumption and shelling efficiency increased with reduction in percent moisture content (mm) with maximum output realized at 60% kernel mechanical damage decreased with increase in percent moisture content up to a minimum at between 15% and 18% moisture content then increased marginally with further rise in moisture content. Mean while, throughput per unit power consumption increased with bulk density of groundnut variety been shelled. In addition kernel pod diameter ratio had a significant influence on the output parameter under study. All the three output under review rose exponentially with increase in feed rate. Throughput per unit power consumption and shelling speed with the highest value obtained at a shelling speed about 12m/s. kernel mechanical damage remain low (less than 4%) for speed below 8m/s and then rose sharply with further increase in speed. All the output parameter increase with reduction in concave clearance with maximum values obtained at 10mm clearance. Steel and rubber paddles yielded the highest throughput per unit power consumption. At low shelling speed (less than 8m/s) rolling rubber and steel pipes resulted in lowest shelling efficiency and kernel mechanical damage, but a high speed resulted into both shelling efficiency and kernel mechanical damage.

2. Materials and Methods

2.1 Testing performance

It was explained by the fact that, the bigger the opening in the chamber, the more pods that can be shelled per revolution. Trains on a manual sheller showed that, in both rubber tyre and wood paddle shellers feed rate of between 50-100 kg/hr at an average of 75 rpm does not significantly affect the shelling performance (Chinsuwa, 1983).

2.2 Shelling Shaft Speed

The testing begins with selection of a desired output shelled kernel per unit time. A kernel throughput of 20kg was deemed adequate for experimental purpose and translates into 100kg kernel in two hours, an amount equivalent to the average Kenyan groundnut yield per hectare as indicated in the introduction section. Determination of shelling shaft speed, in the revolution per minute (rpm) was done by considering groundnut characteristic of volume and both bulk and solid densities of pods and the sieve in shelling chamber was set to enable computation of the volume of pods shelling per unit revolution.

2.3 Shelling Performance

Groundnut were made ready or experiment by sorting and cleaning by hand removal of defective pods and unwanted materials like solid and stone particles. The nut were then divided into five different groups, each portion were measured on the weighing machine.

2.4 Feed Rate

A sliding gate in the form of rectangular plate fitted on one set of the slanting surface of the conical hopper was used to regulate the feed rate.

A fixed weight of groundnut was shelled at various gate positions and the corresponding feed rate in kilogram per hour (kg/hr) was recorded. In the first set of the experiment, a fixed quantity of 2.5kg in 50 second at pre-set level of moisture content, shelling blade type. Computation of shellers was done as described in section 2.3. The second; third, fourth and fifth sets of experiments were carried out in similar manner to the first one, but at feed rate of 2.4kg/54 seconds 2.3kg/57 seconds, 2.2kg/50 seconds and 1.9kg/48 seconds.

2.4.1 Shelling Speed

From the literature review, motorized shellers are commonly run at shaft speeds of between 160 rpm and 400 rpm, 350 rpm, 480 rpm and 580 rpm. The selected shaft are attained by mounting pulleys available on the world market with diameter range of 100mm to 250mm interchangeably on the two ends of fan shaft. Belt of appropriate length are utilized to transmit power from the fan shaft to the shelling shaft. Velocity ratio and belt length formulae are used to calculate the diameter and lengths of the required pulleys and belts for experiments.

Actual speeds during operation are measured by the use of tachometer. Five (5) levels of experiments are carried out in this section with a replication of three for each experiment; in the first level a specified weight of groundnut were shelled at a shaft speed of 150 rpm at a selected level of moisture content, variety, feed rate, concave clearance and shelling blade type. In the second, third, fourth and fifth level of experiment speed of 250 rpm, 350 rpm 480 rpm and 580 rpm are applied (Butts *et al.,* 2009).

Tangential velocity changes proportionally with radius of the shelling blade for a given constant angular speed. Hence there are tangential velocities for the shaft speed to obtain the shelling speed for the blade. The following formulae are used;

$$V = wr$$

$$w = \frac{2\pi N}{60}$$

Where:

V= tagential velocity

w= angular velocity

r= shelling blade radius

N= shaft in revolution per minute

Table 2.1 showing shaft speed, N (rpm) and tangential shelling speed, V (m/s)

Shaft speed, N (rpm)	Tangential Shelling Speed, V (m/s)
150	3.2
250	5.3

350	7.4
480	10.1
850	12.2

Source: Nyaanga *et al.,* (2007)

Concave Clearance

Concave clearances are normally determined by measuring the distance between the shelling blades and concave sieve at the point where clearance was at a maximum.

Shelling Blade Type

In most experiments five types of blades are employed. The first type was made of iron paddle having a curved shape of radius 20mm and thickness of 2mm, length of 420mm and distance of 32mm along the circumference, the second type was similar to the first, but with paddle curved with strips of rubber. Thirdly, steel pipe acted as the shelling blade. The thickness of the pipe was 2mm with a diameter of 10mm. the fourth type as similar to third but with extra circumscribe pipe free to roll around it axis. The fifth type consisted of pipe covered with rubber strips.

3. Results and Discussions

3.1 Result

The result shows that machine through put per unit power consumption increases with decrease in groundnut moisture content. This could be explained by the fact that the dry pods were more brittle than the wet ones hence they fractured faster upon been subjected to impact and frictional force during the shelling process. Fewer motor revolutions were required to achieve complete shelling of a given quantity of groundnut pods with less moisture contain. The highest throughput per unit power consumption was achieved at 6% moisture content

Shelling efficiency was found to increased with reduction in moisture content with the highest efficiency been released at 6% moisture content. The explanation of influence of moisture content on throughput per unit power consumption explained above also hold true for shelling efficiency. According to Nyaaga *et al.,* (2007) pods with higher moisture content tend to fix instead of cracking and breaking hence leading to a higher percentage of unshelled groundnuts.

It was observed that kernel mechanical damage was highest at the lowest moisture content between 15% and 18% and the increased marginally with further increase in moisture content. (Nyaaga et *al.,* (2007).On the other hand, damage of kernels with very high moisture content was observed to occur by the way of splitting along the middle axis. This could be attributed to a decrease in seed mechanical strength as explained by Gamal *et al*; (2009).

3.2 Groundnut Variety

The following varieties of groundnut were used to carry out test under this section, i.e "Dan Dakar and Dan Kaduna"

They were chosen to represent a wide spectrum of pod and kernel physical characteristic such as size, density as presented in table 3.1

The result shows that the variety of "Dan Dakar" yielded the highest throughput per unit power consumption. It can also seen from the experiment that influence of the variety under investigation on shelling efficiency and low kernel mechanical damage follow the same pattern. The variety of "Dan Kaduna" resulted in both high shelling efficiency and low kernel mechanical damage as explained by Adedeji and Ajuebor, (2002).

Experiments were carried out on several physical characteristics of groundnut varieties under study indeed to explain the observation observed above. It can be infrared from the results that throughput per unit power consumption increase with pod bulk density of the variety of groundnut been shelled in most researches thus variety (G7 with the highest pod bulk density of 301.16kg/m^3 had the highest while ICGV 99658 with lowest pod bulk density of 212.43 kg/m3 had the second last lowest throughput per unit power consumption. Groundnut kernel pod diameter ratio proved to be vital characteristics as far as shelling efficiency and kernel mechanical damage are considered. Some result has shown that a high ratio translated into low shelling efficiency and a high kernel mechanical damage. Following is a possible explanation for this scenario. A low kernel to pod diameter ratio corresponds to a wider air space between the husk and the kernel.

This makes it relatively easier for the kernels to be released when the pods are fracture and they are less prone to impact and frictional force occasioned by the rotating shelling blades. In addition, kernel been heavier collides with greater momentum than a small one, making it more variable to cracking or splitting during shelling process. However the collision and rubbing action that generates the forces that result in the shelling of groundnut pods as well as the momentum of the shelling speed blade.

This would lead to an increase in throughput per unit power consumption, shelling efficiency and kernel mechanical damage.

Table 3.1 showing the variety, weight of unshelled groundnut, weight of shelled groundnut and chaff weight (kg)

Variety	Unshelled g/nut (kg)	Shelled g/nut (kg)	Time taken (s)	Chaff weight (Kg)
Dan Dakar	2.5	1.8	50	0.8
	2.5	1.7	54	0.7
	2.4	1.5	57	0.6
	2.3	2.0	46	0.9
	2.4	1.6	50	0.8
Dan Kaduna	2.2	1.2	50	0.7
	1.9	1.0	1mins 5sec	0.6
	1.9	1.5	48	0.9
	2.2	1.6	59	0.8
	2.4	1.4	47	1.0

Mechanical loss= weight of unshelled g/nut (kg) - weight of shelled g/nut (kg)
Therefore, mechanical loss in "Dan Dakar" groundnut is equal to:
2.5+2.5+2.4+2.3+2.4-1.8+1.7+ 1.5+2.0+1.6= 12.1-8.6=3.5kg
Mechanical loss in "Dan Kaduna" groundnut is equal to 2.2+1.9+1.9+2.2+2.4-1.2+1.0+1.5+1.6+1.4=10.6-6.7=3.9kg
Mechanical loss in "Dan Kaduna" groundnut is 3.9kg, so in general, our mechanical loss is equal to:
=22.7-15.3=7.4kg
Machine efficiency =output ×100%

Input

= 15.3/22.7

=0.674×100%

=67%

Therefore, the machine efficiency is equal to 67%

3.3 Discussion

Table 3.1 shows the weight of shelled, unshelled and chaff differences in each of the varieties are different. As indicated in the table, the percentage of mechanical loss in "Dan Kaduna groundnut" is greater than that of "Dan Dakar" because of their differences in shape and size. The size of "Dan Kaduna" variety is bigger than the size of "Dan Dakar". However, the percentage of unshelled groundnut is higher in "Dan Dakar" because of their smallness in size. The sieve used under this research work has a larger diameter and some of the nut of "Dan Dakar" variety to escape unshelled due to their smallness in size. It has also been observed that the time taken in the process of shelling also differs due to the following reasons:

This had happened in the process of putting the groundnut to the hopper, because each set of the groundnut were not put to the machine at uniform time. Secondly, well dried groundnut can be shelled faster than partially dried groundnut some set of the groundnut had a much percentage of partially dried groundnuts than other sets. For this reason, the moisture content in the partially dried groundnut leads to the decrease in time during shelling process. The machine efficiency was calculated by dividing the output by the input multiplied by 100%. Finally, the mechanical loss was also calculated, by subtracting the shelled nut in kilogram (kg) from the unshelled nuts in kilogram (kg).

4. Conclusion

Finally, the objectives of this research work have been achieved, considering the result from this research work. The study shows that the groundnut and machine characteristic considered, influenced the throughput per unit power consumption, machine efficiency, kernels mechanical loss, weight of unshelled groundnut, weight of shelled groundnut and weight of the chaff in Kilogram (kg).

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