

Original Research Article

Design, fabrication and performance evaluation of groundnut seeds dehuller as influenced by varietal differences

Abstract

Several studies have been carried out to investigate the performance of developed groundnut dehullers, but very few studies have considered the influence of groundnut varietal differences on the dehuller performance. Therefore, the objectives of the study is to; (1) determine the influence of dehulling speed and varietal difference on the evaluation parameters of the developed machine; and (2) determine the main and interactive effects between the dehulling speed and groundnut variety on the developed machine evaluation parameters. Well designed and fabricated groundnut seed dehulling machine consists of the following components: hopper, dehulling unit, discharge unit, machine frame and drive system. The hopper houses the shaft and rotating circular plate covered with rug (which act as an adhesive) that rub roasted groundnut seeds at any orientation against a stationary circular plate, and discharges to the sprout unit. Results showed that for the dehuller, the red Valencia, white-runner type and Kampala gave dehulling efficiencies of 74.26 – 88.22, 79.69 – 91.3, and 77.21 -89.77%, respectively. Result of the analysis showed that only speed is the variable significantly ($P < 0.05$) impacting the dehulling efficiency in their main effect, while the variety has no effect on dehulling efficiency (insignificant- $P > 0.05$). However, the interaction effect between the rotating speed and variety caused significant ($P < 0.05$) effect on the dehulling efficiency. Therefore, in order to further reduce drudgery through the development of machine for dehulling groundnut, the dehulling speed together with the variety of the groundnut seed must be prioritized.

Keynote: Groundnut variety; Dehuller; Dehulling efficiency; Operational conditions

1. Introduction

Groundnut (*Arachis hypogaea* L.) is a legumous oil seed crop cultivated in the semi-arid and subtropical regions of the world. It is an important crop in many countries, especially in Africa, including Nigeria where it is a good source of protein (25 – 34 %), cooking oil (48 – 50 %) and vitamins (Ajeigbe *et al.*2014). The haulms are good sources of feed for livestock, especially during the dry season when fresh green grasses are not available. This serves as an

additional sources of income for farmers in the dry season when the fodder is in high demand. Several value-added products developed from groundnut are available around the world such as, groundnut flours, roasted and boiled groundnut, groundnut butter, groundnut candy, and so on. local delicacies have also been developed for localized consumption purpose in Nigeria. For example, in many part of West Africa and Sudan, partially defatted groundnut paste is produced after the oil has been extracted, and is used for making “kuli-kuli” in Nigeria and “coura-coura” in Burkina Faso. The full-fat groundnut paste is a common food ingredient in West Africa, Sudan and South Africa (Freeman *et al.* 1999).

In Nigeria, traditional commercial groundnut producing areas encompass the Sahel, Sudan and Derived Savanna, Northern Guinea and most parts of the Southern Guinea vegetation zone. The major groundnut producing states are Kano, Katsina, Kaduna, Jigawa, Sokoto, Zamfara, and Kebbi in the North-West; Adamawa, Bauchi, Yobe, and Borno in the North-East; and Benue, Plateau, Taraba, Nawarawa, FCT Abuja, Kogi, Niger and Kwara in the Central Zone (Ajeigbe *et al.* 2014). Despite, the high demand and economic importance of groundnut, processing groundnut after harvest to the stage of direct consumption is one major constraint facing groundnut production in the developing countries (Akintade *et al.* (2014).

Processing involves the biological, physical, mechanical and biochemical manipulation of agricultural produce in order to preserve it for further use. It involves the series of operation taken to change agricultural products into a consumer – finished product. Almost all crops and livestock products including groundnut requires some form of processing after harvest. This is done in order to extend storage life, facilitates cooking, preparation for further processing or make the product suitable for direct consumption, hence the need to dehull roasted groundnut seed. Rural based processing offers opportunities in terms of employment, add value to products, reduces waste due to spoilage and financial loss. It encourage development of technical and marketing skills. Other reasons for processing is to maintain the quality and stability of the product. Processing also increases the variety of food product available to the consumer and lastly processing plays an important role in ensuring that food is affordable (Sahay and Singh, 1994).

Dehulling is the removal of the thin seed coat from the groundnut seeds after roasting. Dehull roasted groundnut can be consumed directly, and can be consumed with popcorn. Also it can be consumed with roasted plantain (called “boli” among the Yoruba tribe in Nigeria).

Dehulled roasted groundnut can be eaten with garden egg (*Solanum Spp.*). Traditionally, roasted groundnut dehulling is done by the women and children by rubbing a sizeable quantity of the roasted seed in their palms and then use mouth to blow away the chaff from the seeds. The dehulling process for other legumes such as sorghum and millet is accomplished either traditionally by hand pounding of tempered grain using pestle and mortar or mechanically using abrasive dehullers (Munck *et al.* 1982).

There have been several attempts to fabricate machines that dehull legumes and other seeds such as sorghum, cowpea, maize etc. Between 1972 and 1976, the then Nigeria's Federal Ministry of Agriculture and Natural Resources established a complete processing plant consisting of a dehuller, hammer mill and a diesel engine to drive the equipment in Maidguri (Ayelegun and Ajewole, 2015). Most groundnut dehulling machines fabricated in Nigeria are too expensive with low efficiency, and as a result of high demand for groundnut, and groundnut product in the world market, the traditional method of using bare hand to dehull and winnowing are associated with series of deficiencies; these include Intensive labour and human drudgery, Exposure of products to unhygienic condition and hence easily contaminated. This is not good for human health especially, during this period of outbreak of pandemic disease like Ebola virus Diseases (EVD) and COVID-19. Also, it is associated with low capacity, low efficiency, high time consuming, and result in wastage. In addition, till date, studies that considered the influence of varietal difference on the evaluation parameters of a developed groundnut dehulling machine are scarce. Therefore, the main aim of this study are is to evaluate the performance of groundnut seeds dehuller as influenced by varietal differences.

2. Materials and Methods

The groundnut used for the study was procured from Ogbese market in Ondo State Nigeria. The sample were selected and cleaned. This is to ensure that the products are free from dirt, pieces of wood, leaves, stones, pebbles and other foreign materials. Prior to dehulling operations, the groundnut seeds were sorted and graded to enhance uniformity and then dried to moisture content range of 8-10 % which was further reduced to 3 – 4 % moisture content through roasting operation. The dehulling machine was designed and fabricated at the Department of Agricultural and Environmental Engineering workshop at the Federal University of Technology, Akure, Ondo State. Major instrument used in the process is the weighing balance.

2.1 Description of major component of the machine

The following are the machine components of the roasted groundnut dehuller; hopper, dehulling unit (rug adhesive), power transmission unit, bearings, frame, electric motor, shafts, belt and pulley.

2.1.1 Electric Motor

The electric motor is the engine that generates the rotational movements required by the machine converting the electrical energy to rotational motion.

2.1.2 Hopper

This structure is the unit in which material to be dehulled is regulated and channeled into the dehulling chamber. The dehulling hopper is mounted on the dehulling unit at an inclination of the groundnut angle of repose.

2.1.3 Dehulling circular plate and Dehulling chamber

These are the (cylinders dimension 500 mm) which dehull the groundnut using abrasive force at the same time changing its orientation. In this system there are one stationary and two rotating circular plates coated with rug (rug thickness 3 mm), powered by the electric motor and the other allowed to be free for clearance adjustment.

The dehulling chamber was the core of the machine with dimension of 910x610x460 mm, it consists of the shaft which bears the dehulling circular plate having outlet on it to pass to the next circular plate. Housing the dehulling plates is the rug surface which counteracts the movement of the roasted groundnut seeds with a very minimal abrasive impact, thereby dehulling it.

2.1.4 Power Transmission Unit

This includes a system of shaft, pulley and belts that transfers the rotational energy gotten from the prime mover (electric motor) to each component of the dehulling machine.

2.1.5 Bearing

This is a machine element that supports another part and reduces friction between moving parts. The bearings used allows for easy rotational movements of the shafts holding it about the fixed point. The bearings used are: pillow bearing and flange bearing.

2.1.6 Machine Frame

The machine frame carries another component making up the groundnut dehulling machine. The machine's frame serves as the mounting base for all of its parts. It is constructed of mild steel (615x460 x 3) mm to provide strength, rigidity, and stability

2.1.7 Collector

The collector is a flat inclined plate where the dehulled groundnut seeds falls. Due to its slit, it allows easy outward movement of the dehulled groundnut seeds (Plate. 1).



Plate 1: Principle of operation

The principles of operation are adhesive method, which was done by the surface of the rug on the circular plate. The roasted groundnut seed dehulling machine consists of the following components: hopper, dehulling unit, discharge unit, machine frame and drive system. The hopper is pyramidal in shape and designed with the angle of repose for groundnut seed. It serves as the inlet in which the roasted groundnut seeds was fed into the dehulling chamber; this is the core of

the machine; it houses the shaft and rotating circular plate covered with rug (which act as an adhesive) that rub roasted groundnut seeds at any orientation against a stationary circular plate with passage made on it, and this discharges to the sprout unit; this is the point where the seed and chaff from the dehulling unit are collected. The frame is the mounting support of all the components of the machine.

2.2 Design Consideration

The physical properties of the material were considered to ensure that the materials used are strong enough and capable of withstanding heat, vibration, humid air, fatigue and stress without failure during operation. Also considered is machine cost. The materials used were sourced locally to reduce cost and hence made the machine affordable by the indigenous groundnut processor. The material used for construction was food grade material (especially the part of the machine in contact with the food). Stainless steel was used so as to prevent corrosion and contamination of the dehulled roasted groundnut.

2.3 Design Analysis of Machine Components.

The machine was designed using the physical properties of groundnut seeds in accordance with the conceptual design

2.3.1 Design Calculations for Roasted Groundnut Dehuller

2.3.1.1 Determination of outer and inner plate of the dehulling chamber

$$\text{Volume of circular pan} = \pi r^2 h$$

Where h = Height of circular pan, r = radius of circular pan

Fixed circular pan,

Diameter of circular pan = 51 cm = 510 mm

Height of circular pan = 14.8 cm = 148 mm

From equation (1), the Volume of fixed circular pan

$$= 3.142 \times 65025 \times 148 = 30237665.4 \text{ mm}^3 = 30237.67 \text{ cm}^3$$

Circular plates, one fixed and two rotating

Height of plate = 1 cm = 10 mm, Diameter of plate = 50 cm = 500 mm

From equation above, the Volume of inner plates;

$$= 3.142 \times 62500 \times 100 = 1963750 \text{ mm}^3 = 1963.75 \text{ cm}^3 \text{ multiply by three (3) circular plate}$$

$$=5891.25 \text{ cm}^3$$

Volume of circular pan that will contain the roasted groundnut seeds = volume of circular plates

$$= 30237.67 - 5891.25 = 24364.42 \text{ cm}^3$$

Therefore, volume of circular pan that will contain roasted groundnut seed = 24364.42cm³

2.3.1.2 Determination of groundnut quantity (mass)

Quantity of roasted groundnut was calculated using the equation

$$P = m/v \text{ (Kundu and Cohen 2002)}$$

Where ρ = density of an average groundnut, V = Volume of groundnut, M = mass of groundnut

Therefore, from the above equation the mass of groundnut seeds to be contained in the circular pan

$$\text{Where } \rho = \text{density of an average groundnut} = 1.01 \text{ g/cm}^3$$

$$V = \text{Volume} = 5891.25 \text{ cm}^3$$

$$M = \rho \times v = 5891.25 \times 1.01 = 52950.16 \text{ g/cm}^3$$

$$M = 5.3 \text{ kg}$$

2.3.1.3 Determination of Power Required to dehull Roasted Groundnut Seed

Total power required is calculated using equations as specified by Akintunde *et al.* (2005);

$$P_T = P_{\text{inner circular plates}} + P_{\text{shaft}} + P_{\text{peeling}}$$

Power for peeling is negligible since seeds are not resident in decorticating room but flow through in pieces.

$$\text{Therefore, } P_T = P_{\text{inner circular plates}} + P_{\text{shaft}}$$

But shaft and inner circular plates are joined together

$$\text{So, } P_T = \text{Torque}_{\text{inner circular plates}} \times \text{Velocity}_{\text{inner circular plates}}$$

$$\text{Velocity of the circular plate with shaft } \frac{2\pi N}{60} \text{ m/s}$$

N is the number of revolutions per minutes of inner plate with shaft, knowing Mass= 5.3 kg, acceleration due to gravity = 9.81 m/s, plate radius = 0.025 m

$$\text{Torque}_{\text{inner circular plates}} = 5.3 \times 9.81 \times 0.025 = 1.3 \text{ Nm}$$

Assuming the speed of the shaft is 150 rpm

$$\text{Velocity}_{\text{inner circular plates}} = \frac{2 \times 3.142 \times 150}{60 \times 1000} = 0.01571 \text{ m/s}$$

Therefore, $P_T = 1.3 \times 0.01531 = 0.0204 \text{ kW} = 20.4 \text{ watts}$

Converting to hp (divide power by 745.7) = 0.027 Hp

Using the factor of safety of 2, power required is 0.054 Hp = 40.8 watts, therefore a motor of 0.1Hp, 75 watts is chosen to power the inner circular plates, shaft and dehull the seeds.

2.3.1.4 Determination of Torque Transmitted by the Electric Motor

Calculating the torque transmitted by electric motor according to Khurmi and Gupta, (2012)

$$T = 9.55 \times \frac{P}{n}$$

Where P = electric motor power 75 watts, n = the number of revolutions per minute of the electric motor 1200 rpm

$$T = 5.97 \text{ Nm}$$

2.3.1.5 Determination of belt length

The driven pulley diameter, D1 = 40 mm

The driving pulley diameter, D2 = 200 mm

Motor speed N1 = 1200 rpm

Shaft speed N2 = ?

Using the relationship for pulley and speed;

$$\frac{D1}{D2} = \frac{N2}{N1}$$

$$N2 = \frac{40 \times 1200}{200} = 240 \text{ rpm}$$

The belt length was obtainable as given by (Khurmi and Gupta, 2005)

$$L = 2C + \frac{\pi}{2}(D1 + D2) + \frac{D2 - D1}{4C}$$

And the centre to centre distance between driving pulley and driven pulley is given as

$$C = 2(40 + 200) = 480$$

Where D1 and D2 are the diameters of the pulley respectively

C = centre to centre distance between driving pulley and driven pulley

$$L = 2 \times 480 + 1.571(240) + 199.98 = 1537.02 \text{ mm}$$

2.3.1.6 Determination of Belt Tensions

The speed was determined using relationship between the speed of driven and driving pulley;

$$V1 = 3.142 \times 40 \times 1200/60 = 2.5 \text{ m/s}$$

$$V = 3.142 \times 200 \times 240/60 = 0.25 \text{ m/s}$$

Using Akintunde et al, (1983) equation ... to determine torque;

$$P = (T_1 - T_2) V$$

Where, P = belt power (W) 75 W; V = belt speed (m/s) 0.25 m/s

T1 and T2 are tensions on the tight and slack sides respectively (N)

$$T_1 - T_2 = 300 \text{ N}$$

Using belt ratio for an open belt;

Where, f = coefficient of friction between belt and pulley using a rubber belt; f=0.42

$$\frac{T_1}{T_2} = e^{0.42 \times 3.142}$$

$$\frac{T_1}{T_2} = e^{1.319}$$

Therefore, $T_1 = 3.74 T_2$

From equation ...

$$T_1 = 300 + T_2$$

$$T_2 + 300 = 3.74T_2; 300 = 3.74T_2 - 1T_2$$

$$T_2 = 300/2.74 = 109.49 \text{ N}$$

$$T_1 = 3.74 \times 109.49 = 409.49 \text{ N}$$

2.3.1.7 Determination of Shaft Diameter

Calculating the shaft loading

Neglecting the weight of shaft, total vertical loading acting on pulley

$$W = T_1 + T_2 = 409.49 + 109.49 = 518.98$$

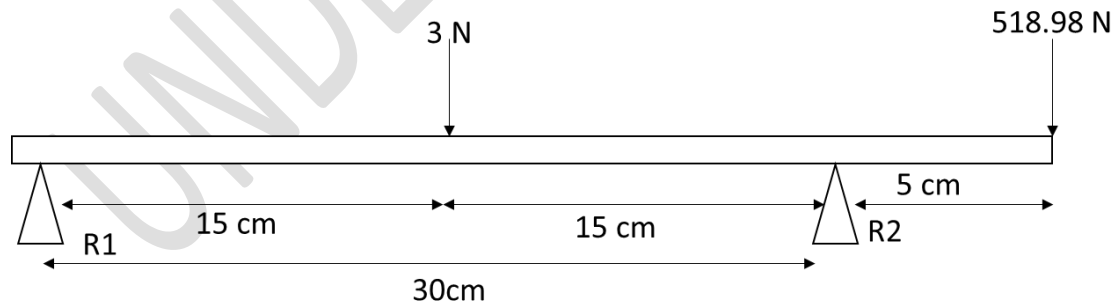


Figure 1. : Shaft loading for roasted groundnut dehuller

$$\text{Taking the sum of loading; } R_1 + R_2 - 518.98 - 3 = 0$$

Taking moment about R2;

$$518.98 \times 0.05 - 3 \times 0.15 + R_1 \times 0.3 = R_2 = 84.99 \text{ N}$$

$$R_1 = -84.99 + 518.98 + 3 = 436.99 \text{ N}$$

$$\sum M = 518.98 \text{ N} \times X - R_1 (X - 0.05) + 3(X - 0.15) - R_2 (X - 0.35)$$

$$\text{At } X = 0; M_b = 0$$

$$\text{At } X = 0.05; M_b = 15.71 \text{ Nm}$$

$$\text{At } X = 0.15; M_b = 16.53 \text{ Nm}$$

$$\text{At } X = 0.35; M_b = 0$$

Therefore, the maximum bending moment, $M_b = 16.53 \text{ Nm}$

The shaft, which was made from mild steel which carried combined load of bending moment and torque; hence the design of the shaft was calculated from the formula given in equation below according to (Spott 1998)

Where $T = 5.97 \text{ Nm}$ $M_b = 16.53 \text{ Mpa}$

Taking the maximum shear stress S_s of Mild Steel rod to be 42MPa

$$d^3 = \frac{16}{\pi S_s} \sqrt{(M_b)^2 + (T)^2}$$

Where T is torque,

M is bending moment of shaft,

d is shaft diameter of the machine,

S_s is maximum shear stress.

$$d^3 = \frac{16}{3.142 \times 42} \sqrt{(16.53)^2 + (5.97)^2}$$

$$d^3 = 0.12 \sqrt{273.24 + 35.64}$$

$$d^3 = 0.12 \times 17.57 = 2.11$$

$$d = 12.83 \text{ mm}$$

therefore, a 15 mm shaft diameter was selected.

2.4 Performance evaluation of roasted groundnut dehulling machine

Performance evaluation of the roasted groundnut dehulling machine was based on dehulling efficiency, mechanical damage and percentage losses, expressed with equations below according to Ayelegun, and Ajewole, (2015)

$$\text{Dehulling efficiency} = \frac{W_2}{W_1} \times 100$$

$$\text{Mechanical damage} = \frac{W_b}{W_g + W_b} \times 100$$

$$\text{Percentage losses} = \frac{W_d}{W_o} \times 100$$

Where W_2 is weight of fully dehulled seed discharged, W_1 is total weight of roasted groundnut fed into the dehulling machine, W_b is weight of broken or spilled seed, W_g is weight of good seeds

2.5 Experimental design and statistical analysis

Roasted groundnut is fed into the dehulling machine which uses rubbing and rotational speed action in dehulling. The experiment is a 3 x 3 factorial design with three levels of dehulling speed (30, 40, and 50 rpm) and three different groundnut varieties (Red Valencia, Runner-type and Kampala). One-way analysis of variance was carried out on the dehulling efficiency, mechanical damage and percentage losses at 5% level of significance using Tukey's test. Also, the main and interaction effects between groundnut varieties and the dehulling speed were carried out on the above mentioned evaluation parameters. All analysis were performed using Minitab software, version 17.0

3. Results and Discussion

3.1: Dehulling of groundnut seed as affected by the operational speed and varietal difference

3.1.1: Fully Dehulled Seed as a function of dehulling speed and varieties of groundnut

The difference in the mean of the fully dehulled seed between the three different varieties (Red Valencia, Kampala and Runner type) of groundnut seed are presented in Table 1 below. The fully dehulled seed ranged between 0.189 kg (Red Valencia variety) and 0.196kg (Runner type) kg at a speed of 30 rpm, while it ranged between 0.178kg (Red Valencia variety) and 0.187kg (Runner type) at 40 rpm and also from 0.160kg (Red Valencia variety) to 0.171kg (Runner type) at 50 rpm. The results showed that at each operational speed, the fully dehulled seed were significantly affected at 5 % level of significance. The lowest operational speed produce the highest fully dehulled seed while the lowest fully dehulled seed was obtained at the highest operational speed. The significant ($P < 0.05$) difference obtained in this study on the fully dehulled seed due to the differences in the varieties could be attributed to the differences in the size, weight and volume of the groundnut seed (Gupta and Das 1999; Adenigba and Sedara, 2021).

3.1.2 Half Dehulled Seed as a function of dehulling speed and varieties of groundnut

Comparison in the mean of the half dehulled seed between the three different varieties (Red Valencia, Kampala and Runner type) of groundnut seed are presented in Table 1 below.

The half dehulled seed ranged between 0.0073kg (Runner type) and 0.0113kg (Red Valencia variety) at a speed of 30 rpm, while it ranged between 0.0123kg (Runner type) and 0.0167kg (Red variety) at 40 rpm and also from 0.009kg (Kampala variety) to 0.024kg (Red Valencia variety) at 50 rpm. The results showed that at each operational speed, the half dehulled seed were significantly affected at 5 % level of significance except for the Kampala variety which produced similar half dehulled seed. The lowest operational speed produce the highest half dehulled seed while the lowest half dehulled seed was obtained at the highest operational speed. The significant ($P < 0.05$) difference obtained in this study on the half dehulled seed may be due to the differences in the varieties, which could be attributed to the differences in the size, weight and volume of the groundnut seed.

3.1.3 Splitting Seeds as a function of dehulling speed and varieties of groundnut

The means of the splitted seeds during the groundnut seed dehulling operation between the three different varieties (Red Valencia, Kampala and Runner type) of groundnut seed are presented in Table 1 below. The splitted seed ranged between 0.00467kg (Kampala variety) and 0.005kg (Red Valencia variety) kg at a speed of 30 rpm, while it ranged between 0.008kg (Red Valencia variety) and 0.01kg (Kampala variety) at 40 rpm and also from 0.0047kg (Kampala variety) to 0.0177kg (Red Valencia variety) at 50 rpm. The results showed that at each operational speed, the splitted seeds were significantly affected at 5 % level of significance. The lowest operational speed produce the lowest splitted seed while the highest splitted seeds was obtained at the highest operational speed. The significant ($P < 0.05$) difference obtained in this study on the splitted seed may be due to the differences in the varieties, which could be attributed to the differences in the size, weight and volume of the groundnut seed.

3.1.4 Chaff as a function of dehulling speed and varieties of groundnut

The trend of the chaff amount from the dehulled groundnut seeds as influenced by the operational speed and variety is illustrated in Table 1 below. The amount of chaff were statistically similar ($P > 0.05$) with respect to the groundnut variety and the operational speed. At operational speed of 30 rpm, the chaff amount ranged from 0.003 kg (Kampala and Runner type) to 0.00333 kg (Red Valencia variety), while at 40 rpm, the chaff content ranged between 0.00267 kg (Runner-type) and 0.003 kg for Red Valencia and Kampala varieties.

3.1.5 Losses as a function of dehulling speed and varieties of groundnut

The influence of the groundnut variety and operational speed on the groundnut losses are illustrated in Table 1 below. At operational speed of 30 rpm, the losses recorded during dehulling operation ranged from 1.395 kg (Runner type) to 2.636 kg (Red Valencia variety), while at operational speed of 40 rpm, the losses ranged between 1.860 kg (Runner type) to 4.341 kg (Red Valencia variety). Also, at 50 rpm, the losses ranged between 1.705 kg (Runner type) to 4.650 kg (Red Valencia variety). However, at each operation speed, there were no significant differences ($P > 0.05$) on the losses recorded during the experiment. Similar observation were recorded in the chaff analysis and result

3.1.6 Dehulling Efficiency as a function of dehulling speed and varieties of groundnut

Dehulling efficiency reduces as speed increased from 30 rpm to 50 rpm (Table 1). For the Red Valencia variety, the dehulling efficiency increased from 74.26 to 88.22 %, while it increased from 79.69 to 91.32% for Runner type variety and from 77.21 to 89.77 % for the Kampala variety. The highest dehulling efficiency was obtained with the Runner type, while the lowest dehulling efficiency was obtained with 88.22 % with red Valencia variety at the 30 rpm. The highest values of dehulling efficiency obtained at the 30 rpm in all varieties could be attributed to the fact that groundnuts fed into the hopper have higher retention time at lower speed than at higher speed. This may make these seeds subjected to dehulling at higher speed to undergo compression and shearing. The result showed that an increase in the dehulling speed to even 40 rpm could lead to a decrease in the dehulling efficiency. This is evident as the significant differences were observed for the dehulling efficiency at dehulling speeds of 40 and 50 rpm, when their means were compared with those obtained at 30 rpm in all varieties. The values obtained in this study is similar to those reported by Adenigba and Sedara, (2021)

3.1.7 Mechanical damage as a function of dehulling speed and varieties of groundnut

The mechanical damage recorded during the experiment increase as the dehulling speed increased in all the varieties of groundnut considered. For the red Valencia variety, the mechanical damage ranged between 2.325 to 8.217 kg while it ranged between 2.481 to 7.907 kg for the Runner type and 2.171 to 8.062 kg for the Kampala variety. At the dehulling speed of 30 rpm, the mechanical damage ranged between 2.171 kg (Kampala variety) to 2.481 kg runner type. Also, at 40 rpm, the mechanical damage ranged from 3.721 kg (Red Valencia variety) to 4.651 kg Runner type, while it ranged from 7.907 kg Runner type to 8.217 kg (red Valencia variety) for the 50 rpm dehulling speed. In all, the dehulling speed significantly ($P < 0.05$)

impacted the mechanical damage in all the varieties considered. There were significant difference ($P < 0.05$) in the means of the mechanical damage at dehulling speed of 40 and 50 rpm when compared with that of 30 rpm for varieties Kampala and Runner type varieties however, there was a significant difference for the Red Valencia variety at 50 rpm. The differences in the mechanical damages as influenced by the speed is also variety dependent. It does not only depend on the above mentioned factors, but also depend on the impact force exerted on the groundnuts by the rubber beaters. The differences in the effect of the variety on the mechanical damages also further showed that seed sizes, mass and volume have a role to play Gupta and Das (1999).

Table 1: Effect of dehulling speed and variety on the groundnut dehulling properties

Variety	Speed (rpm)	Fully	Half	Splitted seed (kg)	Chaff (kg)	Losses (kg)	Dehulling efficiency (%)	Mechanical damage (%)
		dehulled seed (Kg)	dehulled seed (kg)					
Red Valencia	30	0.189a	0.0113c	0.005b	0.00333a	2.636a	88.22a	2.326b
	40	0.178b	0.0167b	0.008b	0.0030a	4.341a	82.79b	3.721b
	50	0.160c	0.0247a	0.0177a	0.0030a	4.650a	74.26c	8.217a
Runner-type	30	0.196a	0.00733c	0.00533c	0.003a	1.395a	91.32a	2.481c
	40	0.187b	0.0123b	0.0090b	0.00267a	1.860a	86.98b	4.186b
	50	0.171c	0.0197a	0.0170a	0.00333a	1.705a	79.69c	7.907
Kampala	30	0.193a	0.0090b	0.00467c	0.0030a	2.481a	89.77a	2.171c
	40	0.182b	0.0133b	0.0100b	0.0030a	4.186a	84.81b	4.651b
	50	0.166c	0.0090b	0.0047c	0.0030a	2.481a	77.21c	8.062a
Main Effect								
Variety		****	****	NS	NS	***	****	NS
Speed		****	****	****	NS	*	****	****
Variety*Speed		***	NS	NS	NS	*	***	NS

3.2 Main and interaction effects of groundnut variety and dehulling speed on the dehulling properties

The main and interaction effects of the dehulling speed and variety of groundnut are illustrated in Table 2 below. Results showed that the main effect of the varieties and the dehulling speed were significant ($P < 0.0001$) on the fully dehulled groundnut seed. This means that the shape, size and weight of the groundnut seed affected the fully dehulled seeds. Similar effect of the varietal differences were observed on the half dehulled groundnut seeds and dehulling efficiency while there were also significant difference on the losses at 0.1% level of significance. This observation is similar to the reports of some researchers (Maduako *et al.*, 2006; Oluwole, *et al.*, 2004; Srivastava, *et al.*, 2013). However, the main effect of the variety was insignificant ($P > 0.05$) on the splitted groundnut seed, chaff and mechanical damage at 5% level of significance.

Also, the dehulling speed significantly ($P < 0.0001$) impacted the fully dehulled seed, half dehulled seed, splitted seed, dehulling efficiency, and mechanical damage (Oluwole, *et al.*, 2004; Srivastava, *et al.*, 2013). This strong impact on the above mentioned parameters could be attributed to the force generated during rotational movement resulting in the dehulling of the groundnut seed cover. The dehulling speed impact/influence was minimal on the losses recorded during the experiment, with the significant difference occurring at 5% level of significance. No significant ($P > 0.05$) difference was recorded in the effect of dehulling speed on the chaff of groundnut. The interaction effect between the variety and dehulling speed was significant ($P < 0.001$) on the fully dehulled seed and the dehulling efficiency. This showed that the prioritization of variety and dehulling speed are necessary to improve the dehulling efficiency of dehulled groundnut seed, as well as the weight of the fully dehulled seed. The significant ($P < 0.05$) main effect of the operational speed on some of the important parameters like dehulling efficiency is in agreement with the reports of some researchers (Pinson *et al.*, 1991; Sudajan *et al.*, 2002; Anil *et al.*, 1998)

Table 2: Main and interaction summary statistics for the groundnut dehulling properties

	Fully	Half	Splitted	Chaff	Losses	Dehulling	Mechanical
Variety	dehulled	dehulled	seed	(kg)	(kg)	efficiency	damage

	seed (Kg)	seed (kg)	(kg)	(%)	(kg)		
Main Effect							
Variety	****	****	NS	NS	***	****	NS
Speed	****	****	****	NS	*	****	****
Variety*Speed	***	NS	NS	NS	*	***	NS

Conclusion

In this study, dehulling machine was designed and fabricated for groundnut. The groundnut dehulling machine was developed and the effects of dehulling speed and groundnut varietal differences were evaluated on the dehulled seed, losses, mechanical damages and dehulling efficiency. Based on the experimental findings, it can be concluded that:

- i) The dehulled seed, losses, mechanical damages and dehulling efficiency varied significantly ($P < 0.05$) as a function of varied speed in all groundnut varieties used for the experiment.
- ii) The main and interaction effects between speed and variety were mostly significant ($P < 0.05$) on the considered evaluation parameters.
- iii) the result obtained after testing the machine shows that 30 rpm operational speed gave the best average dehulling efficiency (91.32 %), and the least mechanical damage (2.17%) with Kampala and Red Valencia varieties, respectively.

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