Digital Innovations & Contemporary Research in SCIENCE, ENGINEERING & TECHNOLOGY
Vol. 8. No. 2, 2020

Article Citation Format
Osuchukwu, C.L., Anyaoha, B, Obaseki, E. Meremikwu, B, & Unuogu, C.C. (2020):
Locally Fabricated Castor Bean Shelling and Winnowing Machine.
Journal of Digital Innovations & Contemp Res. In Science.,
Engineering & Technology. Vol. 8, No. 2. Pp 59-78

Article Progress Time Stamps

Article Type: Research Article
Manuscript Received: 27th May , 2020
Review Type: Blind
Final Acceptance: 15th June, 2020

Locally Fabricated Castor Bean Shelling and Winnowing Machine

[1]Osuchukwu, C.L., [2]Anyaoha, B, [3]Obaseki, E. [4]Meremikwu, B, & [5]Unuogu, C.C.
[1,2,3,4]Department of Mechanical Engineering Technology, Imo State Polytechnic Umuagwo, Owerri
[3]Department of Mechanical Engineering Technology, Federal Polytechnic Nekede
[5]Comprehensive Secondary School Ngugo Imo State.
E-mails: [1]chimabertdon@gmail.com, [2]chinonsomeremikwu@yahoo.com [3]efoba@yahoo.com
Phone: +2348035768073

ABSTRACT

The performance evaluation of a locally developed Castor fruit and seeds de-husking and shelling machine was carried out, the development of the machine was embarked upon in order to reduce the drudgery associated with the processing of the Castor seed. The machine consists of two major compartments; the shelling unit and the de-husking unit. A blower was incorporated to facilitate easy and proper cleaning and separation of the seeds from the chaff. Performance Tests were carried out using 1kg Castor Bean seed, and the following results were gotten for the average weights of Castor seeds shelled, Castor seed not shelled, chaff not blown and chaff blown out recovered after de-husking and shelling of Castor seeds were: 729.5g, 120.15g, 78.23g and 68.13g respectively, this shows that the shelling efficiency and seed recovery rate was high and average time used for this sample was 62.03 seconds. While the percentage shelling efficiency, percentage loss, seed recovery rate and mass flow rate are given as 84.962%, 0.39%, 99.6%, and 16.06 kg/s, the average time for the constructed machine for de-husking and shelling of 1000g of Castor seeds was 62.03 seconds. This shows that the fabricated machine saves time in de-husking and shelling of Castor seed.

Keywords: Castor fruit, de-husking and shelling, machine, performance test, mass flow rate.

1. INTRODUCTION

Engineering is all about using science and mathematics to solve human problems, and to reduce human effort in doing work. The construction of castor bean shelling and winning machine was conceived and executed for the sole purpose of enabling man (the castor bean stake-holders) deal with castor oil and/or cake with ease of time and energy and in extension for profit maximization. Enugu state for example is one of the states that ranksthe highest in production of local magi which is gotten from Castor Bean. Scientists and researchers all over the world are also interested in findings associated with castor bean oil and cakes. All these are centred on Castor Bean seed which must first be cracked so as to have access to the area of interest of either the Enugu-based Magi producer or the Researcher who wants to investigate the chemo-physical properties of the oil for either bio-diesel usages or other investigations. The aforementioned facts triggered the desire to construct this piece of mechanical equipment which has the capacity to de-husk 300g of Castor Bean in 60 seconds.

2. LITERATURE REVIEW.

2.1 Castor Bean.

Castor (*Ricinus communis*) belongs to the Euphorbiaceae or spurge family (Phillips and Martyn, 1999;http://www.billcasselman.com/cwod_archive/beaver_castor_two.htm), containing a vast number of plants native to the tropics. The castor seed (*Ricinus communis*) is a seed of large plant, castor oil plant, grown throughout the tropics. This plant is believed to be a native of Africa, new encyclopaedia particularly in Nigeria where all the species are found (Gupta et al 1964). Today India and Brazil are the largest producers of castor seeds and castor oil, while USA and UK are major buyers. The castor oil plant is grown commercially for pharmaceutical and industrial uses of its oil. It is used in the production of synthetic resins, plastics, fibres, paints, vanishes and various chemicals including drying oils and plasticizers. In addition to these, castor oil and its derivatives are used in cosmetics, hair oil, fungistatic (fungus-growth inhibiting) compounds, embalming fluid, printing inks, soap, fat liquor, grease and hydraulic fluids, dying and textile finishing materials (Oria et al 1999). Outlined are the economic values of castor seed and its derivatives and the urgent need for design efforts to be made to harness the commercial potentials in castor seed.

It is a semi-tropical perennial plant grown extensively in warm-temperature and tropical regions of the world. Castor plants can be basically divided into two types, tall (giant) and short (dwarf). The caster plant is a robust annual plant that grows between 2 - 5 meters in one season with a temperature of about 23^{0C} and relative humidity of about 50%. Castor seed is a drought resistant crop, requiring between 380 – 500 mm of rain during a growing season of between 140 – 150days. It does not tolerate heavy rainfall or water logging. It prefers deep sandy loam soil with a PH of 6 (Weiss, 1983; Popova, 1963). Under dry conditions, yields are about 1.0 to 1.2 tones/hectares but reaches 1.5 to 1.8 tones/hectares under irrigation. Fertilizer requirements for castor are similar to those of sun flower (40 – 60 kg of Nitrogen and 50 kg of phosphorus and potassium per hectare). Good yield responses have been obtained from 75 kg/ha of Nitrogen and 25 kg/ha of both phosphate and potash. Unbalanced nitrogen application encourages growth of foliage at the expense of flower and seed formation. Castor grows both in the wild and cultivated. Castor seed originated in Africa and grows in the wild in East and North Africa.

2.2 Benefits of Castor Bean.

A poultice of castor leaves is useful as an external application to boils and swellings. Coated with some brand oil such as coconut oil and heated, the hot leaves can be applied over guinea-worm sores to extract the worms. A paste of kernel without the embryo, boiled in milk, is also given as a medicine for the treatment of lumbago, rheumatism and sciatica (Lewis and Elvin-Lewis, 1977; Simpson and Ogorzaly, 1986). Castor oil is regarded as one of the best laxative and purgative preparations available. It is of particular benefit for children and pregnant women due to its mild action in easing constipation, colic and diarrhea due to slow digestion. Castor oil is used for a range of industrial purposes from soap making to vanishes. Castor oil is used very effectively in the treatment of rheumatic and skin disorders. The oil of castor is massaged over the breast after child birth to increases the flow of milk, as it stimulates the mammary glands. Castor leaves can also be used to foment the breasts, for the same purpose. If used regularly as hair oil, it helps the growth of the hair and cures dandruff (Zahir *et al.,* 2010).

Other uses and benefits of castor seeds are; according to Ayurvedic and Unani Treatises (Lewis and Elvin-Lewis, 1977), as natural birth control, if a woman chews one castor seed daily for a period of seven days after menstruation, she becomes sterile. This has been interpreted by many that castor seed is a herb for birth control and if the woman swallows one castor seed, after the menstrual circle, she will not conceive during that month. When pregnancy is desired, the practice can be given up and conception follows after a year. Castor oil massaged over the body, before birth keeps the skin healthy and imparts sound sleep. Such an oil bath may be taken once a week. Applying castor oil over hand and feet before going to bed keeps them soft and similarly over the eyes brows and eye lashes keeps them well groomed (Marter, 1981; Gideon, 1965).

The negative aspects of castor oils are: repeated use of castor oils as a laxative causes secondary constipation that is recurrence of the condition after cure. Persons suffering from kidney infection should not take castor oil as a purgative. It should also not be used when there is abdominal pain or intestine infections such as appendicitis, enteritis or inflammation of the small intestine and peritonitis. Large doses of castor oil during the early months of pregnancy may cause abortion (Windholz *et al.,* 1983). According to FAO (2008), the world production of castor seed was 1, 209, 756 metric tones. India is the largest producer of castor seed followed by China, Brazil, Ethiopia and Paraguay accounting for about 85% of the global production of seed. The statistical data of castor production in Nigeria has not yet been found because farmers in Nigeria are not growing castor in large quantities.

Often before castor is used it has to be processed. One of the major problems in the post harvest processing of castor is the dehusking and shelling of the castor fruits and seeds. Basically castor can be processed by traditional and mechanical methods. The traditional method makes use of little or no modern technology, (i.e. the seed is separated from the spiny husk by sun drying in the open until the casing splits, foreign materials are separated by hands picking, de-husking and shelling process is manual, after that the kernels are crushed into paste (Cake) form using mortar and pestle, then the oil extracted by boiling the crushed seed in water and allowing the oil to float to the surface where it is schemed off) hence poor quality of oil extraction (Nkpa *et al.,* 1989). On the other hand, the mechanical methods (that is the use of machines) available are yet to meet the required efficiency and the quality of oil extracted.

5

Consequently, de-husking and shelling of castor through the traditional method is tedious, time consuming and of low quality. In developed countries there are basically two types of castor seed sheller which include power operated and hand operated shellers. The power operated is usually equipped with rubber – covered vertical discs. One disc is stationery, while the other is rotated by an electric motor, which also powers cleaning fan to separate the hulls from the seed. The distance between the discs is adjustable permitting efficient hulling without excessive cracking of the seed coat (Schoenleber and Taylor, 1954). The hand – powered sheller has the same configuration with the power operated sheller. In Nigeria, castor is processed locally through the traditional method which makes use of little or no modern technology. Here, the seed is separated from the spiny husk by prolonged sun drying in the open until the casing splits or are beaten or rubbed with wooden plank. In most parts of the country, the pods after harvest are collected into heaps over which water is sprinkled to soften the husk and facilitate de-husking.

Prolonged exposure of castor to sun or heat does affect the oil content of the seed. The traditional method of processing castor is tedious, time consuming and low productivity and energy sapping. Castor plant grows optimally in tropical summer rainfall areas. It grows well from the wet tropics to the subtropical dry regions with an optimum temperature of 20°C–25°C. The high content of the oil in the seeds can be attributed to the warm climate conditions, but temperatures over 38°C can lead to poor seed setting. Additionally, temperatures low enough to induce the formation of frost is known to kill the plant (Bassam N.E 2013). As of 2008, three countries (India, China, and Brazil) produced 93% of the world's supply of castor oil. Because production is concentrated mainly in these three countries, total castor production varies widely from year to year due to fluctuations in rainfall and the size of the areas utilized for planting. As a consequence, this concentration has led to cyclic castor production. Thus, diversification of castor production regions and production under irrigation would hopefully reduce the climatic impact on castor supplies (Severino *etal* 2012).

In the United States, the hazardous chemical products found in the castor plant, especially ricin has been a major concern (Severino et al 2012). The body of scientific literature related to castor plants, especially on the detailed processing parameters involved in commercial production, has been relatively small over the past century (Severino et al 2012). Over the years, there has been considerable interest and research done on the uses and properties of castor but not on a commercial scale. Castor oil studies have shown increasing growth with the number of manuscripts increasing six folds since the 1980s (Fig. 1).

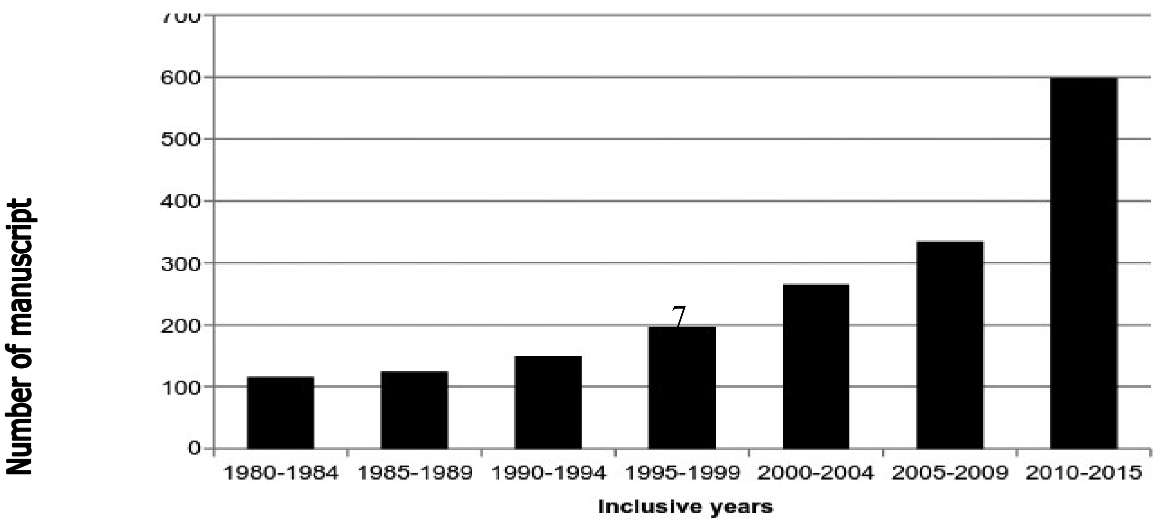

Figure 1: Castor oil studies Showning increasing growth with the number of manuscripts increasing six folds since the 1980s
(Muzenda etal 2012 and Mbah et al 2014)

While alternative breeding programs and marketing can lead to economic growth of castor oil production, at the commercial level, various projects fail due to the lack of knowledge about novel processing methods and parameters used in castor oil production. This manuscript discusses those processing parameters in detail. Although the castor bean processing method can typically be considered a simple process, it can also be complicated if the operators are unaware of its exact processing parameters and operating procedures. Specifically, process parameters for castor oil production should be optimized to achieve high oil extraction efficiency through a solvent extraction method (Muzenda etal 2012 and Mbah et al 2014). No scientific literature currently exists discussing in detail the commercial castor processing parameters. This contribution discusses in detail the commercial castor processing parameters and the important key points needed on how to manufacture the desired quality of castor oil, both of which are important to castor oil producers.

Plate 1. Castor beans.
(Salimon et al 2010)

2.2 Castor Oil and its Properties

Castor beans are cultivated for their seeds (Fig. 2), yielding a viscous, pale yellow nonvolatile and nondrying castor oil (Salimon et al 2010). The physical properties of castor oil is shown in Table 1 below.

Table 1. Physical properties of castor oil.

PHYSICAL PROPERTIES	
Viscosity (centistokes)	889.3
Density (g/mL)	0.959
Thermal conductivity (W/m°C)	4.727
Specific heat (kJ/kg/K)	0.089
Flash point (°C)	145
Pour point (°C)	2.7
Melting point (°C)	-2 to -5
Refractive index	1.480

2.3 Grain Husking/Hulling Process

The husking of grain has been described as the primary refining process by which the texture and culinary properties of such grains are improved by the removal of fibrous seed coats (Onoja U.S 1982, Uzo F.N.A 1981 and Kurien P.P 1977) defined husking or shelling as the process of removing the fibrous coloured hulls of legumes seeds as traditionally practiced as primary process in Asia and African countries where such legumes are grown in large quantities and consumed in a variety of food preparations. It also helps in promoting ease of digestion and effective utilization of nutrient by the body tissue (Siegel,et al 1976). It has been reported that hulling may efficiently shorten the cooking period of grains. The hull contributes very little to the food value hence they can be disposed of (Onoja,U.S 1982). (Manuwa,S.I 2007) reported that commercial processing of legumes is mostly based on the dry process techniques and many of the operations particularly hulling/husking have been mechanized.

2.4 Types of De-husking Machine

(a) The shearing type disc shellers
(b) Types working by attrition mechanism and
(c) The abrasive huller employing carborandum stones or other abrasive devices, are being used in hulling and splitting of legumes (Uzo F.N.A 1981).

Reported the use of types (a) and (b), while (Reichart, et at 1977) gave similar report and suggested a third type which makes use of the roller-milling principles. All three types require pre treatment of the grains. The disc sheller is successfully used for soaked and dried legumes where the husk is fairly loose, while the roller machine is suitable for hulling legumes moistened with water. The abrasive huller has been tested for dry seeds such as cowpea and found effective. The problem with the disc-Sheller is that it results in excessive breakages of grains not graded into uniform sizes. It is for this reason that (Onoja U.S 1982) concluded that the machine is more suitable for the production of hulled splits. However, good design and operation will yield highly split grains. It has been also reported that grains with thick and rough seed coats require a greater force than those with thin ones. The roller machine is therefore generally more suitable for splitting than hulling. Inadequacy of pre-milling treatment is often made-up by the use of greater abrasive force, and hulling is usually achieved after several passes. Moisture on its part has a contrasting effect on hulling and splitting.

A reduction in moisture level helps in achieving hulled whole grains while excessive moisture results in splitting of the grains (Siegel A, et al1976) Some other methods have been applied in West African countries for products such as cowpeas in which the seeds are sorted and agitated until husks are separated out. While some of these methods (*Pius et al.; JSRR, Article no. JSRR.2014.004*927) are applicable to the shelling of castor seeds, majority are not. The husks are thick and ductile and shelling can only be achieved by impact and tearing using roller-milling mechanism.

Description of the [Machine] Castor Sheller is comprised of the following components:

Feeder: This unit comprises of the hopper, whose aperture lays vertical at the base. The hopper has only one of its sides in a slant. Opposite the start side is a vertical side, which has the aperture of the hopper at its bottom. Within the aperture by two feed rollers, the free one is on top of the driven one. The free one is constantly under a vertical force, which tends to compress it downwards upon the lower driven one. At the two free ends of the free roller's axle, are loads, which provide the downward force mentioned earlier. The loads are varied as required. A pulley is attached to the staff of the driven roller. The input for the shaft is taken from the shaft of the thresh comb via a v-belt.

The Threshing Unit: It is comprised of the thresh comb. This is made up of a shaft upon which small rods (tongs) are welded to it in a line at intervals. There are two of such lines-each welded to opposite sides of the shaft. Each of the tongs is carved to forming an arc of small curvature. The shaft rests on ball bearings of each end. Attached to one of the ends of the shaft is a pulley for drive. The pulley/shaft rotates in the direction of carve of the tongs. Just a distance beneath the thresh comb is a sloppy tray which slopes downwards into a trench. The trench is also sloppy in the direction perpendicular it the direction of slop of the tray. The trench ends as a sprout.

Blower Unit: The blower is located just under the hopper and opposite the slope of the tray. It is a centrifugal fan and is comprised of four straight impellers attached to the shaft, all in an in volute casing. A pulley is attached to the shaft at one of the ends.

Power Transmission Unit: This is composed of a 5HP electric motor. The 5HP electric motor transmitted power to shelling unit and blower unit both are interconnected by pulleys and belts. Belt and Pulley: The belts and pulley was selected based on the speed of the driving motor, speed reduction ratio, centre to centre distance between the shafts at the condition under which the shelling action must take place. An ac motor with 1440 rev / min (24 rev / s) was used with a pulley diameter of 50 mm. The shelling unit of 282 rev / min (5 rev / s) is desired. A low speed of shaft rotation is expected during shelling and blowing operations since the castor seed is fragile and his chaff is lighter in weight.

The Frame: The frame of the machine is fabricated with mild steel angle iron.

Work Principle of the Machine: The machine is put on with the aid of an electric switch connected to the electric motor. It is left to run for 60 seconds before it is loaded with castor pods by feeding manually through the hopper. The pods slide into the shelling unit which rotates of 600 rpm. The reaction, abrasion and impact forces between the sieve, pods and raps bars force the pods through the geometry on the sieves causing removal of the shells from the pods. The seeds and the chaff falls under gravity to the blower unit which supplies the needed amount of air for seed and chaff separation to take place. (Agidi et al,2016)

3. MATERIALS AND METHODS

The principle element in the design of the castor seed shelling machine is the milling shaft. This should be made of material that is suitable for conditions of service as well as the loads and stresses that are accurately calculated. The shaft material chosen for this project was the plain (medium) carbon steel (080M40), which contains between 0.4 to 0.46% carbon. This was because of its enhanced strength, hardness, and good ductility through heat treatment and moreover, its low cost and availability.

3.1 Method

Different engineering drawings to highlight the stages of the work and show how it will look after fabrication. This describes the step by step procedure used in the fabrication

1. **Hopper**: This is a funnel shaped device used to move materials from one receptacle to another. The design of the hopper involves the mapping and dimension using a sheet metal of mild steel.
2. **Fan/Blower**: This blows off the shelled chaff from the seeds. It is placed under the shelling chamber and it is directly beside the discharge sprut.
3. **Petrol Engine**: This is the prime mover that supplies the power to the machine that makes the shelling and dehusking work. This transfers energy from the shaft via the pulley through the belt to the machine.
4. **Shelling Chamber:** The shaft having the attachment of the crusher is seen. It separates to the husk from the seed via an impact force on the walls of the shelling chambers.
5. **The Frame**: This carries the petrol engine, the blower and the hopper in fact it is the skeleton of the machine.
6. **Shaft, bearing and housing**: This helps in rotary movement of the machine with the help of the petrol engine that powers it.

Fig 2: Side View of the Machine with the Blower

Fig 3: Side View Of The Machine With The Blower

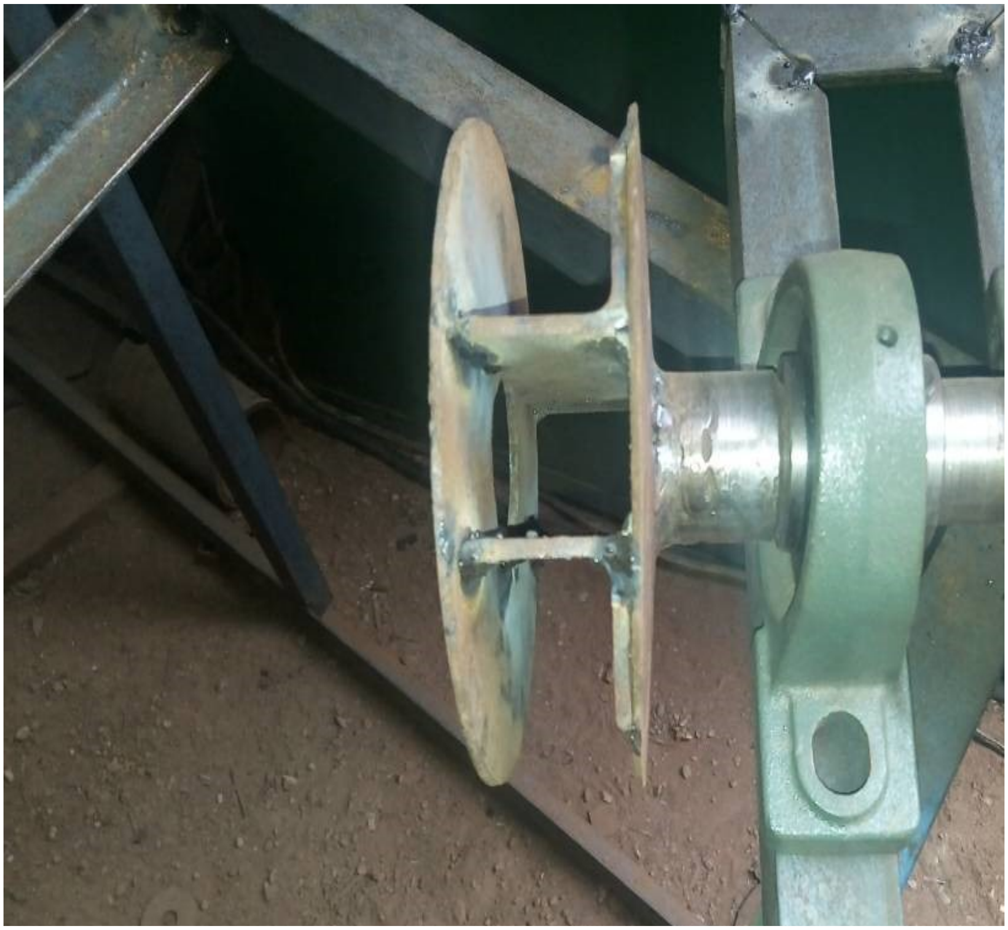

Fig 4: Plan of The Shaft And Bearing Housing

Fig 5: Front View Of The Shaft And Crusher

Fig 6: Pictorial View of the Equipment

Fig 7: The Blower

Fig 8: The Prime Mover Or Engine Side Of The Machine

3.2 Maintenance and Repairs

Maintenance can generally be defined as a combination of actions carried out to retain an item in or restore it to an acceptable condition. It can also be seen as the operation that is done to put items to a near new state after a period of time alternatively. Maintenance is an important aspect of logistics and include those activities needed to keep weapons, vehicles and other materials in operable conditions when necessary or to improve their usefulness through modification; such maintenance activities include inspection, testing classification as to serviceability, adjustment, servicing, recovery, excavation, repair, overhaul and modification.

1. The machine is maintained periodically to avoid it being broken down, untimely; this involves testing lubrication, inspection of the equipment minor adjustment performed.
2. Organizational maintenance involves recovery, evacuation, inspection, troubleshooting and replacement of worn-out parts this is done if there is breakdown of parts of the machine.

3. In case of depot maintenance, it involve complete rebuilding of the entire machine or assembly this makes for continuous processing by the machine with increased efficiency.

3.3 Maintenance can be classified into four basic parts, namely:

1. Emergency or breakdown maintenance
2. Planned maintenance
3. Correction or repair maintenance
4. Preventive maintenance

21

1. Emergency or breakdown maintenance

This is an unplanned maintenance which is carried out as a result of equipment or infrastructural breakdown to bring the equipment or infrastructure back to life. This type of maintenance could be avoided in most cases if be avoided in most cases if and only if adequate maintenance scheduled in form of planned maintenance. Emergency breakdown gives rise to loss of productive hours exclusive damage to assets or other components as well as hazards.

2. Planned maintenance:

This is maintenance organized and carried out with fore thought control and the use of records to predetermined plan. The principal objective of maintenance is the upkeep of equipment and infrastructure in good working condition in order to make it available for use on continuous bases, for an equipment to be operational always, the tear and wear arising from usage and weather changes must be assessed properly and addressed appropriately. Note that preventive maintenance is normally planned while corrective maintenance may or may not be planned.

3. Correction or Repair Maintenance

This is the type of maintenance carried out in equipment or infrastructure that has ceased to perform, so as to restore it to an acceptable good working condition, it is sometimes called repair and is conducted to get equipment working again.

4. Preventive Maintenance:

This is maintenance carried out at predetermined interval or to other prescribed criteria so as to reduce the likelihood of an equipment or infrastructure not meeting an acceptable standards, preventive maintenance has the following meaning care, servicing, test measurement, adjustments, and parts replacements. 22

4. RESULTS AND DISCUSSION

The machine was test run and it was found to de-husk 1000g of castor bean seed in 62.03sec. The machine was first run under the no load condition using the prime mover of 2500rpm of petro unit, the no-load test was carried out to ascertain the smoothness of operation for the machine rotating parts, the actual test was conducted using castor bean seeds, the testing of the machine was targeted at evaluating its shelling efficiency, cleaning efficiency percentage, losses and seed recovery. 3000g of castor bean seed was obtained from the market and it was divided into three equal sizes with the digital scale of 1000g each, the test was carried out using the 1000g sample and repeated two more times.

CASTOR SEED SHELLED TABLE
Table 1:

Weight of Castor Bean (A) g	Weight of Castor Seed (B) g	Weight of Castor Not shelled (C) g	Weight of Chaff not blown out (D) g	Weight of Chaff blown out (E) g	Time (F) Sec.	Efficiency %
1000g	725.80	120.10	82.20	69.30	63.01	72.58
1000g	737.20	119.20	78.20	61.40	63.07	73.72
1000g	725.50	121.15	74.30	73.70	60.02	72.55
AVERAGE	729.5	120.15	78.23	68.13	62.03	72.95

Table 2:

Parameters	Aggregate Castor Bean
Shelling efficiency %	84.96
Percentage Loss %	0.39
Seed recovery rate (%)	99.61
Mass flow rate (kg/s)	16.06

4.1 Discussion

The performance test carried was to determine the efficiency of the machine using castor bean seed, Table 1 gives the average weights of castor seed, shelled castor seed; not shelled, chaff not blown out, chaff blown out for the three samples of castor seeds, the average weights of castor seed shelled, castor seed not shelled, chaff not blown and chaff blown out recovered after de-husking, and shelling castor seeds are 729.5g, 120.15g, 78.23g and 68.13g respectively, this shows that the shelling efficiency and seed recovery rate was high and the average time used for the three samples was 62.03 seconds, Table 2 gives the summary of the results for the de-husking and shelling of castor seed, the percentage shelling efficiency, percentage loss, seed recovery rate and the mass flow rate are given as 84.962%, 0.39%, 99.6% and 16.06 kg/s. The average time for the constructed machine for de-husking and shelling 1000g of castor seeds was 62.03 seconds, therefore the constructed machine reduced the drudgery involved in manual shelling with a saving in operating time. Also from the test carried out, the shelling efficiency, percentage loss, seed recovery rate and mass flow rate were calculated as 84.962%, 0.39%, 99.61% and 16.06 kg/s respectively. The shelling efficiency was normal but need to be improved on, during subsequent work, the percentage loss is 0.39% for a locally fabricated machine, the seed recovery rate was high showing that 99.61% materials was recovered and the mass flow rate was normal which shows that the fabricated machine saves time in de-husking and shelling castor seed.

The performance evaluation of locally developed castor fruit and seed de-husking and shelling machine was successfully carried out, the machine was evaluated using castor seed and the following results obtain as shown in tables overleaf.
The shelling efficiency of the machine differs significantly at different drum speeds of the machine.

5.1 Test Results Calculation

Using the approach adopted by Onyechi et al(2014).

- Percentage efficiency – $\frac{B+C}{1000} \times \frac{100}{1}$ (1)

- Percentage loss = $\frac{1000 - B+C+D + E \times 1}{1000} \times \frac{100}{1}$ (2)

- Seed Recovery = $\frac{B+C+D+E}{1000} \times \frac{100}{1}$

- Mass flow rate = $\frac{B+C+D+E}{1}$ (3)

Castor Seed Shelled Calculations

Average Weight of Castor Seed = $\frac{725.80 + 737.20 + 725.50}{3}$ (4)

$= 729.5g$

Average Weight of castor seed Not shelled = $\frac{120.10 + 119.20 + 121.15}{3}$ (5)

$= 120.15g$

Average Weight of Chaff Not Blown out = $\frac{82.20 + 78.20 + 74.30}{3}$ (6)

$= 78.23g$

Average Weight of Chaff Blown Out = $\frac{69.30 + 61.40 + 73.70}{3}$ (7)

$= 68.12g$

Average Time (Sec) = $\frac{63.01 + 63.07 + 60.02)}{3}$ (8)

= 62.03 Seconds

Digital Innovations
& Contemporary Research in SCIENCE, ENGINEERING & TECHNOLOGY
Vol. 8. No. 2, 2020

$$\text{Shelling efficiency \%} = \frac{B + C}{1000} \times \frac{100}{1} \tag{10}$$

$$= \frac{729.5 + 120.15}{1000} \times \frac{100}{1} \tag{11}$$

$$= \frac{849.65}{1000} \times \frac{100}{1} \tag{12}$$

$$\text{Percentage efficiency} = \frac{849.65}{1000} \times \frac{100}{1} \qquad = \frac{0.84965 \times 100}{1} \tag{13}$$

$$= 84.965\%$$

$$\text{Percentage Loss} = 1000 - \frac{B+C+D+E}{1000} \times \frac{100}{1} \tag{14}$$

$$= 1000 - \frac{729.5+120.15+78.23+68.13}{1000} \times \frac{100}{1} \tag{15}$$

$$= 1000 - \frac{996.01}{1000} \times \frac{100}{1} \tag{16}$$

$$= \frac{3.99}{1000} \times \frac{100}{1} \qquad = 0.39\% \tag{17}$$

$$\text{Seed Recovery rate} = \frac{B+C+D+E}{1000} \times \frac{100}{1} \tag{18}$$

$$= \frac{729.5 + 120.15 + 78.23 + 68.13}{1000} \tag{19}$$

$$= \frac{729.5 + 120.15 + 78.23 + 68.13}{1000} \times \frac{100}{1} \tag{20}$$

$$= \frac{996.01}{1000} \times \frac{100}{1} \tag{21}$$

$$= \underline{99.60\%}$$

$$\text{Mass Flow rate} \quad = \frac{B + C + D + E}{T} \quad = \frac{996.01}{62.03} \tag{22}$$

$$= \underline{16.06\ kg/s}$$

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The performance evaluation of locally fabricated castor bean seed, de-husking and shelling machine was successfully carried out. The Machine was evaluated using castor seeds and the following results, obtained, shelling efficiency 84.96% percentage loss, 0.39% seed recovery rate, 99.61% and mass flow rate 16.06kg/s. This shows that for the machine, the efficiency is normal, but need to be improved on subsequent work, the percentage loss is okay for locally fabricated machine, the seed recovery rate was high. Showing that 99.61% materials of castor bean seed was recovered showing that the fabricated machine saves time in de-husking and shelling castor seeds.

5.2 Recommendation

Further studies should be carried out using two different samples of the castor bean seeds, to know the exact time expended for its shelling and de-husking, more-so, alternative power source for powering the machine is recommended. Further studies should be carried out in the following areas:

- Use of different samples of castor bean seed to run the test (Large and Small Sample).
- Use of alternative energy to power the machine (e.g. solar, and gasoline engine).
- Make the machine to be mobile by putting tyres or rollers to its base.
- Introduction of damper to reduce vibration of the machine.
- The winnowing fan may be arranged to be independent and blower used instead for increased performance.
- Larger frame that will bring more stability of the machine is also recommended.

REFERENCES

1. Food and Agricultural Organisation of the United Nations (2008): Economic and Social Department. The Statistical Division. http://en.wikipedia.org/wiki/Castor_oil_plant. Retrieved June, 2012.
2. Agidi Gbabo, Abdullahi Lukman, Alhassan Kuku and Ndagi Baba (2016). Design and Performance Assessment of a Spike toothed Drum Mechanism for Shelling of Castor. National Cereals Research Institute, Badeggi, Bida, Niger state, Nigeria
3. Arnold, H. A. and M. A. Sharp (1944). The Improved Castor..Bean Shelle~Description, Operation, and Adjustment of the 24·inch Sheller and Separator The University of Tennessee Agricultural Experiment Station.
4. Gideon, C. A. (1965): Castor Cultivation in India, India Central Oil seeds Committee Hyderabad, India.
5. Gupta, R. K and Das, S.K (1997): Physical Properties of Sunflower seed. Journal of Agricultural Engineering Research. (p. 66, 85-91) http://www.billcasselman.com/cwod_archive/beaver_castor_two.htm. Retrieved 2012-06-14.
6. Lewis, W. H and Elvin-Lewis, M. P. F (1977): Medical Botany: Plants Affecting man's Health. John Wiley and Sons New York.
7. Marter, A. D. (1981): Castor - Markets utilization and prospects. Tropical Production Institute London.
8. Mohsenin, N. N. (1984): Physical Properties of Food and Agricultural Materials. A Teaching Manual, Gordon and Breach Scientific Publishers New York.
9. Nkpa, N. N Arowolo, T. A and Akpan, H. J (1989): Quality of Nigerian Palm oil after bleaching with local treated clay, JAOCS, Journal of the American Oil Chemists' Society.
10. Onoja US. Dehulling of Cow Pea II (Vigna Unquiculate), A Master Degree thesis Department of Food Science Technology, University of Nigeria; 1982.
11. Phillips, R., Martyn, R., (1999). *Annuals and Biennials*. London: Macmillan. p. 106. ISBN 0-333-74889-1.
12. Onyechi, C. P., 1, S. P. Obuka Nnaemeka1*, Okpala Charles1, N. Oriah Vincent2 and A. Igwegbe Chinenye (2014). Journal of Scientific Research & Reports 3(7): 924-938, 2014; Article no. JSRR.2014.004 SCIENCEDOMAIN international www.sciencedomain.org
13. Popova, E.V (1963): Castor Oil plant, Lenin Academy of Agriculture Scientific and Industrial Application. Botany Men, Culture Lenin, U.S.S.R.
14. Sahaya, K. M and Singh, K. K (1994): Unit Operations of Agricultural Processing. Vikas publishing house PVT. Limited Jang Puna, New Delhi, India.
15. Schoenleber, L.G and W. E Taylor (1954): Development of a portable Castor Bean huller Agric Engineering Journal p.35, 237 326.
16. Sharma, P. C and Aggarwal, D.K (1998): Machine Design (Mechanical Engineering Design) in S.I Units S. K. Kataria and Sons publishers and Book Sellers, Delhi, India.
17. Simpson, B. B. and M. C. Ogorzaly (1986): Economics Botany: Plants in our World. M. C Graw-Hill, New York.
18. Weiss, E. A. (1983): Oil Seed Crops. Tropical Agricultural Science, Longman London.
19. Windholz, M, S. Budavari, R. F, Blumetti and E. S OHerbein (1983): The Merck index; An Rahway Encyclopedia of Chemicals, Drugs, and Biological, Merck and Co inc., New Jersey.
20. Zahir A.A., Rahuman A.A., Bagavan A., Santhoshkumar T., Mohamed R.R., Kamaraj C., Rajakumar G., Elango G., Jayaseelan C., Marimuthu S. (2010): Evaluation of botanical extracts against Haemaphysalis bispinosa Neuman