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DEVELOPMENT OF YAM MINISETT PROCESSING MACHINE

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A B S T R A C T

This study involves development and performance analysis of a yam minisett processing machine for effective yam production. The minisett cutting technology was developed to advance projectile cutting profile motion required for yam minisett processing as obtained in the native technique. The machine comprising the frame, speed reducer, pulley, belt, crank mechanism, connecting rod, hopper, seed yam carrier, cutting blades, and discharge chute, average length and breadth of the seed yams used for designing the minisett processing machine was also determined as 247.80mm and 66.75mm respectively. All materials used in the fabrication of this machine were sourced locally, and the estimated cost for producing one unit of the machine is Two hundred and eighteen thousand, five hundred naira only (N218, 500.00). Performance analysis results show that the crank shaft speed, connecting rod length and the number of blades were used as functional operational parameters while the machine capacity and efficiency are the functional performance indicators of this Yam minisett processing machine. The results show that the machine operates at an optimal efficiency and capacity of 96.24% and 28,888minsett/hr respectively, obtained at a crank shaft speed of 10-80rpm, connecting rod length of 470-540 mm and cutting blade number settings of 13.

1. INTRODUCTION

Yam is a tuber crop found mostly in West Africa and the Caribbean. It is known botanically as *Dioscorea*. It is among the major root crops consumed by rural and urban communities of West Africa. In Nigeria, especially among the people of South Eastern Nigeria and some tribes in Rivers State, yam is the most celebrated carbohydrate food, superseded only by cassava when it comes to the area of land under cultivation (Chukwu & Ikwelle, 2000), whose major function is to supply calories to the body. Amongst crops planted in Nigeria, yam is the fifth most cultivated and harvested. It comes behind cassava, maize, guinea corn, and cowpeas (Adesin et al., 2020). In the tropics, it is the third most produced and harvested root and tuber crop with cassava and potato ahead of the list presented by NBS - National Bureau of Statistics (2012).

Aighewi et.al. (2014), noted that yam plays an important role in the growth of the society as it provides cash and dietary carbohydrate to millions of people. Apart from its carbohydrate values, yams also have high medicinal and nutritional values. Some of its nutritional contents include: potassium 816 mg, Manganese 4.40 mg, Vitamin E 0.39 g, Vitamin K 2.6mg, Beta Carotene 83mg, copper, fiber and antioxidants. These values are high, compared to the amount of nutrient contents found in major staple foods such as cassava, sweet potato, plantain, rice, wheat, potato, soybean, sorghum, and maize (Akubuilo et al., 2007). This further shows that its importance cannot be over emphasized.
There are several ways of preparing yam tuber for consumption. These processes include: baking, boiling, frying, processing into flour for the preparation of "Amala", processing into porridge, or even pounding into meal (pounded yam) and eaten with soup. (Verter & Beavarova, 2014). Apart from its nutritional values, yam

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has strong social and traditional values. In some Igbo communities in Nigeria, it is associated with a deity, Njoku (god of yam); and the yam festival is celebrated yearly in honor of this deity. It is also used in many traditional rituals and sacrifices (Agbarevo & Nwachukwu, 2014).

Nigeria is the world's largest producer of yam with an annual production of more than 27 million tonnes. This is about 65% of the world's annual production (FAO, 2013; FAO 2019). Although this sounds like a lot, studies show that the potentials in yam production are yet to be optimized. (Verter & Becvarova, 2014). FAO (2013), pointed out correctly, that the food deficit which is the order of the day in the country would have been effectively reduced if enough efforts were made by every stakeholders in the agricultural sector to increase the productivity of tuber and root crops. Due to the negligence, over the years, the yam industry, despite having made a certain level of profit, has been greatly affected by lots of factors, among which the notable ones include unavailability of planting material and high production costs which are also associated with the unavailability of good quality of seed yam; among others, (Ajieh, 2012). Traditional method of yam planting involves the use of small, whole tubers known as the seed yam. These seed yams weigh between 500g to 1500g. Although small, when they are due for harvest, they yield the large marketable ware yams, (Nweke & Ezumah, 2012).

In reality, yam planting material (seed yams) is often difficult to obtain, they are expensive and sometimes, the seed yams are of low quality (Chukwu & Ikwelle, 2000). Further research made by Ogbonna et al. (2011) reveals that the high cost of planting material is majorly due to the low seed-tuber ratio in yam production. In view of this short supply of seed yam, farmers during harvest, often reserve some portion of their ware yam (meant for consumption) as the subsequent season's planting material. Oguntade et al. (2010), observed that the traditional methods of seed yam production have some economic disadvantages as it result to competition between edible and saleable tubers and the tubers used as planting material. Hence, the annual wave of yam seed scarcity in this region (Orkwor et al., 2000).

In a bid to find a lasting solution to the problem of unavailability of good quality seed yam, researchers in the National Root Crops Research Institute (NRCRI) Umudike, Nigeria and International institute of Tropical Agriculture (IITA) Ibadan, also in Nigeria developed a method called the yam minisett technique (NRCRI, 1985). This engender large-scale production of seed yams, although the merits of this seed yam production technology are numerous but its level of adoption by farmers is low due to high risk of non-germination of minisetts and laborious features of manual cutting process which is involved in it, also the high cost of tubers are so much to contain. The manual cutting of the mother yam into minisetts using knife is prone to accident and also tedious, energy sapping, time consuming, resulting to inconsistency in the shape and size. Hence, effective mechanization of this cutting process constitutes the desire of stakeholder in this sector.

The yam minisett technique involves the cutting of "mother" seed tubers into small setts (called minisetts) weighing about 25-100 g, as shown in Figure 1. Each of the minisett must possess a reasonable amount of peel (periderm), it is where the sprouting occurs (Ironkwe et al., 2008; Kalu et al., 1989). After cutting, the minisetts are treated with chemicals so as to protects it from diseases and pests (Emokaro & Law-Ogbomo, 2008). Then it is planted, after which it produces small whole seed tubers at its due season, which are called seed yams. In turn, the seed yams are planted to produce ware tubers used as food.

Figure 1. Cutting of a yam tuber into minisetts.

According to Aighewi et al. (2014), there is a positive correlation between the size of the minisett planted and the size of the seed yam produced. Akubuo (2002) described that two basic steps are involved in cutting seed yams into minisetts. The first step consists of cutting approximately 2cm thick section perpendicular to the yam tuber axis, the second step is cutting each section into four quarters along two perpendicular diameters of the disc.

Akubuo (2002), wrote that when the Yam minisett technique (YMT) was first introduced, most extension services recommended that the farmers should use minisetts of about 25g, which they must first plant in a nursery till they pre-sprout. It was not until the early 2000s that researchers developed an adaptation of the YMT which employed the use of larger minisett size that can be planted directly into the field without it passing through the nursery stage (Okoro, 2008). This modified version of YMT is called the Adaptive Yam Minisett Technique (AYMT). In the AYMT, the yam tuber is cut into minisetts of about 50g to 100 g of which are planted directly into the field. One major difference between the YMT and the AYMT is the flexibility associated with AYMT.

Although the yam minisett technique has been in existence since the 1970s, no machine has been specifically developed for cutting the yams into minisetts. Nonetheless, there are still other tuber related

inventions that run on ideas that can be applied in developing the yam minisett machine. Cassava chipping machine by Bolaji et al. (2018) basically uses shear strength developed through rotational motion of its blade to cut cassava into chips. A potato cutting machine is used for cutting potatoes, sweet potatoes into strips, chips and crinkle type (Ashby, 2011). In Bangladesh, Design and development of a manual potato cum sweet potato slicer by Hoque and Saha (2017) from Farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research institute.
Hoque and Saha (2017) went ahead to make the slicer to be manually operated and power was transmitted to the blades through the shaft via rotating handle.
Potato slicing machine of Aremu et al. (2017) was insinuated that the materials used for the construction of this potato slicing machine were sourced locally; Turmeric slicing machine by Tanimola et al. (2019) for cutting and slicing turmeric which is essential in pharmacological or biological activities. Turmeric cutting machine by Murumkar et al. (2016) was designed and fabricated by The All India Coordinated Research Project on Post-Harvest Engineering and Technology developed. Ginger rhizomes splitting machine by Simonyan et al. (2014) consisting of frame, feeding unit, pressing mechanism, splitting mechanism, power transmission and discharging unit operates on the slider crank mechanism based on sawing principle to split ginger rhizomes.
Motorized yam slicer by Ehiem and Obetta (2011) reduces tubers of yam into smaller thickness for faster drying. There are many machines use to cut tuber crops as earlier described, however, none is suitable for minisett cutting process because some of the machines were designed for post-harvest food processing thereby fabricated with stainless material which is costly (Morse & McNamara 2017). The existing machines cannot be used for minisett cutting because there are designs for slicing root crops either circular or stripes but minisett cutting is done by both horizontal and longitudinal cutting at the same time. The process of cutting blades moving in a particular direction cannot give a minisett cut thereby a minisett cutting machine with cheaper locally available materials and the cutting process arranged in a way that both horizontal and longitudinal cutting can be done at instant in consideration of the engineering properties of the crop is highly needed to assist farmers in practicing minisett technique.

2. MATERIALS AND METHODS

2.1. Description of the developed Yam minisett processing machine.

The developed machine comprises mainly of the following parts as shown in Figure 2: the frame, speed reducer, pulley, belt, crank mechanism, connecting rod, hopper, seed yam carrier, cutting blades, and a discharge chute.

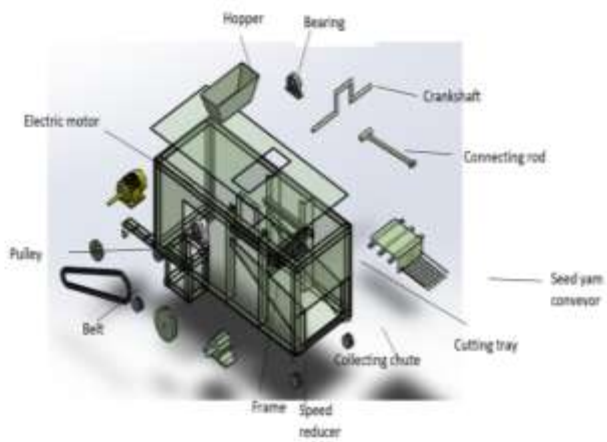

Figure 2. Parts of the yam minisett processing machine

The yam minisett cutting machine is powered by an AC source from the supply mains. This power is supplied to a 5hp electric motor which in turn provides the energy required to operate the machine. Through the use of an A-type V belt, 150mm pulley on the electric motor and a 300mm pulley on the speed reducer, the rotational motion generated in the electric motor is transmitted to a speed reducer which helps to generate enough torque required to cut the yam into minisetts. It achieves this by reducing the speed of the motor by a ratio of 20:1. The speed reducer is connected to a crank shaft mechanism which converts the rotational motion of the speed reducer into the required translational motion.
The crank shaft is a 25mm diameter mild steel rod with a length of 617mm and is supported on both ends using ball bearings. The translational motion created by the crank shaft moves the connecting rod to and fro the machine (like a piston). The connecting rod is a 5mm thick mild steel bar with a length of 467mm. A metal plate of length 300mm and width 80mm is attached to the free end of the connecting rod. This plate is known as the yam carrier. With the help of the connecting rod, the yam carrier guides the yam from the output end of the hopper to the cutting blade and also provides the force/push required to cut the yam into minisett. The movement of the connecting rod opens and closes the output end of the hopper (closing during its forward movement to the cutting tray and opens when the connecting rod gets back to its initial position).
The frame is the main supporting structure upon which other components of this machine are mounted. The frame is a welded section constructed with 2.5mm thick angle iron and covered with a 1.5mm thick mild steel plate. The hopper, shafts, discharge chute, crank mechanism and speed reducer are mounted on the frame while the electric motor is mounted on a motor sitting, welded to the side of the frame.
The yam to be cut into minisetts is first cleaned to remove the soil that sticks to its body, through any economic effective means, considering not peeling the outer layer of the yam. After which it is introduced horizontally into the hopper, it fall into the processing tray as the output end of hopper is open. The running machine carried the yam by the yam carrier, the yam guided by the connecting

rod and forks like carrier, pushes the yam to the point where the cutting blade is arranged and stationed. Cam mechanism was applied in the machine.

The arm length (or travel distance) of the connecting rod (with the yam carrier attached to it) is designed to be just half an inch less than the distance of the cutting blades position, At the surface of the yam carrier, small poles of about 2.54cm in length were welded to it Together, this system makes sure the yam completely passes through the cutting blade. The cutting blade is designed in a way that allows it cut the yam both horizontal and circular at the same time, into several minisett of about 25g.

Figure 3. The yam minisett processing machine

After being cut into minisett, the processed yam falls out through the other side of the cutting blade into the discharge chute from where it is collected using a container. The yam minisett processing machine is shown in figure 3.

2.2 Design analysis of the machine

2.2.1. Design Considerations

The design, material selection and development of the Yam minisett cutting machine were based on the following concept and considerations:

i. The machine was designed to process only yam tubers into minisetts. Hence, the yam to be processed must be made free from soil before being fed into the machine. This aids easy processing and also preserve the longevity of the cutting blades.
ii. The cutting blades are arranged in the cutting tray in a way that the yams will be cut into minisett sizes weighing about 25g.
iii. The discharge chute was inclined at an angle greater than the angle of repose of yam minisett with steel.
iv. The maximum size of yam that can be used for the minisett technique was considered in the design of the hopper.
v. The principle of two stroke engine was used in the design of the hopper and the crank mechanism. Hence the hopper opens and closes as the connecting rod translates from one end to the other.
vi. The shaft used as the connecting rod is selected to be able to exert force greater or equal to the force required to cut seed yam by a sharp stainless blade and also greater than the opposing force of seed yam per area.
vii. The length of the connecting rod in relation to the yam travel distance was considered in the design so as to ensure the complete cutting of the tuber into minisett.
viii. All parts of the developed machine were fabricated using locally sourced and available materials for easy operation and maintenance in case of breakdown.

The power transmission system of the developed yam minisett cutting machine consists of; Electric motor, which transmitted motion to the speed reducer through belt and pulley arrangement, this turned the crankshaft which transmitted a rotational to the connecting rod where the motion was converted to linear motion and pushed the yam carrier to and fro as seen in Figure 4

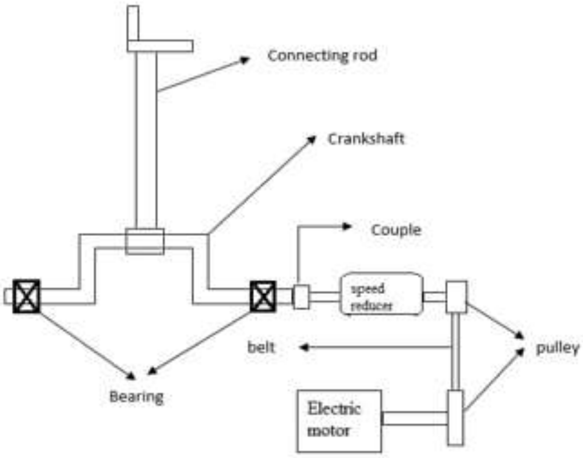

Figure 4. Power transmission system of the developed machine (plan view)

Since the shape of a yam is like a rectangle, the hopper was designed to have rectangular openings. The average length of a seed yam tuber was considered in the design of the hopper. During the design, ten seed yams weighing about 8kg were considered, and their length and breadth obtained using a measuring tape and weighing balance. Table 1 shows the length and width of each seed yam specimen.

Table 1. Length and width of each seed yam specimen

Specimen No	*Length (mm)*	*Width (mm)*
1	270	58.7
2	283	63.3
3	222	64.7
4	263	59.2

5	278	68.9
6	246	72.6
7	200	74.3
8	196	69.4
9	240	71.4
10	270	65.0
Average	**247.80**	**66.75**

The average length of a yam tuber was obtained as 247.80mm while its breadth was obtained as 66.75mm. Based on these, the outlet of the hopper was designed to have a rectangular shape, with a dimension of 300mm by 90mm (allowance included). The inlet was unanimously chosen to have a dimension of 450mm by 120mm. The distance between the inlet and the outlet was chosen as 150mm, which is more than twice the average width of a yam.

2.2.2. Selection of pulleys, belts and determination of their speeds

The machine requires two pulleys; one is mounted on the electric motor shaft while the other was mounted on the speed reducer. Due to its availability, cost and performance, mild steel pulleys with groove angle of 38^0 each were selected. The power developed by the 1600rpm electric motor is transmitted to the speed reducer with a speed ratio of 20:1 through a belt drive comprising of pulleys of diameters, 150mm (mounted on the electric motor) and 300mm (mounted on the speed reducer). These pulley diameters were selected based on standard speed ratio from literature (Khurmi & Gupta, 2005).

The speed of the shaft on the speed reducer and the crank shaft were determined as 800rpm and 40rpm respectively using equation 1. (Khurmi & Gupta, 2005).

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \tag{1}$$

Where ;

D_1 = Diameter of the driving pulley
D_2 =Diameter of the driven pulley.
N_1 = Speed of the driving pulley in r.p.m
N_2 =Speed of the driven pulley in r.p.m

The design center distances between the electric motor and the speed reducer was determined as 566mm, using equation (2) (Sharma &Aggarwal, 2006).

$$C = \frac{1.5D_2}{VR^{1/8}} \tag{2}$$

while the minimum length of the belts required to drive the speed reducer shaft was determined as 1838.57mm using equations (3) (Khurmi & Gupta, 2005; Sharma & Aggarwal, 2006).

$$L = 2C + 1.57(D_2 + D_1) \quad + \frac{(D_2 - D_1)^2}{4C} \tag{3}$$

Where*:*

L = Belt length in inches
C = Center distance between two pulleys in inches
D_1 = Diameter of the driving pulley
D_2 =Diameter of the driven pulley.
VR = Velocity ratio of the both pulleys
P = Pitch of the belt

By assumption, the power transmitted by the drive should not exceed 3.75KW (Khurmi & Gupta 2005; Degarmo et al., 2003: Sharma & Aggarwal, 2006). Hence "type A" V-belt with standard pitch length of 1941mm (IS: 2494-1974 standard) and coefficient of friction, μ of 0.3 was selected. The actual center distance between the motor and speed reducer pulleys was obtained as 617.2mm using equations 4 - 6 (Sharma et al.1985; Khumi & Gupta 2005; Sharma & Aggarwal, 2006).

$$C = p + \sqrt{p^2 - q} \tag{4}$$

$$p = \frac{1}{4} - \frac{\pi}{8}(D_2 + D_1) \tag{5}$$

$$q = \frac{(D_2 - D_1)^2}{8} \tag{6}$$

The angle of contact of the driven pulley was determined as 166° using equation 7 while the peripheral velocity of the belt was determined as 12.566m/s from equation 8.

$$\theta = 180 - 2\left[sin^{-1}\left(\frac{D_2 - D_1}{2C}\right)\right] \tag{7}$$

$$v = \frac{\pi D_1 N_1}{60} \tag{8}$$

2.2.3. Determination of belts tensions and shaft diameters

Tension in tight and slack sides of the belt ($T_1$and T_2) were obtained as 155.4 N and 10.75 N respectively for the motor and speed reducer respectively using Equations 9 - 13 respectively (Burr & Cheatham 2002; Khurmi & Gupta, 2005; Sharma & Aggarwal, 2006).

$$T_1 = T_{max} - T_c \tag{9}$$

$$T_{max} = \sigma \text{ x } a \tag{10}$$

$$T_c = mv^2 \tag{11}$$

$$2.3 \log\frac{T_1}{T_2} = \mu\theta cosec\beta \tag{12}$$

Assuming the grove angle of the pulley, 2β =38° and β=19°

Where:

θ is the angle of contact of the belt between the two pulleys (rad)
T_{max} = Maximum tension on the belt
T_c = Centrifugal tension on the belt

Torque on the crank shaft was determined as 21697.5Nmm using equation 13.

$$T = (T_1 - T_2)\frac{D_2}{2} \tag{13}$$

2.2.4 Crank shaft:

The crankshaft has a speed reducer on one end, with its other end pivoted on a ball bearing. The connecting rod or conveyor is attached at the center of the crankshaft. The forces acting on the crank at angle of rotation are illustrated in figure 5.

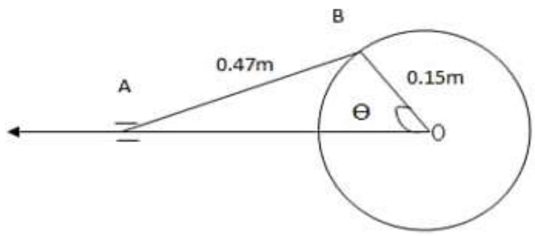

Figure 5. Free body diagram of the crank and the connecting rod

The connecting rod AB is a mild steel circular bar of length 0.470m, width 0.025m, thickness 0.005m and a density of 7850kg/m^3. The length of the connecting rod was chosen in relation to the yam travel distance so as to ensure the complete cutting of the tuber into minisett. The crank has a radius of 0.15m. Using the relative velocity method (Kurmi & Gupta, 2005), the velocity V_{AB} of the connecting rod was obtained as 2.7m/s with equation 14. The inertia force acting on the rod was obtained using equation 14 and 15 as 4.6N.

$$\rho = \frac{m}{l x b x t} \tag{14}$$

$$F_i = m \times g \tag{15}$$

Where,
g = acceleration due to gravity, $10m/s^2$
ρ= density of connecting rod.
l, b, t represents length, width and thickness respectively.

2.2.5. Determination of number of blades

The number of the fixed blades (S_n) were determined as 16 using the expression adapted from Adebayo et al. (2014) as:

$$S_n = \frac{l_s}{s_t} \tag{16}$$

Where:
S_n = the number of blades on the tray
l_s= length of the tray with blades = 320mm
S_t = the desired thickness of minisett (spacing of blades) = 20mm for 25g yam minisett (Akubuo, 2002).

2.2.6. Selection of electric motors

The power required to drive the machine was obtained as the sum of the power required to drive the belt, $P_1$and the power required to drive the crankshaft, P_2.$P_1$was determined as 1.816KW using equation 17 and P_2 was determined as 1.817KW using equation 18. Hence, power required to drive the entire machine was determined as 3.634KW (4.86hp) using equation 19 (Khumi & Gupta, 2005; Sharma et al. 1985). Taking care of 10% possible power loss due to drives friction, the power required to drive the yam minisett processing machine, A 5hp single phase electric motor was therefore used as the prime mover of the machine.

$$P_1 = \frac{(T_1 - T_2)V}{1000} \tag{17}$$

where:
V= velocity of the belt
T_1 = Tension in tight side
T_2 = Tension in slack side
P_1 = power to drive
P_2 = power required to drive the crankshaft

$$P_2 = \frac{2\pi N_{CS} T_{CS}}{60} \tag{18}$$

Where:
N_{CS} = speed of crankshaft
T_{CS} = torque on the crankshaft

$$P_T = P_1 + P_2 \tag{19}$$

Where:
P_T = total power required to drive the machine

2.3 Performance testing procedure

The developed yam minisett cutting machine was tested after fabrication to evaluate its performance. Each test performed was carried out in ten (10) different experimental runs for an average weight of 8kg of yam. The test performance indicators evaluated in the tests are Capacity (or Throughput), and efficiency .Two experiments were carried out on the machine, the first was to determine the effect of speed on the efficiency while the second was to determine the effect of speed on the capacity of the machine. Each test involved operating the machine at a constant time duration of five (5) minutes. The length of the connecting rod (i.e. the travel distance of the yam) was also kept constant for each of the experimental run. The speed of the crankshaft was varied from 10rpm to 100rpm using pulleys of different diameter to achieve various speed ratios.

The number of yam minisetts produced during each test was recorded. The numbers of well-cut minisett were recorded, and those with improper cuts were also recorded. Yam minisetts with regular sharp cuts, good finishing and an average weight of 25g or more were considered as good one, while those that did not meet the above criteria were considered as scraps but was used in economic viability analysis, (Bolaji et al., 2018). Each minisett was weighed on a weighing balance to determine its actual weight. Thereafter, the capacity and efficiency of the machine were computed in each case using the following relations in equation 20 and 21.

$$C_m = \frac{N_g}{t} \tag{20}$$

$$\eta_c\% = \frac{N_g}{N_T} x\ 100\% \tag{21}$$

Where t = Time of the operation = 5 minutes,
N_g = Number of well-cut yam minisetts
N_T= Total number of yam minisetts produced

3. RESULT AND DISCUSSION

The number of minisetts produced during each test was recorded. The number of well-cut minisetts was recorded, and those with improper cuts were also recorded, and with these values the Capacity and the efficiency of the machine at each experimental run was obtained. Tables 2 and 3 showed the obtained values of capacity and the efficiency of the machine respectively from different experiments.

Table 2. Experimental Analysis of the yam minisett processing machine capacity

Experiment No.	**Capacity/mins**					
	1	**2**	**3**	**4**	**5**	**Mean**
1	478.59	478.60	478.90	480.20	480.58	479.66
2	481.45	482.01	479.99	480.57	480.98	[illegible]
3	481.47	481.47	481.39	481.50	[illegible]	[illegible]
4	479.98	479.98	482.01	[illegible]	[illegible]	[illegible]
5	479.99	480.01	481.11	481.55	480.99	480.73
6	480.55	480.92	480.31	481.49	481.48	480.95
7	481.02	480.57	480.39	481.50	481.49	480.99
8	480.97	481.55	481.50	481.47	480.99	481.30
9	481.49	482.01	481.47	481.45	480.98	481.48

Table 3. Experimental Analysis of the yam minisett processing machine efficiency

Experiment No.	**Efficiency%**					
	1	**2**	**3**	**4**	**5**	**Mean**
1	90.6	91.2	90.78	90.26	91.4	90.85
2	71.9	72.04	70.8	71.42	70.4	71.3
3	96.6	95.6	94.8	96.4	97.2	96.12
4	96.20	96.20	95.99	96.19	96.62	96.24
5	87.5	86.8	87.6	88.02	88.1	87.6
6	87.5	87.4	88.2	[illegible]	88.01	87.55
7	68.7	[illegible]	68.8	[illegible]	68.4	68.78
8	65.6	[illegible]	64.32	[illegible]	64.90	65.19
9	63.1	[illegible]	63.42	[illegible]	62.84	63.17

Results from ten experimental runs at varying speeds and the corresponding capacity or throughput obtained are tabulated in Table 4. Factors such as length of connecting rod, number of blades and duration of experiment were kept constant at 470mm, 16, and 5mins respectively.

Table 4. Effect of the crankshaft speed on the capacity of the yam minisett processing machine

S/NO.	**SPEED OF CRANK SHAFT (RPM)**	**TOTAL NUMBER OF MINISETT PRODUCED**	**TOTAL NUMBER OF WELL-CUT MINISETTS**	**TOTAL NUMBER OF POORLY CUT MINISETT**	**CAPACITY/MINS**
1	10	1924	1922	2	384.4
2	20	1970	1966	4	393.2
3	30	2151	2147	4	429.55
4	40	2278	2275	3	455.00
5	50	2393	2385	8	477.00
6	60	2415	2405	10	481.00
7	70	2441	2425	16	485.00
8	80	2472	2450	22	490.00
9	90	2490	2460	30	492.00
10	100	2527	2485	42	497.00

From Table 4, it can be seen that at crank shaft speed of 100rpm, the largest number of yam minisett (2527) were obtained from the machine, and the machines capacity was calculated to be 497minisett/mins, while at crank shaft speed of 10rpm, the lowest number of yam minisett which was 1924 were obtained from the machine, and the machines capacity was calculated to be 384.4minisett/mins. Table 4 shows that as the speed of the crankshaft increases, the capacity of the machine also increases. Results of the tests carried out to determine the effect of crankshaft speed on the efficiency of the developed machine are displayed in Table 5.

Table 5. Effect of crankshaft speed on the efficiency of the yam minisett processing machine

S/NO.	**SPEED OF CRANK SHAFT (RPM)**	**TOTAL NUMBER OF MINISETT PRODUCED**	**TOTAL NUMBER OF WELL-CUT MINISETTS**	**TOTAL NUMBER OF POORLY CUT MINISETT**	**EFFICIENCY%**
1	10	16	14	2	87.5
2	20	32	28	4	87.5
3	30	48	44	4	91.7
4	40	64	61	3	95.3
5	50	80	75	5	94.2
6	60	96	86	10	89.5
7	70	112	96	16	85.7
8	**80**	**128**	**106**	**22**	**82.8**
9	90	144	114	30	79.2
10	100	176	134	42	76.1

Table 5 shows that machine's efficiency increased as the speed increases from 10rpm to 40rpm. From 40rpm, the machine's efficiency decreased as the speed increased. The machines highest efficiency (which was obtained at 40rpm) was recorded to be 95.3% while its lowest efficiency was recorded as 76.1 at a speed of 100 rpm.

The reduction in the machine's efficiency at 100 rpm, even though it is at this speed that the machine produced at its highest capacity can be explained by the fact that the total number of poorly cut minisett is the highest at this speed.

Generally, the results of the performance tests performed on the machine show that low crankshaft speed is required to produce well-cut minisett and high machine efficiency while a high crank shaft speed is required for better machine capacity (throughput). It also showed that factors like length of the connecting rod and the number of blades also affects the machine's efficiency. For instance, the number of minisett per batch is determined by the number of blades, while the cutting efficiency of the machine is highly influenced by length of the connecting rod.

The machine is afordable because all the materials used for its construction were sourced in the local market. The total cost of producing the machine is Two hundred and eighteen thousand, five hundred naira only (₦218, 500.00) using the prevailing economic indicators which is the market prices of materials in Abia state of Nigeria between January and December, 2021.

4. CONCLUSIONS

Development and techno-economic evaluation of a yam minisett processing machine were accomplished in this study. Materials used for the development of this machine are locally sourced. This development is done due to inability of existing root crops cutting/slicing machines to perform simultaneous horizontal and longitudinal cutting operations required for effective yam minisett production as obtained in native technique. Average length and breadth of a yam tuber used for designing the minisett processing machine was also determined as 247.80mm and 66.75mm respectively. The developed machine comprises the frame, speed reducer, pulley, belt, crank mechanism, connecting rod, hopper, seed yam carrier, cutting blades, and discharge chute as major components. The dimensional design of the machine was done with a solid works which was used to get the exploded view of the machine.

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