World Academics Journal of Engineering Sciences
Vol.10, Issue.1, pp.24-36, March 2023
E-ISSN: 2348-635X
Available online at: www.isroset.org

Research Paper

Development of a Motorized Leafy Vegetable Slicing Machine for Vegetables

Mary Adewale[1*], Abdulganiy Raji[2], Adewale Sedara[3]

[1,2]Dept. of Agricultural and Environmental Engineering, University of Ibadan, Ibadan, Nigeria
[3]Dept. of Agricultural and Biosystems Engineering, Iowa State University, Iowa, USA

Corresponding Author: maryadewale36@gmail.com

Received: 29/Jan/2023; **Accepted**: 07/Mar/2023; **Published**: 31/Mar/2023

Abstract— In this study, a leafy vegetable slicer machine was developed for the local vegetable consumed in Nigeria, which are Fluted Pumpkin (Ugu), Green Amaranth (Efo Tete), and African Amaranth (Efo Soko). The main parts of the machine are the hopper, slicing unit, sieve, rotating shaft, and transmission unit. Fabricated with locally sourced materials and leafy vegetables were sourced from local farmers. Three-speed levels (300, 500, and 700 rpm) and feeding mass (0.2, 0.25, and 0.3 kg) were used to evaluate the slicing efficiency, percentage retained, and capacity of the machine for the three varieties of leafy vegetables. The highest efficiency of 95.2% was attained at a speed of 500 rpm for the African amaranth variety, and the operating time was 57secs; 94.0% was attained at a speed of 700 rpm for the Fluted pumpkin variety, and the operating time was 79secs and 92.1% was attained at a speed of 700 rpm for Green amaranth variety and the operating time was 57 secs. The machine slicing capacity ranges from 3.58 to 19.28 kg/hr. The highest percentage retained was 49.6%, obtained at a speed of 500 rpm, and the operating time was 64 secs for the African amaranth variety. The result of the Analysis of Variance on the slicing capacity of the three varieties of leafy vegetables shows that speed had a significant effect ($p<0.05$) on the slicing capacities, while the effect of feeding was not significant, and the effect of speed on the slicing efficiency of the three variants of leafy vegetables was not significant ($p<0.05$). This equipment can decrease human drudgery and make chopping vegetables much faster and easier.

Keywords— leafy vegetable, slicer machine, slicer efficiency, Fluted Pumpkin (Ugu), Green Amaranth (Efo Tete), African Amaranth (Efo Soko).

1. Introduction

Any part of a plant that may be consumed raw or cooked is referred to as a vegetable. As the cheapest and most plentiful possible source of protein, leafy greens are highly valued in Africa due to their economic potential and capacity to manufacture amino acids from a range of fundamental materials [1], [2], [3]. Leafy crops can withstand abiotic conditions like heat and drought [4]. They are extremely perishable, especially when kept at room temperature. Because of their large surface area, the leaves are more susceptible to moisture loss. When cooked, the result is a loss of crispiness, wilting, and hardness [5]. Vegetables improve the taste and consumption of our primary foods. They also provide most of the nutrients lacking in other food sources, such as calcium and iron, and minerals.

Generally, a balanced diet and addressing nutritional deficits require vegetables [1]. A tropical vine known as the "fluted pumpkin" (Telfairia occidentalis), also known as "Ugu" by the Igbo ethnic group of Eastern Nigeria, is grown there for its edible seeds and as a leafy vegetable [6], [7]. It is a low-growing creeping leafy vegetable with long, twisted tendrils and huge lobed leaves [8]. Amaranthus hybridus, also called green amaranth, is cultivated as a green vegetable in parts of India, Mexico, the southern United States, and Africa [9], [10], [11], [12]. The leaves are rich in protein and contain much energy. While in season, amaranth leaves give some African tribes up to 25% of their daily protein [13]. Young seedlings are pulled up by the roots and picked in West Africa before being sold in markets. These are the boiled greens that Africans eat the most frequently. According to [4], the use of local leafy vegetables is dwindling in favor of exotic crops. Which is because they are not usually cultivated but mostly gathered.

Slicing, cutting, crushing, chopping, grinding, and milling are different size reduction methods. They can be achieved mechanically without altering the material's chemical properties [14]. Cutting is the penetration of a sharp knife through a material, resulting in a new surface and smaller sizes required for a particular purpose. Several methods have been devised, but these methods have not been helpful in efficiently enhancing the slicing operation, as most of the machines are manually operated, and there are no rollers (for compression) in others. [15] reported that cutting force and specific energy studies on different vegetables help to design the appropriate slicing or cutting devices and that the cutting tool parameters also influence the shape of the final output. [16] reported that the variation in the width of slices was greater in motorized slicers because the feeding could not be adequately controlled, and the cutting force required for slicing was 1.121N.

Therefore, the main objective of this research is to develop a leafy vegetable-slicing machine. It was in recognition of the need to remove drudgery, avoid user harm and associated hardships, minimize losses, and get the most out of vegetables economically that there arose the need for a motorized leafy vegetable slicing machine that is made of slicing blades enclosed in a slicing drum to ease problems related to manual slicing of leafy vegetables, thereby enhancing long shelf life and mass production of sliced vegetables at a faster and easier rate.

2. Related Work

A manual vegetable slicing device was designed and built by [17]. The device was made out of a hopper, a drum for slicing, blades, a discharge chute, a handle, and a frame. The vegetable was reduced to its smallest size by the rotating motion of the cutters (slicing blades) from the handle, and the sliced vegetable was collected at the discharge chute.

For small-scale food processing, [18] designed a motorized leafy vegetable cutter. Frame, loading chamber, discharge chute, cutting blades, and power transmission unit made up the machine. Vegetables supplied into the loading chamber were transported via the hopper to the cutting chamber, where they were sliced into a variety of sizes by the spinning action of the cutting blades.

The automated leafy vegetable cutter designed by [18] was assessed by [19]. When put to the test, the green vegetable cutting machine had an output of 29 kg/h with an efficiency of more than 80%.

The manual tomato slicing device designed by [20] was redesign by [21]. The same operating theory was applied. The new machine has improvements such as better cutting blades, a collecting unit, and the usage of aluminum in place of wood for machine components. The device's production capacity and slicing efficiency were 92% and 3.012 kg/h, respectively.
A motorized machine for slicing fluted pumpkin leaves was designed by [16]. The device was composed of a frame, a rubber belt conveyor, a three-bladed cutting disc, a driving shaft, a bearing assembly, and a power drive mechanism (gear). The device has a 6.67 kg/h capacity and a 73.2% efficiency.

[22] developed a slicer machine for slicing bananas and potatoes, assessed in terms of slicing capacity, broken percentage, and uniform slicing. Around 68.78 kg of bananas and 91.8 kg of potatoes may be sliced each hour on average, respectively.

A vegetable-slicing device designed by [23] was discovered to have a 1.717 kg/h capacity. [24] designed a manually operated potato-slicing machine with the goal of increasing process throughput and efficiency. The weight of the sliced vegetable divided by the weight of the vegetable before slicing was used to calculate the machine's capacity and efficiency, which were found to be 42.93 kg/h and 88.8% respectively.

A fruit and vegetable slicing machine with a 96 kg/h capacity and a 70% efficiency was designed by [25]. [26] created a prototype vegetable cutter that was tested on carrots. The cutter was constructed with a 0.5 hp, 1400 rpm motor, a 30 kg/h cutting capacity, and an 86% efficiency.

A mechanical tomato slicer designed by [27] feeds tomatoes to revolving blades using a gravity feeding method. The machine's efficiency and capacity were determined using a 0.25 hp and 1200 rpm motor, the machine's capacity and efficiency were determined to be 468 kg/h and 60.34%, respectively. For greater effectiveness, it was advised that the knife carriage be strengthened.

For small-scale food processing businesses, [28] developed a power-operated banana slicer with an emphasis on the cutter assembly. The cutter plate and the cutting blade make up the assembly. It was powered by a 360 rpm motor. The machine's efficiency was determined to be 93% and its effective capacity to be 100 kg/h.

Cutting force, according to [29] increased with increasing load speed, while shear energy remained constant. Knife cutting angles from 0^0 to 40^0 sharpening angles resulted in a decrease in cutting power, strength, energy values, and specific energy values. The maximum cutting force measurement was recorded by a knife with a sharpening angle of 17.50, and the lowest by a knife with a sharpening angle of 2.50.

[30] claim that when the speed of the slicing disc rose, mechanical damage reduced and efficiency and throughput capacity improved. The findings of the experiment were as follows: the greatest value of throughput capacity was 184.11 kg/h, the highest value of slicing efficiency was 99.88%, and the mechanical damage index value decreased from 16.05% at 300 rpm to 0.30% at 1200 rpm.

3. Theory/Calculation

3.1 Design Considerations

The following were considered in the design of the machine due to the nature of the leafy vegetables: cutting force required for slicing of vegetables, 1.121 N (as recommended by [16] the choice of material for construction was chosen based on the need to prevent corrosion and contamination of the leafy vegetables and locally available materials were used in the fabrication of the slicing machine. The cutting blade is thin and sharp in order to penetrate and slice the leafy vegetables. The machine was designed for ergonomics convenience and ease of operation as well as to eliminate drudgery involved in the traditional way of slicing vegetables.

3.2 Design Calculations of the Major Component Parts

Components design for leafy vegetable slicing machine and design parameters.

3.2.1 Design of blades

Cutting blade length is 135 mm (about twice the width of an average fluted pumpkin leaf) as recommended by [16]. Length of 360 mm and width of 110 mm were considered for the slicing unit of the leafy vegetable slicer and the number of cutting blades was determined using Equation 1. The area provided for the slicing unit is $41400\ mm^2$. Also, blade of 1 mm thickness was used for the machine and separated by a distance of 20 mm from each other.

$$N_{bl} = \frac{w}{t+s} \quad (1)$$

$Area = l \times w = 41400\ mm^2$

where: w is width, l is length, t is thickness and s is spacing. Thus, 9 blades were vertically arranged spirally to fill the whole width and 5 blades were arranged on a side of the slicing unit. Also, the total force acting on the blades is 28 N.'

$$\text{Number of blades} = \frac{width}{thickness+spacing} \quad (2)$$

$$= \frac{110mm}{1mm+11mm} = 9\ blades$$

Total forces acting on the blades was calculated as 14 blades × 2N (assumed value) = 28N

3.2.2 Selection of electric motor

The total torque required (T) was computed from Equation 3 [31];

$$T = F \times r \quad (3)$$

where,

T = Torque (Nm)

F= total force required (N)

r= radius of the cutting plate (m)

But angular velocity, ω in rad/sec can be computed from Equation 4.

$$\omega = \frac{2\pi N}{60} \quad (4)$$

where,

N = Number of revolutions per minute

Power required; P in Watts was computed from Equation 5.

$$P = \omega T \quad (5)$$

$$T = F \times r \quad (6)$$

Where,

F= total force required (N)

r= radius of the cutting plate (m)

$T = 28\ N \times 0.127\ m$

$T = 3.556\ Nm$

But angular velocity, ω in rad/sec can be computed from Equation 7.

$$\omega = \frac{2\pi N}{60} \quad (7)$$

$\omega = \frac{2\pi \times 75}{60}$

$\omega = 7.85 rad/sec$

Power required; P in Watts was computed from Equation 8.

$$P = \omega T \quad (8)$$

$P = 3.556 \times 7.85 = 27.91\ W$

Since $746\ W = 1\ hp$

$27.91\ W = xhp$

$x = \frac{27.91}{746}$

$P = 0.0374\ hp$

$P = 0.0374\ hp$

Therefore, a single phase 1hp electric motor will be selected.

3.2.3 Pulley design

The diameter of the pulley was obtained from velocity ratio relationship in Equation 9.

$$\text{Velocity ratio, } D_1 N_1 = D_2 N_2 \quad (9)$$

where,

D_1 is the diameter of the motor (mm)

N_1 is the speed of the motor (rpm)

D_2 is the diameter of the shaft pulley (mm)

N_2 is the required speed of shaft (rpm)

The diameter of the pulley was obtained from velocity ratio relationship in Equation 10.

$$\text{Velocity ratio, } D_1 N_1 = D_2 N_2 \quad (10)$$

Where,

D_1 is the diameter of the motor (mm)

N_1 is the speed of the motor (rpm)

D_2 is the diameter of the shaft pulley (mm)

N_2 is the required speed of shaft (rpm)

$D_2 = \frac{1440 \times 50}{500} = 144\ mm$

The nearest pulley diameter is 144 mm.

3.2.4 Weight of cutting blade

The cutting blades are 14 in number and are attached to the shaft and slicing unit. The dimensions are length is 135 mm, breadth is 30 mm and thickness is 1mm. Therefore, the volume,

$$V = L \times B \times t \quad (11)$$

where,

L =Length (mm)

B =Breadth (mm)

t =Thickness (mm)

$$\text{The total weight of blades} = \rho V g n \quad (12)$$

where,

ρ = density of stainless steel ($8030\ kg/m^3$)

V= volume of cutting blade (m^3)

g= acceleration due to gravity (9.81m/s)

n= number of blades

The cutting blades are 14 in number and are attached to the shaft. The dimensions are length is 135 mm, breadth is 30 mm and thickness is 1 mm. Therefore, the volume,

$$V = L \times B \times t \quad (13)$$

$V = 0.135\ m \times 0.030\ m \times 0.001\ m$
$= 0.0000041\ m^3$
$W = \rho V g n$

Where,
W = total weight of blades
ρ = density of stainless steel (8030 kg/m^3)
V= volume of cutting blade (m^3)
g= acceleration due to gravity (9.81 m/s)
n= number of blades
$W = 8030 \times 0.0000041 \times 9.81 \times 14 = 4.47\ N$

3.2.5 Belt design
Length of belt was calculated using Equation 15 ([32]);

$$L = \frac{\pi}{2}(d_1 + d_2) + 2x + \frac{(d_1-d_2)^2}{4x} \quad (15)$$

where,
L= length of belt (mm)
x = distance between the centres of the two pulleys = 235 mm
d_1 =diameter of larger pulley(mm)
d_2 =diameter of smaller pulley(mm)
Length of belt was calculated using Equation 16 ([32]);

$$L = \frac{\pi}{2}(d_1 + d_2) + 2x + \frac{(d_1-d_2)^2}{4x} \quad (16)$$

Where,
L= length of belt (mm)
x = distance between the centres of the two pulleys = 241 mm
$d_1 = diameter\ of\ larger\ pulley$ (mm)
$d_2 = diameter\ of\ smaller\ pulley$ (mm)
$x = \left(\frac{d_2}{2} + \frac{d_1}{2}\right) + d_1$
$x = \left(\frac{50}{2} + \frac{144}{2}\right) + 144$
$x = 144 + 97$
$x = 241\ mm$
$L = \frac{\pi}{2}(d_1 + d_2) + 2x + \frac{(d_1-d_2)^2}{4x}$
$L = \frac{\pi}{2}(50 + 144) + 2(241) + \frac{(144-50)^2}{4(241)}$
$L = \frac{\pi}{2}(194) + 482 + \frac{8836}{964}$
$L = 795.6\ mm = 0.80\ m$
A flat belt with total length of 1.03 m is recommended to drive the slicing unit.

3.2.6 Angle of contact of motor machine pulley
The lap angle of the belt was calculated using Equation 17 ([32]);

$$\theta = (180 - 2\alpha)\frac{\pi}{180}\text{rad (considering an open belt)} \quad (17)$$

$Sin\ \alpha = \frac{d_1-d_2}{x}$

α=$Sin^{-1}(\frac{d_1-d_2}{x})$
Where;
x= centre distance (mm)
α= joint angle (°)
α=$Sin^{-1}(\frac{144-50}{241})$
α= 23°
$\theta = (180 - 2(23°))\frac{\pi}{180}$
$\theta = 2.34\ rad$
$\theta = 2.34\ rad$

3.2.7 Coefficient of friction
[32] reported that the coefficient of friction (μ) for leather belts on cast iron pulley, at the point of slipping is given by the Equation 18.

$$\mu = 0.54 - \frac{42.6}{152.6+v} \quad (18)$$

where,
v = speed of belt (m/min)
$v = \frac{\pi N_1 D_1}{60}$

where;
N_1= Speed of the prime mover (rpm)
D_1= pulley diameter of the prime mover (m)
$V = \frac{\pi(1440)(0.05)}{60}$
$V = 3.77\ m/s$
V= 3.77 m/s= 226.2 m/min
$\mu = 0.54 - \frac{42.6}{152.6+226.2}$
μ= 0.428, $v = 3.77\ m/s$

3.2.8 Tensions in the belt
The tension in the slight and slack side of the belt labeled $T_1$and T_2 respectively was calculated using Equation 18 ([32]);

$$2.3 \log\left[\frac{T_1}{T_2}\right] = \mu\theta \quad (18)$$

where,
T_1= Tension in the tight side of the belt
T_2=Tension in the slack side of the belt
μ=coefficient of friction between belt and pulley = 0.449
θ= 2.34 rad
$T_2 = \frac{T_1}{1.76}$
$2.3 \log\left[\frac{T_1}{T_2}\right] = \mu\theta$
$\log\left[\frac{T_1}{T_2}\right] = \frac{1.000}{2.3}$
$\left[\frac{T_1}{T_2}\right] = 2.72$
$T_2 = \frac{T_1}{2.72}$

3.2.9 Belt tension due to centrifugal force
The tension of the belt was calculated using Equation 19 and 20 ([32]);

$$T_c = MV^2 \quad 19)$$

$$M = b \times t \times \rho \quad (20)$$

where,
ρ= density of belts (leather) = $1000\ kg/m^3$
b= belt width (129 mm) = 0.129 m
t= nominal belt thickness (8 mm) = 0.008 m
A standard flat belt thickness as explained by [32]; was selected.
$M = 0.129 \times 0.008 \times 1000 = 1.032\ kg/m$
$Tc = MV2$
$Tc = 1.032 \times 3.772$
$Tc = 14.7\ N$

The centrifugal tension is 28 N.
$T_1 = T - Tc$
$T = 3Tc$
$T = 3 \times 14.7 = 44\ N$
$T_1 = 44 - 14.7 = 29\ N$
$T_2 = \frac{T_1}{1.76}$
$T_2 = \frac{56}{1.76}$
$T_2 = 10.6\ N$
$T_2 = 11\ N$
$T_1 = 29\ N$
$T_2 = 11\ N$

3.2.10 Power transmitted by belt
The power transmitted per belt, P was calculated using Equation 21 ([32]);

$$P = (T_1 - T_2)V \quad (21)$$

where,
T_1= Tension in the tight side of the belt
T_2= Tension in the slack side of the belt
V = speed of belt in m/s
$P = (29 - 11)\ 3.77$
$P = 67.86$ W = 0.06786 kW

3.2.11 Design of shaft
The shaft diameter was calculated using Equation 22 ([32]);

$$d^3 = \frac{16}{\pi Ss}\sqrt{[K_b M_b]^2 + [K_t M_t]^2} \quad (22)$$

Where,
d = Shaft diameter
Ss = Allowable shear stress for shaft = $40\ M\ N\ /\ m^2$
Kb = Shock factor for bending moment = 1.5
Kt = Shock factor for torsional moment = 1.0
Mb = Maximum bending moment (Nm), M_t= Maximum torque (Nm). To determine both Mb and Mt, the forces acting on the shaft must be calculated.
For a belt drive, the torque is found from Equation 23.

$$M_t = (T_1 - T_2)R \quad (23)$$

Where,
T_1= Tight side of belt on pulley, N
T_2= loose side of belt on pulley, N
R= radius of pulley, m
$R_1 + R_2 = 18.80 + 4.47 = 23.27\ N$
$\therefore R_1 = 23.27 - R_2$
$R_2 \times 0.37 = (18.80 \times 0.05) + (4.47 \times 0.315)$
$R_2 = \frac{2.35}{0.37} = 6.346\ N$
$R_1 = 23.27 - 6.346$
$R_1 = 16.92\ N$
A shaft diameter of 20 mm which is the nearest standard size was selected.

4. Experimental Method/Procedure/Design

4.1 Description of the Component Parts of the Leafy Vegetable Slicing Machine
The leafy vegetable slicing machine consists of the frame, the hopper, sieve, a rotating shaft with cutting blades and slicing unit. The specifications of the machine include; overall length of 370 mm, overall width of 115 mm and overall height of 840 mm.

4.1.1 The slicing unit
The slicing unit consists of stationary blades with dimension of 55 mm by 30 mm by 1 mm. The blades were arranged on a side with a distance of 35 mm from each and held in position to the slicing unit in a specified direction and it interlocks with the moveable blades on the rotating shaft.

4.1.2 The rotating shaft
The rotating shaft has 9 blades with dimension of 135 mm by 30 mm by 1mm at a spacing of 10 mm welded spirally. The diameter of the shaft is 20 mm.

4.1.3 The sieve
It has 7 openings of 8 mm by 130 mm and they were made at the centre of a plate 1mm thickness, in order to concentrate the discharge of the leafy vegetables at the centre of the screen. The cylindrical sieve length is 370 mm while the diameter is 180 mm.

4.1.4 The frame and engine seat
The frame was made from angle iron cut to the required dimension and welded. The length and width are 370 mm and 115 mm respectively and the height is 335 mm. The engine seat (340 mm by 190 mm) was welded to an angle iron located 85 mm high from the ground level. Slotted holes were made on it for attaching the engine with bolts.

4.1.5 Hopper
This has a base dimension of 115 mm by 150 mm and top dimension of 115 mm by 165 mm with a slant height of 280 mm and welded to the slicing unit.

4.1.6 Bearing
Bearings are on the shaft to support it. There are two bearings on the shaft, one on each side of the frame supporting the shaft.

4.2 Mode of Operation and working principle
The machine operates on a shearing and cutting principle, the blades around the shaft will be making the necessary cuts, and the rotation of the blades will also provide the slicing and

motion. The leafy vegetable slicer consists of frame, hopper, sieve, a vertical rotating shaft with cutting blades, slicing unit and power transmission elements. It was powered by an electric motor and rotary motion produced by the power unit was transmitted to the cutting blades through belt and pulley. The hopper serves as a means of feeding the leafy vegetables for the cutting process. The cutting blades will then reduce the size of the vegetables as a result of the rotary motion of the cutting edge in the vegetables and the sliced vegetables will be collected at the discharge chute.

4.3 Design Drawing

The drawing was done using AutoCAD, orthographic and isometric drawings of the leafy vegetable slicing machine with dimensions while the assembly drawing and exploded view are shown in Figures 1-2.

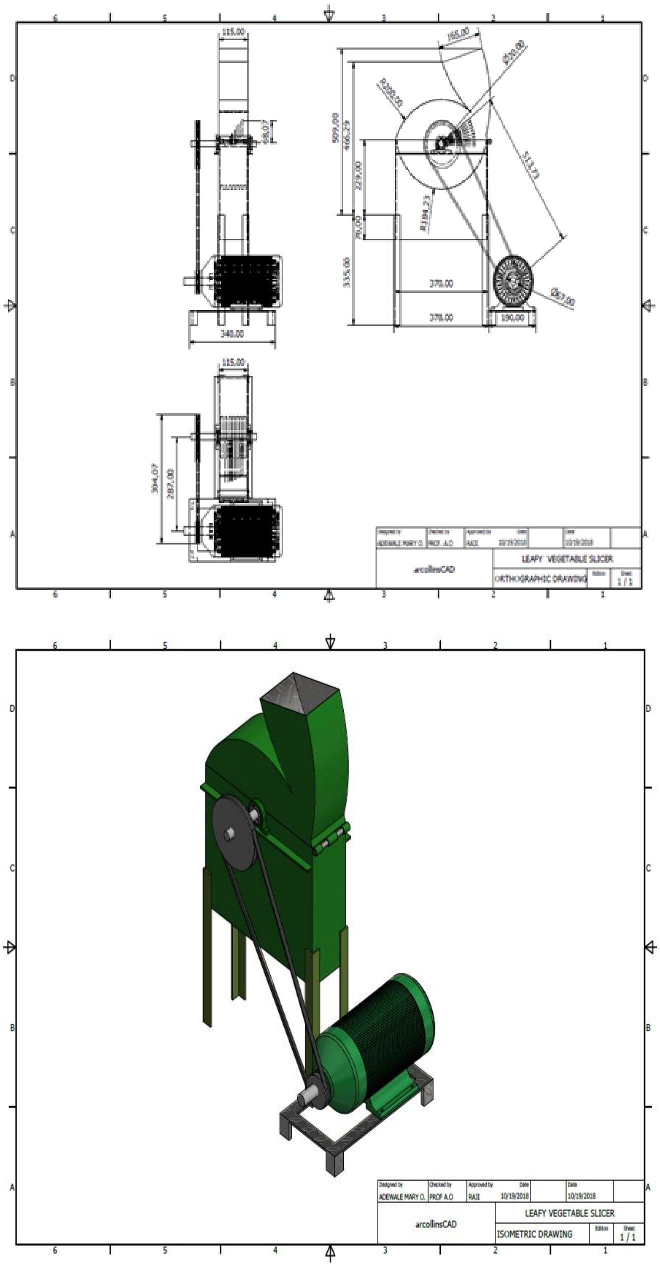


Figure 1: Orthographic and Isometric Drawing of the Leafy Vegetable Slicing Machine

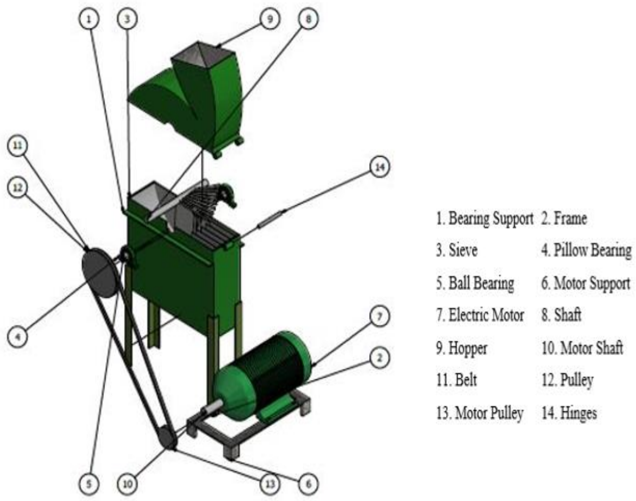


Figure 2: Exploded View of the Leafy Vegetable Slicing Machine

4.4 Experimental Design

The machine was operated empty for 5 minutes before feeding it with the leafy vegetables. The experiment is a 2x3x3 randomized design using leafy vegetable slicing machine operating speeds (300, 500 and 700 rpm) and feedings mass (0.200, 0.250 and 0.300 kg) for three varieties (Fluted pumpkin, green amaranth and African amaranth) of leafy vegetable. Each combination of speed, feeding and variety of leafy vegetable was replicated three times and the representative value is the mean of the three readings.

4.5 Performance Evaluation

The performance of the leafy vegetable slicing machine was evaluated under various operating conditions. Plots were also made to determine the effect of speed and feeding on the slicing efficiency (SE), percentage leaf retained and capacity on the machine.

Percentages of sliced and retained leafy vegetables were calculated according to Equations 24 and 25 while the output capacity was calculated using Equation 26 for each variety of leafy vegetables.

$$SE = \frac{W_s}{W_T} \times 100 \tag{24}$$

Where,
W_s = weight of sliced vegetables (g)
W_T = total weight of vegetables fed (g)

$$Percentage\ Retained = \frac{W_r}{W_T} \times 100 \tag{25}$$

Where,
W_r =weight of retained vegetables (g)
W_T = total weight of vegetables fed (g)

$$C = \frac{W_T}{T} \tag{26}$$

Where,
C = Capacity (kg/h)

w_T = total weight of vegetable sliced (kg)
T = slicing time (h)

4.6 Data Analysis

The data were subjected to graphical representation and statistical analysis using Analysis of variance (ANOVA) method to determine areas of significant differences in means of effect of speed and feeding on slicing efficiency, percentage retained and capacity of the leafy vegetable slicing machine.

5. Results and Discussion

5.1 Slicing efficiencies of the machines for fluted pumpkin (Ugu), green amaranth (Efo Tete), and African amaranth (Efo Soko)

Figure 3 shows the effect of speed on the slicing capacity of the machine at different feeding mass for the three variety of vegetables (fluted pumpkin (Ugu), green amaranth (Efo Tete), and African amaranth (Efo Soko)). For fluted pumpkin (Ugu), the highest slicing capacity was observed using 0.3 kg feeding mass, the slicing capacity increases linearly for 0.25 kg and 0.3 kg feeding mass, while at 0.2 kg the slicing efficiency increases and decreases. The slicing capacity of the machine increased with an increase in the speed of the machine, and the highest capacity was recorded at 700 rpm for 0.300 kg loading. It was observed that using fluted pumpkin (Ugu), there is an increase in slicing capacity as feed mass increases and this was due to the increase in vibration of the machine as a result of the increase in speed; hence the sliced leafy vegetables moved faster through the sieve, and this was in line with [28] who reported in his work that the capacity of the slicer increased with an increase in speed. The Analysis of the Variance result in Table 1 for using fluted pumpkin (Ugu), showed a significant difference ($p<0.05$) in the machine capacity as the speed increased. There was no significant difference in the slicing capacity as the quantity loaded increased as the plot gives almost straight lines except for the values at 0.200 kg.

Using Green amaranth (Efo Tete), the slicing capacity ranged from 6.136 to 19.286 kg/h and the highest slicing capacity OF 19.286 kg/h was observed at speed 700 rpm and 0.3 kg feeding mass. It was observed that slicing capacity increases with an increase in the speed of the machine at each of the feedings, as shown in Figure 3b, and this was in tandem with previous researchers ([33]; [28]; [16]). This increase in slicing capacity was due to the increased vibration of the machine due to the increase in speed. Hence the sliced leafy vegetables moved faster through the sieve. The Analysis of Variance using Green amaranth (Efo Tete) is shown in Table 2, it was observed that speed has a significant effect on the slicing capacity of the slicing machine, while the effect of quantity loaded was not significant.

Figure 3 shows the data on the slicing capacity from the variation of speed for African Amaranth. The slicing capacity ranged from 5.2 to 19.6 kg/h. the highest was observed at 700 rpm speed and 0.3 kg feeding mass. It was observed that the capacity increased as speed increased, as shown in Figure 3. The finding aligned with [33], who reported increased speed increases chipping capacity. The maximum capacity of 19.172 kg/h was obtained at a speed of 700 rpm. This increase in slicing capacity was due to the increase in vibration of the machine due to the increase in speed; hence the sliced leafy vegetables moved faster through the sieve. The ANOVA of the effect of speed on slicing capacity is shown in Table 3. There is a significant difference in the machine capacity as speed increases at $p<0.05$ due to the increase in the rotation of slicing blades as speed increases.

Table 1: ANOVA Table for Slicing Capacity of Fluted Pumpkin (Ugu)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	64.17507	2	32.08753	18.96329	0.009102*	6.944272
Mass	6.935069	2	3.467534	2.049265^{n}	0.243954^{ns}	6.944272
Error	6.768347	4	1.692087			
Total	77.87848	8				

ns = no significant difference; * = significant difference

Table 2: ANOVA Table for Slicing Capacity of Green Amaranth (Efo Tete)

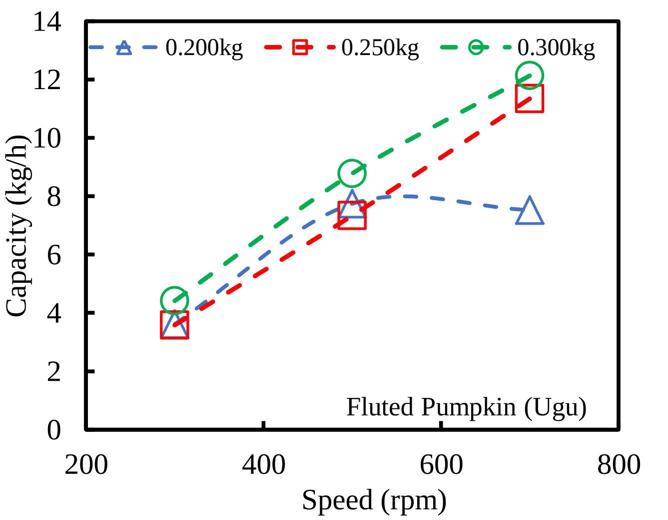
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	208.9384	2	104.4692	23.59312	0.006107*	6.944272
Mass	3.417954	2	1.708977	0.3859	0.702646^{ns}	6.944272
Error	17.7118	4	4.427951			
Total	230.0681	8				

ns = no significant difference; * = significant difference

Table 3: ANOVA Table for Slicing Capacity of African Amaranth (Efo Soko)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	194.3073	2	97.15364	42.31884	0.002036*	6.944272
Mass	13.46137	2	6.730687	2.9317	0.164456^{ns}	6.944272
Error	9.183015	4	2.295754			
Total	216.9517	8				

ns = no significant difference; * = significant difference



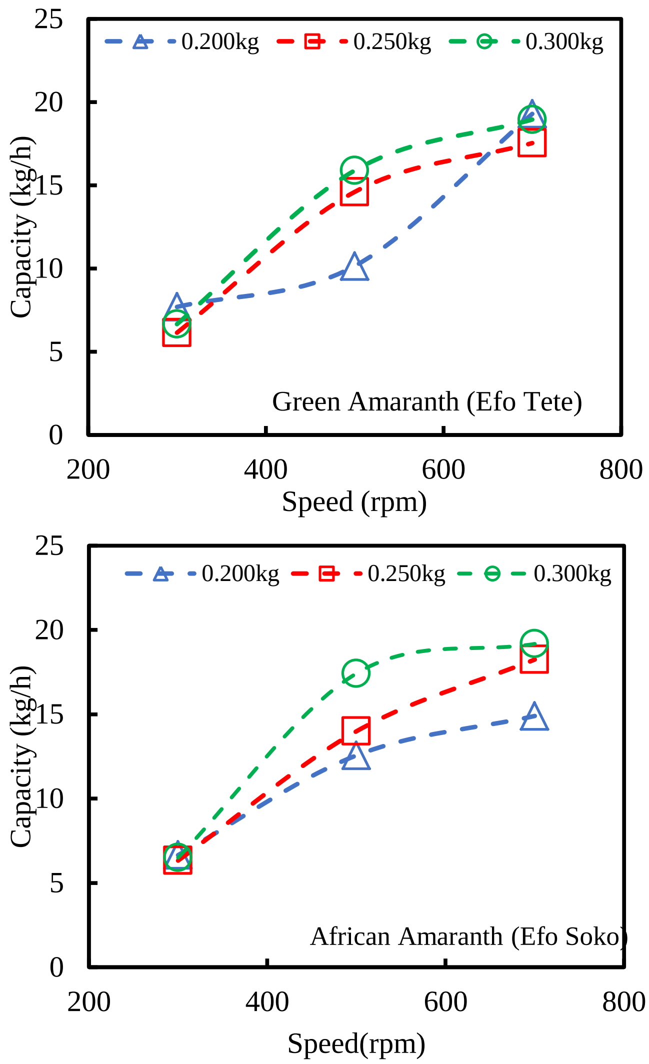


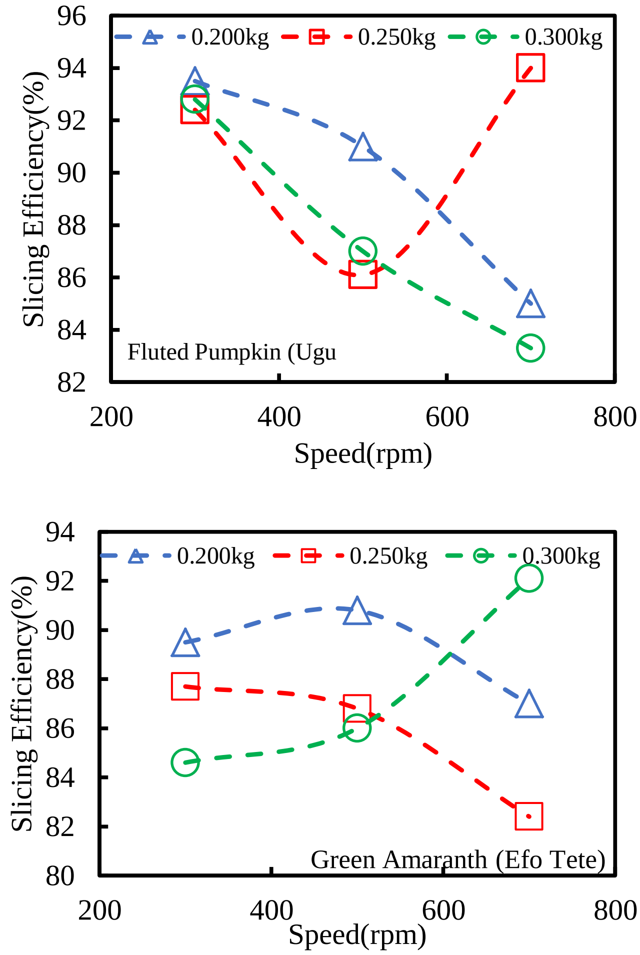
Figure 3: Effect of Speed on Slicing Capacity of Fluted Pumpkin (Ugu), Green Amaranth (Efo Tete) and African Amaranth (Efo Soko) a leafy vegetable slicing machine

5.2 Slicing efficiencies of the machines for fluted pumpkin (Ugu), green amaranth (Efo Tete), and African amaranth (Efo Soko)

The effect of the speed and loading on the slicing efficiency of the machine is shown in Figure 4, and the ANOVA is shown in Table 4 the three variety of vegetables (fluted pumpkin (Ugu), green amaranth (Efo Tete), and African amaranth (Efo Soko). Using fluted pumpkin (Ugu), shows that the slicing efficiency slicing efficiency ranged from 83% -94.2%. the highest slicing efficiency of 94% was observed at 700 rpm using 0.25 kg feeding mass. Increase in speed leads to decrease in slicing efficiency for 0.2 kg and 0.3 kg feeding mass, while for 0.2 kg feeding mass, slicing efficiency decreases and increases as the speed increases. Using fluted pumpkin (Ugu), slicing efficiency of the machine decreased with an increase in the speed of the machine, which agrees with the findings of [16], though with a higher value. The effect of the speed and quantity loaded on the slicing efficiency of the machine ($p<0.05$) were not significant (Table 4).

Using Green amaranth (Efo Tete), the slicing efficiency increased and decrease for 0.3 kg feeding mass, but decrease using 0.25 kg feeding mass, while using 0.3 kg feeding mass, it decreases and increased.The speed of operation selected to evaluate the slicing efficiency was 300, 500, and 700 rpm. The slicing efficiency ranges from 82.4 to 92.1%, as shown in Table 5 using Green amaranth (Efo Tete). It was observed that as speed increases, the slicing efficiency decreases for 0.200 and 0.250 kg loading, while as speed increases, the slicing efficiency increases for 0.300 kg. The finding was also in line with [34] who reported in their work that as speed increased, the slicing efficiency decreased, and the efficiency, when compared with that of [34] showed a higher value indicating an improvement over the previous design. The optimal slicing efficiency of 92.1 % was obtained at 0.300 kg and 700 rpm. The effect of speed and quantity loaded on the slicing efficiency was insignificant at $p<0.05$, as shown in Table 5.

The effect of speed variation on slicing efficiency is presented in Table 6 for African Amaranth. An increase in speed led to a decrease in slicing efficiency, as shown in Figure 4c, and this was in tandem with previous researchers [28]; [16]. The maximum slicing efficiency of 95.2 % was observed at a speed of 500 rpm. The result of the Analysis of Variance for slicing efficiency, as shown in Table 6, shows that the effect of speed on the slicing efficiency of the machine was not significant, while the effect of quantity loaded also was not significant at $p<0.05$



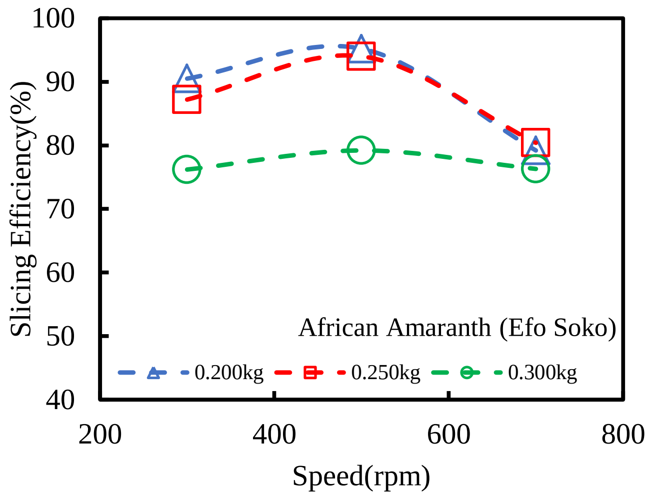


Figure 4: Effect of Speed on Slicing Efficiency of Fluted Pumpkin (Ugu), Green Amaranth (Efo Tete), African Amaranth (Efo Soko) a leafy vegetable slicing machine

Table 4: ANOVA Table for Slicing Efficiency of Fluted Pumpkin (Ugu)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	53.92889	2	26.96444	1.659748^{n}	0.298647^{ns}	6.944272
Mass	15.36889	2	7.684444	0.473002^{n}	0.65405^{ns}	6.944272
Error	64.98444	4	16.24611			
Total	134.2822	8				

ns = no significant difference; * = significant difference

Table 5: ANOVA Table for Slicing Efficiency of Green Amaranth (Efo Tete)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	0.86	2	0.43	0.031563^{n}	0.969168^{ns}	6.944272
Mass	18.10667	2	9.053333	0.664546^{n}	0.563396^{ns}	6.944272
Error	54.49333	4	13.62333			
Total	73.46	8				

ns = no significant difference; * = significant difference

Table 6: ANOVA Table for Slicing Efficiency of African Amaranth (Efo Soko)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	187.0867	2	93.54333	4.227629^{n}	0.103137^{ns}	6.944272
Mass	272.2467	2	136.1233	6.152004^{n}	0.060191^{ns}	6.944272
Error	88.50667	4	22.12667			
Total	547.84	8				

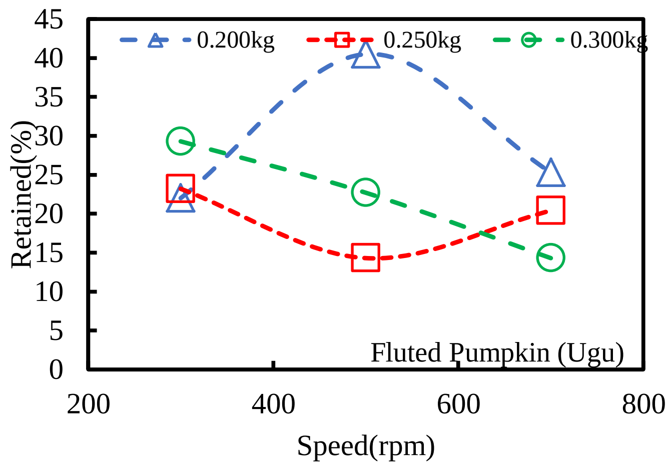
ns = no significant difference; * = significant difference

5.3 Percentage of vegetables retained fluted pumpkin (Ugu), green amaranth (Efo Tete), and African amaranth (Efo Soko)

Using Fluted Pumpkin (Ugu), the effect of speed and quantity loaded on the percentage retained in the machine is presented in Table 7. The percentage retained in the machine was found to decrease with an increase in speed for 0.300 kg feeding; however, at 0.200 and 0.250 kg, there was no definite pattern of variation for the speeds as shown in Figure 5 for Fluted Pumpkin (Ugu) with the highest value recorded at 40.5 kg at 500 rpm and 0.2 kg feeding mass. Which could be attributed to the aperture of the screen observed during the evaluation. The effect of speed and quantity loaded is insignificant on the percentage retained in the machine at p>0.05, as shown in Table 7. The effect of the speed variation on the percentage retained, as shown in Figure 5, shows that as speed increases, the percentage retained decreases at the feeding of 0.300 kg, and the highest value of percentage retained in the machine was observed at the speed of 500 rpm for 0.200 kg feeding.

The percentage retained increases initially as efficiency increases to an optimum level before decreasing, and this forms a bell shape, as shown in Figure 5 for Green Amaranth (Efo Tete), with the highest value recorded at 37 kg at 500 rpm and 0.2 kg feeding mass. Which could be attributed to the aperture of the screen observed during the evaluation. The Analysis of Variance (Table 8) shows that the effect of the speed is not significant on the percentage retained and that the quantity loaded significantly affects the percentage retained at p<0.05. The effect of speed and feeding on the percentage retained in the machine is shown in Figure 5. The percentage retained increases initially as efficiency increases to an optimum level before decreasing, forming a bell shape as shown in Figure 5 for African Amaranth (Efo Soko), with the highest value recorded at 49.6 kg at 500 rpm and 0.25 kg feeding mass.

Which could be attributed to the aperture of the screen observed during the evaluation. The Analysis of Variation (Table 9) for the effect of speed and feeding percentage retained was determined. It was found that the effect of speed has a significant difference on the percentage retained, while the effect of quantity loaded has no significant difference at p<0.05.



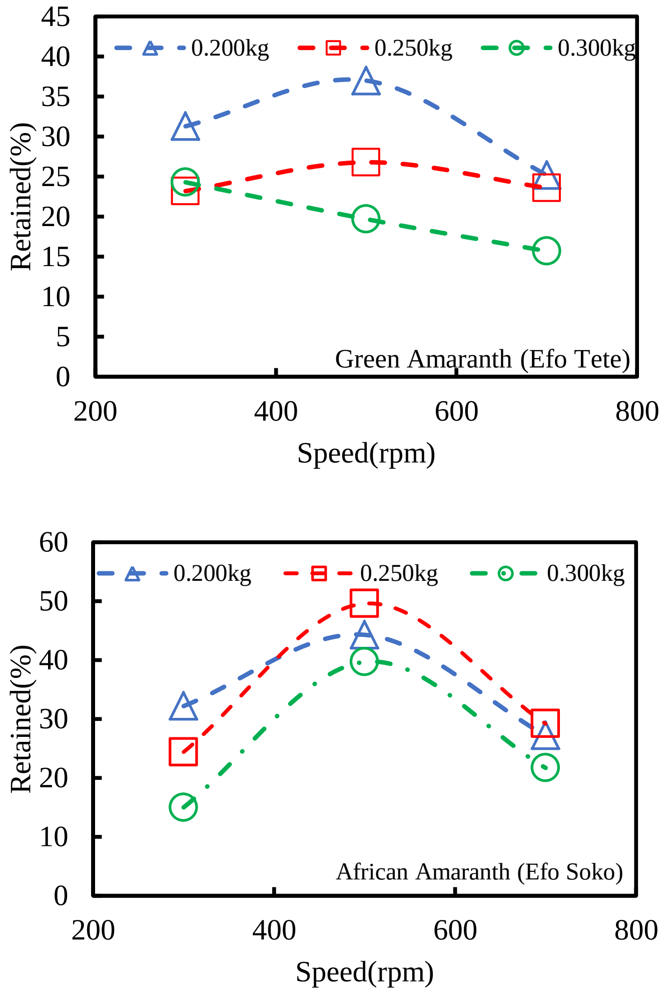


Figure 5: Effect of Speed on Percentage Retained of Fluted Pumpkin (Ugu), Green Amaranth (Efo Tete) Retained, African Amaranth (Efo Soko) a leafy vegetable slicing machine

Table 7: ANOVA Table for Percentage of Fluted Pumpkin (Ugu) Retained

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	58.38889	2	29.19444	0.401577^{n}	0.693533^{ns}	6.944272
Mass	158.5356	2	79.26778	1.090349^{n}	0.418837^{ns}	6.944272
Error	290.7978	4	72.69944			
Total	507.7222	8				

ns = no significant difference; * = significant difference

Table 8: ANOVA Table for Percentage of Green Amaranth (Efo Tete) Retained

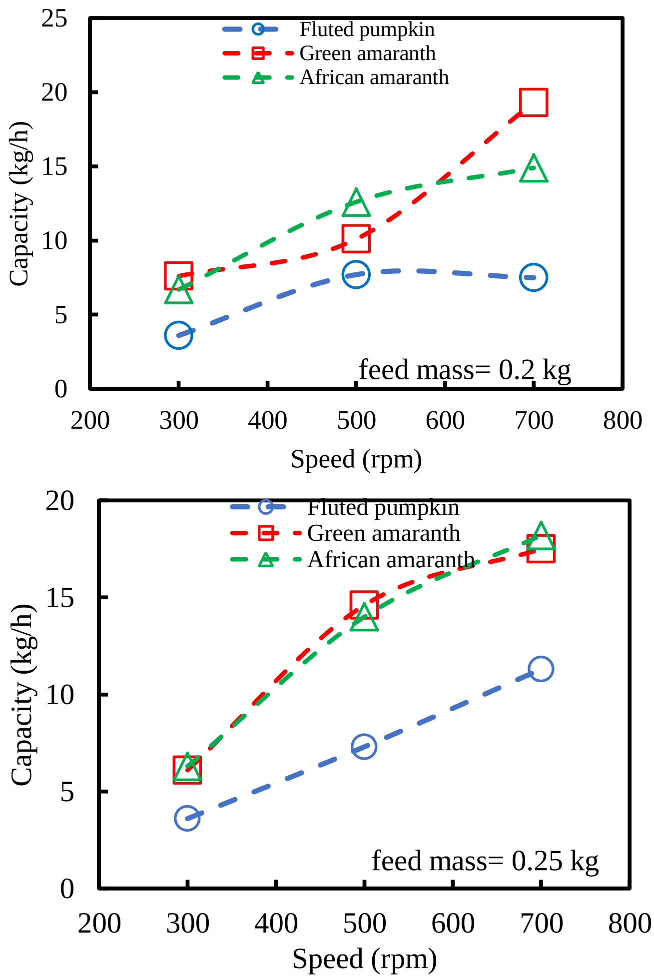
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	65.28667	2	32.64333	2.654649^{n}	0.184623^{ns}	6.944272
Mass	192.4067	2	96.20333	7.823529 *	0.04145^{ns}	6.944272
Error	49.18667	4	12.29667			
Total	306.88	8				

ns = no significant difference; * = significant difference

5.4 Effect of loading on capacity of machine fluted pumpkin (Ugu), green amaranth (Efo Tete), and African amaranth (Efo Soko)

The effect of speed and vegetable variety on the slicing capacity of the machine is presented in Figure 6a. The slicing capacity increased with an increase in speed, and the Analysis of Variance (Table 9) showed that the effect of speed and vegetable variety was not significant (p<0.05). The highest slicer capacity was 19.3 kg/h observed at 700 rpm speed for green amaranth, which indicates that for slicing activity to be the more productive speed of 700 rpm should be carried out for green amaranth. The effect of the speed and vegetable variety on the slicing capacity of the machine is presented in Figure 6b, and the ANOVA is shown in Table 10.

The result from Figure 6b shows that the capacity increased with an increase in speed with a significant difference (p<0.05). The highest capacity was recorded for African amaranth, 18.2 kg/h at a speed of 700 rpm. At this feeding of 0.25kg, the machine increased its capacity from 12 kg/h to 18 kg/h. It was observed that as speed increases, the capacity of the machine increases, as shown in Figure 6c, and the ANOVA result (Table 11) showed that the effect of variation of speed and vegetable variety was significant (p<0.05).
At 0.3 kg feed mass, it was observed that fluted pumpkin gives the lowest machine of 12.1 kg/h capacity, while the highest capacity of 19.2 kg/h was observed for African spinach.



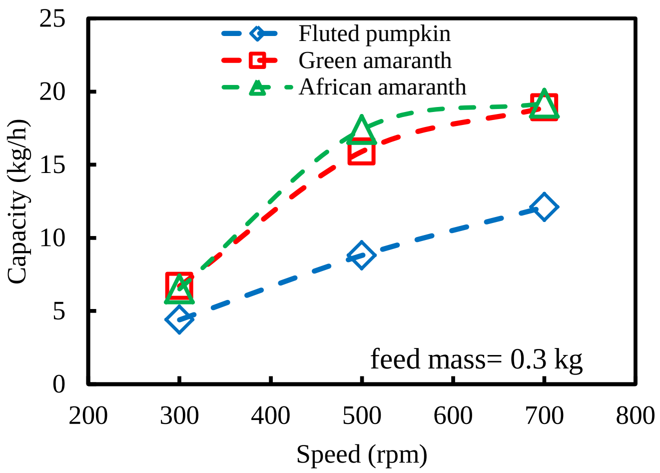


Figure 6: Effect of Vegetable Variety on Slicing Capacity at 0.2 kg, 0.25 kg, 0.3 kg a leafy vegetable slicing machine.

Table 9: ANOVA Table for effect of Vegetable variety on slicing capacity at 0.200 kg loading

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	94.48667	2	47.24333	6.77162	0.051988 ^{ns}	6.944272
Vegetable variety	64.02667	2	32.01333	4.588629	0.092145 ^{ns}	6.944272
Error	27.90667	4	6.976667			
Total	186.42	8				

ns = no significant difference; * = significant difference

Table 10: ANOVA Table for effect of Vegetable variety on slicing capacity at 0.250 kg loading

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Speed	164.4689	2	82.23444	39.89811	0.00227*	6.944272
Vegetable Variety	57.97556	2	28.98778	14.06415	0.0155*	6.944272
Error	8.244444	4	2.061111			
Total	230.6889	8				

ns = no significant difference; * = significant difference

Table 11: ANOVA Table for effect of Vegetable variety on slicing capacity at 0.300 kg loading

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	192.0689	2	96.03444	29.43334	0.004048*	6.944272
Columns	64.64889	2	32.32444	9.907032	0.028213*	6.944272
Error	13.05111	4	3.262778			
Total	269.7689	8				

ns = no significant difference; * = significant difference

Figures 7-9 shows the samples of sliced leafy vegetables, retained leafy vegetables and unsliced leafy vegetables for Green Amaranth, African Amaranth and Fluted pumpkin

Figure 7: Samples of Sliced Leafy Vegetables (Green Amaranth, African Amaranth and Fluted pumpkin)

Figure 8: Samples of Retained Leafy Vegetables (Green Amaranth, African Amaranth and Fluted pumpkin)

Figure 9: Samples of Unsliced Leafy Vegetables (Green Amaranth, African Amaranth and Fluted pumpkin)

6. Conclusion and Future Scope

The slicing machine was designed, fabricated, and evaluated. The test results showed that an increase in speeds results in an increase in slicing capacity and a decrease in slicing efficiency. The highest slicing efficiency of 95.2% was attained at a speed of 500 rpm and a maximum slicing capacity of 19.3 kg/h at a speed of 700 rpm. The highest percentage retained was 49.6% at a speed of 500 rpm. The effect of loading has a significant effect on the machine's capacity, and the effects of vegetable variety on the slicing capacity of the machine were significant. In this study, timeliness was eliminated quantity of unsliced vegetables, but there is a need to reduce the percentage retained on the screen. The slicing efficiency obtained shows that the machine can be adapted for small-scale and medium-scale production and it is easy to operate

Data Availability
This data is unavailable cannot be released, because it's a thesis for a university
Study Limitations are funding and getting freshly harvested vegetables.

Conflict of Interest
There is no conflict of interest from the authors

Funding Source
Funding was from personal savings

Authors' Contributions
Author-1 Conceptual design, investigation, methodology, writing - original draft
Author-2 involved in proofing, gaining ethical approval, approved the final version of the manuscript.
Author-3 Draft arrangement data analysis and contributed in the section of review and editing
All authors reviewed and edited the manuscript

Acknowledgements
Authors appreciate the entire Department of Agricultural & Environmental Engineering, School of Engineering and Engineering Technology, University of Ibadan, Ibadan, Oyo state, Nigeria

References

[1] P. C., Agu, Ezeh, E. M. and C. I. Nwosu. "Characterization of Nutritional and Phytochemical Compositions of Locally Consumed Leafy Vegetables from Afikpo, Ebonyi State, Nigeria." *Caritas Journal of Physical and Life Sciences*, Vol. **1**, issue **1**, pp. **1-8, 2022.**

[2]. E. I. Adeyeye, and F. O., Omolayo. "Chemical composition and functional properties of leaf protein concentrates of Amaranthus hybridus and Telfairiaoccidentalis". *Agriculture and Biology Journal of North America*, Vol. **2**, Issue **3: 499-511, 2011**

[3]. G. O., Igile, I. A., Iwara, B. I. A., Mgbeje, F. E., Uboh and P. E., Ebong. "Phytochemical, proximate and nutrient composition of vernoniacalvaonahook (Asterecea): A green-leafy vegetable in Nigeria". *Journal of Food Research*, Vol. **2**, Issue **6,** pp. **1-10, 2013.**

[4]. I., Maseko, T., Mabhaudhi, S., Tesfay, , H. T., Araya, M., Fezzehazion, and C. P., Du Plooy. "African Leafy Vegetables: A Review of Status, Production and Utilization in South Africa". *Sustainability*, Vol. **10**, Issue **1**, pp. **1-16, 2017.**

[5]. E. C., Nwanekezie, and P. N., Obiakor-Okeke. "Mineral Content of Five Tropical Leafy Vegetables and Effect of Holding Methods and Time". *American Journal of Experimental Agriculture*, Vol. **4,** Issue **12**: pp. **1708-1717, 2014**. https://doi.org/10.3390/su10010016

[6]. M. M., Odewole, O.A., Adesoye, and O.A., Shadare. "Determination of some mechanical properties of Ugu seed (Telfairia occidentalis) in relation to the design of cracking machine". *Science Technology and Arts Research Journal*, Vol. **4**, Issue **3: 187-191, 2015**.

[7]. A. M. A., Sakpere, O. T., Oladipo, Y. O., J. O., Mukaila, Ayinde, and O. M., Oluwaniyi. "Indigenous Leafy Vegetables and Health Management in South-Western Nigeria: A Review Based on Osun State". *Food Security and Safety: African Perspectives*, Vol. **21**, Issue**14**, pp. **15-134, 2022.**

[8]. M. J., Horsfall, and I. A., Spiff. "Equilibrium Sorption Study of A13+, CO2+ and Ag+ in Aqueous Solution by Fluted Pumpkin (Telfaria Occidentalis Hook F) Waste Biomass". *Acta Chemistry of Slovia* ,Vol. **1**, Issue **52:** pp. **174-181, 2005**.

[9]. R. L., Sealy, E. L., McWilliams, Novak, J., Fong, F., Kenerley, C. M., Janick, J. and J. E., Simon, (ed.). "Vegetable amaranths: cultivar selection for summer production in the south. Advances in new crops". *Proc. of the first National Symposium 'New crops: research, development, economics'*, Vol. **12**, Issue **2**, pp. **396–398, 1990.**

[10]. J. C., Norman, and V. D., Shongwe. "Influence of some cultural practices on the yield and quality of amaranth (Amaranthus hybridus L.)". *Advance Horticultural Science*. Vol. **5**, Issue **7**: **169–172, 1993.**

[11]. J., Allemann, E. V. D., Heever, and J., Viljoen. "Evaluation of Amaranthus as a possible vegetable crop". *Appl. Plant Sci*. Vol. **18**, Issue **10: 1–4. 1996**.

[12]. C., Mapes, F., Basurto, and R. Bye, "(Ethnobotany of quintonil: knowledge, use and management of edible greens Amaranthusspp. (Amaranthaceae) in the Sierra Norte de Puebla, Mexico". *Economical Botony*. Vol. **22**, Issue **51: 293–306. 1997**.

[13]. S. I., Manuwa, A. M., Sedara, and F. A., Tola. "Design, fabrication and performance evaluation of moringa (oleifera) dried leaves pulverizer". *Journal of Agriculture and Food Research*, Vol **1**, Issue **2**, pp. **22-34. 2020.**

[14]. A., Leo, and A., Balogun. "Design and Performance Evaluation of a Multi-Crop Slicing Machine". *International Symposium on Food Processing, Monitoring Technology in Bioprocesses and Food Quality Management, Potsdam, Germany*. Vol. **23**, Issue **3**, **622-640, 2009.**

[15]. V., Singh, M., Das, and S. K., Das. "Effects of knife edge angle and speed on peak force and specific energy when cutting vegetables of diverse texture". *International Journal of Food Studies*, Vol **2**. Issue **5**: pp **22-38. 2016**.

[16]. C. N., Anyanwu, C. A., Kalu, V. C., Okonkwo, J. I., Ume, and I., Onyekwelu. "Design and development of fluted pumpkin (Telfaria occidentalis) leaves slicing machine". *Nigerian Journal of Technology (NIJOTECH),* Vol. **37**, Issue **3**: pp **813-817. 2018.**

[17]. C. P. N., Awili, B. V., Omidiji, and I. I., Awili. "Design of Manual Vegetable Slicing Machine". *The Nigerian Journal of Research and Production*, Vol. **15**, Issue **2**: pp **1-10. 2009.**

[18]. S., Adenekan. "Development of a leafy vegetable cutting machine". Unpublished B.Eng. thesis submitted to the Department of Agricultural Engineering, Federal University of Technology, Akure, Ondo State, Nigeria. **2013**.

[19]. M. O., Adewale. "Modification and Evaluation of a leafy vegetable cutting machine". Unpublished B.Eng. thesis submitted to the department of Agricultural Engineering, Federal University of Technology, Akure, Ondo State, Nigeria. **2014**.

[20]. O. S., Kamaldeen, and E. F., Awagu. "Design and Development of a Tomato Manual Slicing Machine, Nigerian Stored Products Research Institute", *International Journal of Engineering and Technology*, Vol **14**, Issue **7**, pp **57-60. 2013.**

[21]. O. S., Kamaldeen, K. A., Arowora, J. S., Abioye and E. F.,

Awagu. "Modification of Manually Operated Tomato Slicing Machine". *International Journal of Engineering Science and Computing*, Vol. **6**, Issue **7**: pp. **1933-1938. 2016.**

[22]. K. R., Pawar, M. P. D., Ukey, M. P. D., Bhosale, K. B., Ghorpade, R. B., Jadhav, and A. A., Patil. "Development of fruit and vegetable slicing machine". *International Research Journal of Engineering and Technology*, Vol. **7**, Issue **3**, **1399-1404, 2020**.

[23]. P.D. Kahandage, and R.H.G.R. Wathsala, and D. A. N. Dharmasena. "Design, Development and Performance Evaluation Operated Leafy Vegetable Slicing Machine for Domestic Use". pp. **1–2, 2017.**

[24]. M.A., Hoque, and K.K., Saha. "Design and development of a manual potato cum sweet potato slicer", *Journal of Science, Technology and Environment Informatics*, Vol. **5**, Issue **2**: pp. **395–401, 2017**. https://doi.org/10.18801/jstei.050217.42

[25]. R.P., Krantidip, D.U., Pravin, D.B., Pritam, B.G., Kaustubh, B.J., Rushikesh and A.P., Aniket. "Development of Fruit and Vegetable Slicing Machine*", International Research Journal of Engineering and Technology (IRJET),* Vol. **7**, Issue **3**: **1399-1404. 2020**

[26]. J. N., Msuya, "Designing and Manufacturing of Vegetable Slicing Machine". *Tanzania Journal of Engineering and Technology*, Vol. **42**, Issue **1**, pp. **5-13, 2023.**

[27]. K., Salaudeen, O., Oladimeji, and A., Fidelis, "Design and Development of a tomato Slicing Machine". *International Journal of Engineering and Technology*, Vol. **13**, Issue **2: 197–208, 2017**.

[28] S. P., Sonawane, G. P., Sharma, and A. C., Pandya. "Design and development of power operated banana slicer for small scale food processing industries". *International Journal of Engineering and Technology*, Vol. **57**, Issue **4,** pp. **144–152, 2011.**

[29]. A.K., Eliçin, and F.G., Pekitkan. "Effect of Various Knife Type, Cutting Angle and Speed on Cutting Force and Energy of Grape Cane", *European Journal of Science and Technology*, Vol. **15,** Issue **1, 519–525, 2019.**

[30]. T.A., Ishola, and L., Adewole. "Development and Performance Evaluation of an Okra Slicer", *Arid Zone Journal of Engineering, Technology and Environment*, Vol. **16**, Issue **2: 269–278, 2020**.

[31]. I. S., Aji, E., James, A., Ejovwoke and D. A., Mshelia. "Development of an electrically operated cassava slicing machine". *Arid Zone Journal of Engineering Technology and Environment*, Vol. **9**, Issue **3**: **90-95. 2013**.

[32]. R. S., Khurmi, and J. K., Gupta. "A Textbook of Machine Design (S.I. Units) Published by Eurasia Publishing House (PVT) Ltd, Ram Nagar, New Delhi", **2005**

[33]. B. O., Bolaji, S. B., Adejuyigbe, and S. P., Ayodeji. "Performance Evaluation of a Locally Developed Cassava Chipping Machine". *South African Journal of Industrial Engineering*, Vol. **19**, Issue **1**: **169-178, 2008.**

[34]. J. O., Awulu, J., Audu, and Y. M., Jibril. "Development of Cassava Chipping Machine Using Electric Motor cum Manual Operation". *Journal of Harmonized Research in Engineering,* Vol. **3**, Issue **2**: **78-84, 2015**

AUTHORS PROFILE

Mary Adewale earned her B. Eng., and M. Sc. in Agricultural and Environmental Engineering from the Federal University of Technology, Akure and University of Ibadan, Nigeria in 2014 and 2019, respectively. Her main research work focuses on Crop Storage and Processing Engineering and Postharvest Engineering Technology. She has 3 years of research experience.

Abdulganiy Raji earned his B. Sc., M. Sc., and Ph.D. in Agricultural Engineering from University of Ibadan, Nigeria and University of Newcastle-upon-Tyne, UK in 1989, 1992, and 1999, respectively. He is currently working as Professor in Department of Agricultural and Environmental Engineering, University of Ibadan. He has published more than 70 research papers in reputed international journals and conferences and it's also available online. His main research work focuses on Crop Storage and Processing Engineering, General Mechanization, Systems Modeling and ICT. He has 25 years of teaching experience and 25 years of research experience.

Adewale Sedaraearned his B. Eng., and M. Eng., in Agricultural and Environmental Engineering from the Federal University of Technology Akure, Ondo State, Nigeria. In 2012 and 2018. He is currently studying for his PhD in Iowa State University, Iowa, USA. He has published more than 15 research papers in reputed international journals including ELSEVIER (SCI & Web of Science) and conferences which is also available online. His main research work focuses on crop-soil- machine interaction and soil dynamics. He has 5 years of teaching experience and 5 years of research experience.

