Modification of a Plantain Slicing Machine

F.B. Akande T.B. Onifade
Department of Agricultural Engineering LadokeAkintola University of Technology, PMB, 4000, Ogbomoso, Nigeria

Abstract

Plantains are wasted due to deterioration when dumped in villages and towns during the peak of harvest. Therefore, it is necessary that plantains are processed into chips for preservation and availability throughout the year. Modern methods of slicing have greatly improved production rate and reduces slicing time. The main objective of this study was to modify an existing plantain slicing machine so as to optimize its efficiency at low cost, reduce total time of slicing and produce hygienic and quality chips. The improvement on the design of the existing slicing machine was achieved through proper focus on the capacity, materials and other design criteria for various component parts. The slicer consists of cutting disc, cutting chamber, feeding chute, the main frame and power transmitting unit. The result of the improvement on the design of this slicing machine showed that maintenance cost is cheap, slicing time of plantain chips was reduced, operation of the machine does not require special skill, the machine is easy and safe to operate, it is free of noise and vibration,the slicing method is continuous with two slicing blades provided inside the cutting chamber and energy for loading and unloading is reduced since feeding chute and collecting bucket are provided. Slicing of plantain is safe since finger injury is reduced. The efficiency of the modified plantain slicing machine is 95.79 % with capacity of 50.49 g/s. The slicer is therefore recommended for commercial use.

Keywords: plantain,slicing machine, redesign, modification of the existing design

INTRODUCTION

Plantain is a basic food crop in developing countries, especially in Africa; it serves as one of the major foods for over 70 million people. The plantain belongs to the family Musa Spp and species of Musa paradisiacal and is originated from Southern Asia, Asia (Anonymous, 2008). In some part of Africa such as Nigeria and Ghana, plantains are also dried and made into flour; banana meal forms important food stuffs with the following constituent water 10.62% protein 3.55%, fat 1.15%, carbohydrate 81.67% and ash 3.01% (Arisa*et al.,* 2013).

Plantain is commonly produced in West Africa especially Cameroon, Benin, Ghana and Nigeria; (FAO, 1990) when ripe plantain is fried, it is generally called dodo (dough-dough). In Ikire, a town in western Nigeria, there is a unique and special way of preparing plantain chips which is popularly called 'Dodo Ikire', this product is made from overripe plantain. The locally made product (dodo Ikire) has a preservative quality that last up to two months without refrigeration (IITA, 2001).

Plantainis an important export crop to industrialized countries, and it is therefore an important source of revenue for many small scale farmers in developing countries (Anonymous, 2008). Provision of a motorized slicing machine will contribute to food security, export earnings and economic growth. Farmers are faced with post-harvest losses since the plantainperish or get rotten easily when ripe, for this reason, many methods of processing (roasting and frying) are being introduced to reduced losses for human consumption, after harvest. Commonly, the process of manual peeling and slicing using knife is time consuming (Awoluyi, 2008; Obeng, 2004).

The manually operated wooden platform plantain slicer is aslow method commonly used in small scale industries as reported by Okafor (2013). This is why the use of mechanized slicer is very necessary to reduce the drudgery of continuous cutting of bulk of plantains and potatoes with knife. The use of motorized slicer will facilitate mass production of the chips. The plantain is pressed and moved across the sharp blades of the machine. The machine operator is endangered by getting his finger cut by the exposed sharp blades when theslicing misses a cut (Okafor, 2013).It is also time consuming since the operator will be operating a slow rate to avoid injury.

Nwanekezie and Ukagu (1999) reported another manually operated cutting knife in which the plantain is placed on top of a sharp blade on the base frame of the machine and the upper handle which also contain sharp blade is pressed down thereby slicing the tuber into chips. The operator gets his hands injured when unloading, because some of the chips stocked in between the sharp blades.This also consumestime because of the slow nature in unloading in order to avoid injury. Designing and fabricating a motorized plantain slicer will reduce drudgery and increase the rate and volume of slice at a particular time. As regard these, it is necessary to design and construct a plantain slicing machine which will slice a finger of raw plantain within a short period of time (FIIRO, 2007).

Most raw materials often occur in large sizes to be usedafter harvesting and, therefore, they must be reduced in size (Earle and Earle, 2004). This size-reduction operation can be categorized into two depending on whether the material is a solid or a liquid. If it is solid, the operations are called grinding and cutting, if it is liquid, emulsification and atomization. These depend on the reaction to shearing forces within solids and liquids (Earle and Earle, 2004).Slicing equipment consists of rotating or reciprocating blades which cut the food material as it passes beneath (Fellow 1988). The food is held against the blades by centrifugal force while for slicing meat, the food is held on a carriage as it travels across the blade. Harder fruit such as apples are simultaneously sliced and passed over stationary knives fitted inside a tube (Fellow 1988).

Banana slicing machine is used for slicing banana plain and rippled chip, peeled bananas are fed manually from the top of the slicer and sliced chips are guided through a guide. It is a hand push machine in which the outlet is mounted over a frying pan. The machine is a single pulley driven shape of slices elliptical about 2-3mm size. It requires low maintenance and easy handling. The machine is provided with cutting plate which has adjustable blade and the machine frame is fabricated in stainless steel (FIIRO, 2008).According to Brennan *et al*, (1990) sliced fruits are much in demand as desert dish with attractive appearance; the portion produced being convenient size for eating. Rotary cutting knives are usually employed to cut the material being presented on them, often on a vibrating belt in to parallel sliced of the thickness.

Fellows (1988) mentioned that most meats, fruits and vegetables fall into the general category of fibrous food. Meat are frozen and tempered to just below their freezing point to improve the efficiency of cutting. Fruit and vegetables have an inherently firmer texture and are cut at ambient or chill temperatures. In general, impact and shearing forces, often applied through a cutting edge are sued in the disintegration of fibrous materials. Much of the equipment used is similar to that used for dry powered material; a typical example is thehammer in a percussion mill which can be replaced by a series of knives which apply the impact along a thing cutting edge (Brennan *et al.*,1990). Also fibrous solids may require conversion in to semi-solid pulps common requirement in jam production.These specialized reduction operations usually employ specially designed equipment(Brennan *et al.*, 1990).

It was observed that the traditional method of cutting plantains into chips is stressful leading to drudgery and prone to finger injury, time consuming, does not produce uniform size of sliced chips, and inevitably leads to low output by farmers with little or no income margin. The observation of the existing plantain slicing machine when tested was non-uniformity in size, broken and discoloured sliced chips which made the products unacceptable. The commonest methods of slicing plantain in our localities today include the use of knife, wooden platform plantain slicer, plastic with metal cutter and existing slicing machine. These methods have a lot of deficiencies in term of slicing time, efficiency, productivity, quality and safety. The equipment is required to be properly maintained and kept clean to provide more reliability and longer service life.

In view of this, there is need to improve on the existing plantain slicing machine powered by an electric motor for commercial quality. The main objective of this study is to improve performance ofan existing machine for slicing plantain by constructing a new slicing blade, changing the position of the cutting chamber, the hopper and evaluate its performance so as to:

- Increase the slicing efficiency at low cost
- Reduce total time of slicing
- Produce quality chips (acceptable colour)
- Achieve noise free operation and vibration with low power consumption

MATERIALS AND METHODS

The processing center, where the existing plantain slicing machine has been used, was visited. The problems associated with its operation due to the shortcomings in its design were identified as the machine was properly examined. The necessary procedures were carried out to eliminate the causes of the shortcomings observed vividly.

Components of the existing slicer

The existing slicing machine (Figure 1) is made up of the following component parts:

- The feeding chute
- The slicing chamber
- The power unit
- The shaft cover

Figure 1: The pictorial view of existingplantain slicer

Problems identified with the existing design of the plantain slicer:

- Discoloration of the sliced chips
- Longer slicing time of the chips
- High noise and vibration during operation
- Production of plenty broken sliced chips

The proposed modification on the existing plantain slicer:

The improvement on the existing machine for slicing plantain was carried out based on the problems associated with its design that is, constructing two new slicing blades, providing hopper with cover, changing the position of the cutting chamber, the feeding chute and electric motor. The orthographic projection of the plantain slicing machine with dimensions is presented in Figure 2.

Design considerations for the improved plantain slicer

Some factors were considered in the design of plantain slicing machine in order toproduce high quality and large quantity of plantain chips. The factors considered are as follows;

- Hygiene: The slicing blade must be washable so that quality chips can be obtained therefore the blade must be made of stainless steel as approved by world health organization (WHO) to guide against corrosion .
- Acceptable Colour: The colour of the sliced products must not change, though it depends on the colour of the plantain to be sliced.
- Aesthetics:The machine physical appearance should look good, attractive and not looking odd, this would make it attractive by choosing a streamlined frame design, choosing light but durable materials, wirings should also be done neatly and an attractive paint color must be selected.
- Size and weight of the machine: The overall size and weight of the machine is an important factor that governs the size of the selected materials and their components such as electric motor. The easy movement of the machine is an important factor, so that anywhere the machine will be needed, it can be easily conveyed to the place.
- Compactness: this is importantwhen the machine is built as small as possible without removing basic components and features.
- Ease of Operation: The machine is designed in a way that it is easy to assemble, disassemble, load, operate and off-load.
- Safety: The wires of the electric motor are all insulated and the electrical switch is carefully selected to ensure complete power cut from the mains when switch off and to prevent electric shock in case the neutral wire becomes the live when plugged to a wrongly connected socket. The casing on the electric motor was also insulated, while sharp edges were made blunt. Rotating parts were also shielded.
- Ease of Maintenance: The machine must also be easily maintained either by routine or weekly cleaning, retightening of bolts, and lubrication of necessary parts e.g. bearing and joints.
- To ensure that the machine does not get wet after the plantain has been sliced in order to prevent rusting of the moving parts.

Feeding chute: The feeding chute is cylindrical inshape and attached to the cutting chamber cover. It has a diameter of 50mm and serves as a receptacle through which plantain is admitted into the machine. It is an open-ended cylinder through which plantain passes into the cutting chamber.

Cutting disc: The cutting disc consists of a disc of diameter 320mm with two attached blades at both ends of the disc. The disc was attached to the shaft with its slot to a key on the shaft. The cutting disc consists of the stainless steel blades, shafts and pulleys. The blades are arranged perpendicular to the plantain tubers. The drive shaft is supported by two ball bearings mounted on the base frame and the cover.

Cutting chamber: The cutting chamber is an open-ended rectangular box designed to house the cutting disc and to collect the sliced plantains.An inclined stainless steel was welded directly below the cutting disc to receive, and dispense the sliced plantains. Perforated sheet metals are put at designated places on the cutting chamber to serve as air inlets, to avoid discoloring of the sliced plantains.

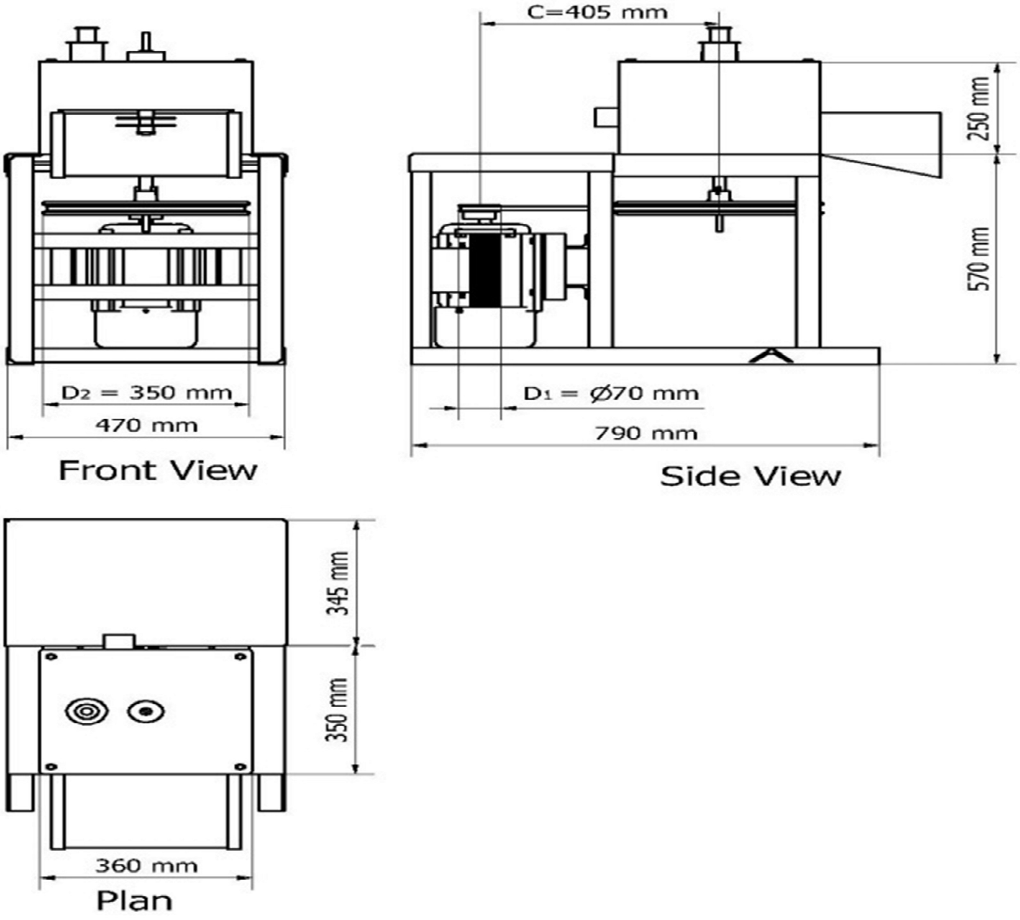

Figure 2: The orthographic view of the plantain slicer

Power Transmitting Unit: This unit consists of shaft, an electric motor, pulleys, v-belt and bearing. Power reduction was achieved with the aid of pulleys of size 70 and 350 mm.V-belts was used to transmit the power because of the distance between the pulleys and its comparative advantages of increased frictional grip with the pulley to avoid slipping of belts. A 1 hp electric motor with a speed of 1440 rev/min was used to power the machine.

OperationalPrinciple of the Slicing Machine

The machine works on shear cutting principle and has the capacity to slice1,200 plantains within a short period of time (46 minutes). Power is transmitted from electric motor to input shaft via a pulley system. The input shaft transmits power to the cutting mechanisms which consists of a disc with attached knives for cutting the plantain feed in vertically from the hopper. The pictorial and exploded view are presented in Figures 3 and 4.

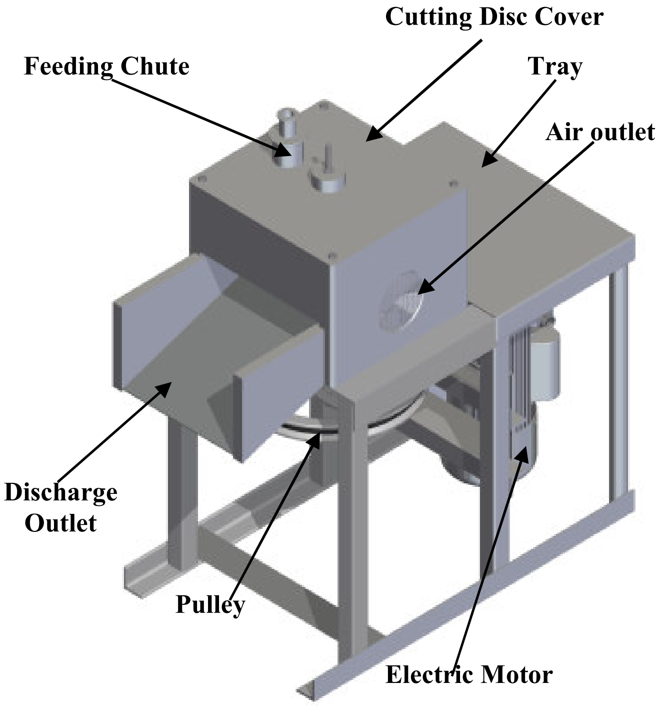

Figure 3: The pictorial view of the slicer

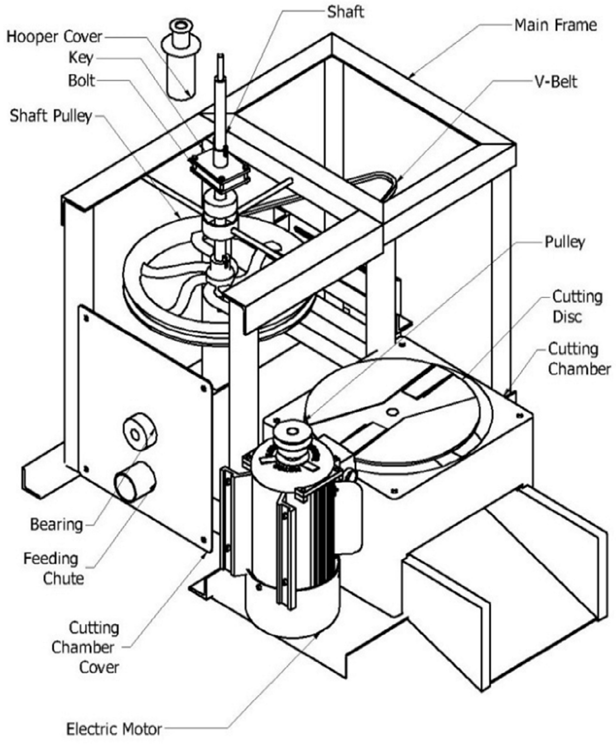

Figure 4: The exploded view of the slicer

Design Analysis

The following are the design procedure and calculation of how the operation parameters of the parts of the machine are determined:

Pulley speed and size

The pulley was designed by considering the power to be transmitted between the electric motor and the shaft connected to the cutting disc. The diameters of the pulleys calculated as employed byKachru (1996).

$$\text{Velocity Ratio(VR)} = \frac{N_1}{N_2} = \frac{D_2}{D_1} \qquad (1)$$

Where,
N_1 = Speed of the pulley on the motor, rpm
N_2 = Speed of the pulley on the shaft, rpm
D_1 = Diameter of the pulley on the motor, mm
D_2 = Diameter of the pulley on the shaft, mm
D_2 is calculated as;

$$\text{VR} = \frac{1440}{288} = \frac{D_1}{D_2} = 5$$

If a pulley of diameter 70mm was used on the motor, a pulley of 350mm is required for the shaft.
$D_2 = D_1 \times 5 = 70 \times 5 = 350$ mm

Length of belt

As described by Khurmi*et al.* (2004) the length of an open belt can be calculated by this formula;

$$L = 2C + \frac{\pi}{2}(D_1 + D_2) - \frac{(D_2 - D_1)^2}{4C} (2)$$

Where,
L = Length of an open belt, mm
C = Centre distance of belt, mm
D_1 = Diameter of the pulley on the motor, mm
D_2 = Diameter of the pulley on the shaft, mm
Given C = from the design, L is calculated as

$$L = 2(395) + \frac{\pi}{2}(350 + 70) + \frac{(350 - 70)^2}{4(395)}$$

L = 790 + 660+ 50= 1550 mm
V-belts are designated by its type and nominal *inside* length. A *V*-belt of type *A* which can transmit power between the ranges of 0.7- 3.5 kW, the standard inside length nearest to 1500mm is 1600mm (Khurmi*et al.,* 2004)

Angle of contact between the belt and pulley

The angle of contact at the small pulley (θ), is thus calculated as;

$$\theta = (180^0 - 2\alpha)\frac{\pi}{180} rad (3)$$

where,

α = wrap angle of the smaller pulley.

$$\sin\alpha = \frac{D_2 - D_1}{2C} \qquad (4)$$

$$\sin\alpha = \frac{350 - 70}{2(395)} = \sin^{-1} 0.35 = 20.8^0$$

$$\theta = [180 - 2(20.8)] \times \frac{\pi}{180} = 2.42 \text{ rad}$$

Tension in the belt

The relation between the tight side and slack side tensions, in terms of coefficient of friction (μ) and the angle of contact is given by Khurmi(2004) as;

$$2.3 \log\left(\frac{T_1}{T_2}\right) = \mu\theta (5)$$

Where,
T_1 = Tension in the belt on the tight side, N

T_2 = Tension in the belt on the slack side, Nand
μ = the coefficient of friction between the belt and pulley = 0.25

$$\log\left(\frac{T_1}{T_2}\right) = \frac{0.25 \times 2.42}{2.3}$$

$$\left(\frac{T_1}{T_2}\right) = 1.83$$

$T_1 = 1.83 \times T_2$ (6)

The expression which shows the relationship between the power transmitted, belt tension and linear velocity is given as;

$P_M = (T_1 - T_2)(7)$
Where,
V= Belt velocity, m/s

$V = \frac{\pi D_1 N_1}{60}$ (8)

$$V = \frac{\pi \times 0.07 \times 1440}{60} = 5.3\, ms^{-1}$$

$$(T_1 - T_2) = \frac{P_M}{v} = \frac{746}{5.3} = 140.75\, N$$

$$1.83T_2 - T_2 = 140.75$$

$$T_2 = \frac{140.75}{0.83} = 169.6\, N$$

$$T_1 = 1.83 \times 72.2 = 310.3 \text{ N}$$

Determination of the Shearing Force for the Raw Plantain

Considering the shear strength of the raw plantain and the area under shear, the impact force required to shear the raw plantain may be obtained from the following equation (Odekunle, 1986):

$\tau_P = \frac{F_p}{A_p}$ (9)

$F_p = A_P \times \tau_P$ (10)

Where,
F_p=Force required for shearing the raw plantain, N
A_P= Area under shear, m^2
τ_P= Shear stress of the raw plantain, N/m

The area under shear can be determined using equation 11;

$A_P = \frac{\pi D^2}{4}(11)$

Where,
D= Diameter of raw plantain

The measured diameter of the raw plantain was in the range of 30-70mm, at an average of 50 mm. The area is calculated from equation 11as:

$$A_P = \frac{\pi \times 0.05^2}{4} = 0.002\, m^2$$

$w = \frac{2\pi N}{60}(12)$

Where
w = angular velocity of rotating disc

N= speed of the pulley on the shaft, 288rpm

$$w = \frac{2 \times \pi \times 288}{60} = 30.2\, rad/s$$

$F_p = \text{ma}(13)$

$a = r\omega^2(14)$

$F_p = m\omega^2 r \ (15)$

Where,
a =linear acceleration m/s^2
m = mass of the cutting disc= 0.3kg
r = radius of the cutting disc = 160mm
F_p = 0.3 x 30.2^2 x 0.16m= 43.8 N
F_p = 43.8 N

The average force required to shear raw plantain of diameters ranging from 30-70mm was reported to be 33.15N (Obeng, 2004). However,
thecalculated force required toshear the raw plantains is greater than this value. This force reduces as the plantain ripens and softens.

$$\tau_P = \frac{43.8}{0.002} = 21900\ N/m^2$$

Determination of the Power Required by the Cutter for Slicing the Raw Plantain
Cutter velocity is another important parameter in the slicing process. The power required by the cutter to slice the raw plantain may be obtained from the following expression by Saeed(2001):

$$P_C = F_P \times V_C \qquad (16)$$

Where,
P_C= Power required by the cutter
V_C= linear velocity of the cutting blade

$$V_C = \omega \times r \qquad (17)$$

$$V_C = 30.2 \times 0.16 = 4.83\ m/s$$

$$P_C = 43.8 \times 4.83 = 211.55\ watt$$

Determination of the Power Required by the Electric Motor
The power required by the electric motor was obtained from equation 18;

$$P_M = P_C \times P_F(18)$$

Where;
P_M= Power of electric motor

P_F= Power factor = 2

$$P_M = 211.55 \times 2$$

= 423 watt
=0.423 kW = 0.57hp

Electric motor of capacity 746W (1hp) with speed of 1440rpm was selected based on safety and availability of the motor.

Determination of the Shaft Diameter
The shaft is subjected to combined twisting moment and bending moment, the shaft was designed on the basis of the two moments simultaneously as shown in Figure 5. As described by Khurmi and Gupta(2010)the equivalent twisting moment may be defined as that twisting moment, which when acting alone, produces the same shear stress (τ) as the actual twisting moment. By limiting the maximum shear stress (τ_{max}) equal to the allowable shear stress

(τ) for the material, T_e is calculated as;

$$T_e = \sqrt{M^2 + T^2} \quad (19)$$

$$= \frac{\pi}{16} \times \tau \times d^3$$

Where;
T_e= equivalent twisting moment (Nmm)
M = Bending moment (Nmm)
T = Twisting moment (or torque) acting upon the shaft (Nmm)
τ = Shear stress induced due to twisting moment/
allowable shear stress (N/mm^2)
d = Diameter of shaft (mm)

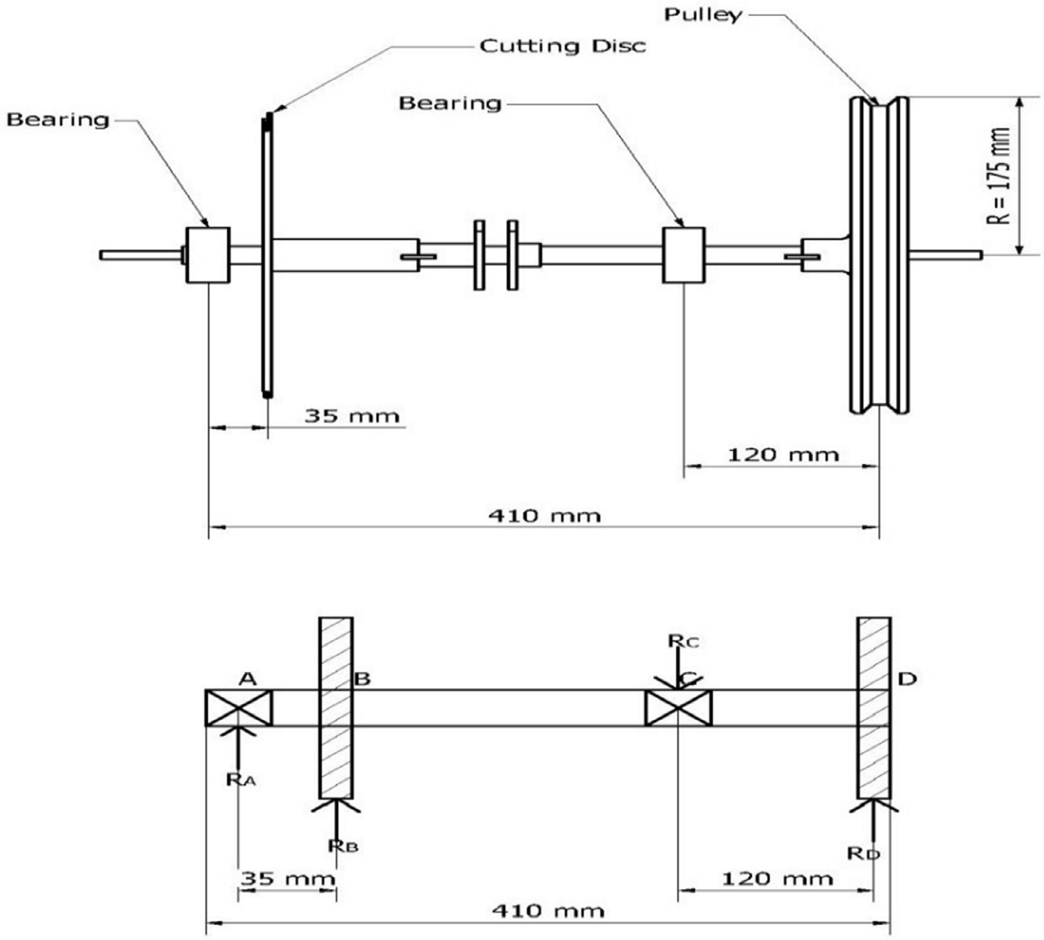

Figure 5: Load diagram of the shaft

The torque and tangential force (F) in Newton, acting on the pulley can be calculated as;

$$T = \frac{60 \times P}{2\pi N} \quad (20)$$

$$= \frac{60 \times 746}{2 \times \pi \times 288}$$

$$= 24.7\ Nm$$

$$F = \frac{T}{R} \quad (21)$$

$$\frac{24.7}{0.175} = 141\ N$$

If moment is taking about point A and B respectively, as shown in Fig. 6, reactions at the bearing are calculated as;

$$R_C = \frac{(43.8 \times 0.035) + (141 \times 0.41)}{0.29} = 205\ N$$

$$R_A = \frac{(141 \times 0.12) - (43.8 \times 0.29)}{0.29} = 14.5\ N$$

Moments at A and D is equal to zero and moment at B and C is calculated respectively as;

$M_B = 43.8 \times 0.35 = 1.53$ Nm
$M_C = 205 \times 0.29 = 59.45$ Nm

The maximum bending moment is at point C, 59.45 Nm. The allowable shear stress (τ) for steel is 45 N/mm, substitutingτ , *M* and *T* in equation (19), shaft diameter (d) can be calculated as;

$$T_e = \sqrt{59.45^2 + 24.7^2} = \frac{\pi}{16} \times 45 \times d^3$$

$$d = \sqrt[3]{\frac{16 \times 64.4 \times 10^3}{\pi \times 45}} = 19.4\ mm$$

Steel shaft of 20 mm diameter was selected and used.

Performance Evaluation

Before testing was carried, the machine was properly assembled and aligned as shown in Figure 3. Lubrication was also done to reduced friction in the rotating members. The belt was connected to the pulley and the electric motor. Testing of the machine with load was then carried out. The electric power was supplied to the machine via electric motor and test run for ten minutes so as to study the behavior of the machine. It was observed during this process that blade rotated without wobbling. The plantain was peeled with a knife to remove its pericap (outer cover). The peeled plantain which was held by hand fed vertically into feeding chute through the hopper and covered with a lid, during this process, sliced plantain (chips) passed through the discharged outlet.

Ten fingers of raw plantain were measured to be 1,176.6 g using a laboratory weighing balance. The plantains were sliced for 23.2 seconds; the weights of the round (properly) and broken sliced plantains were 1131.1 g and 45.5 g, respectively. Figure 6 shows the plantain chips produced by the modified slicing machine.

Figure 6: Sliced plantain (chips) produced by the slicing machine

Operating capacity: The operating capacity, c,was calculated using equation 22 as stated by Gupta and Khurmi (2004):

$$c = \frac{w}{t} \quad (22)$$

Where;

$$w = total\ weight\ of\ sliced\ plantain\ (g)$$
$$t = time\ taken\ to\ slice\ (s)$$
$$c = \frac{1{,}176.6\ g}{23.2\ secs} = 50.7\ \text{g/s}$$

Slicing Efficiency: The slicing efficiency (%)of the machine was determined using equation 23 as expressed by Gupta and Khurmi (2004):

$$\eta = \frac{W_{RSP} - W_{BSP}}{W_{BSP}} \times 100 \qquad (23)$$

$W_{RSP} = weight\ of\ round\ sliced\ plantain, g$
$W_{BSP} = weight\ of\ broken\ sliced\ plantain, g$

$$\eta = \frac{1131.1\ g - 45.5\ g}{1131.1\ g} \times 100$$

$$\eta = 95.97\ \%$$

Results and Discussions

Several fingers of plantain were cut in the workshop and crop processing laboratory to during the initial stages of the slicer development. Series of remedial actions were taken to ensure the machine's functional requirement for its intended use. Results from design analysis showed that Force required for shear a finger of raw plantain is averagely 43.8 N. The angular speed of rotating disc is 30.2 rad/s. A 1600 mm length of belt was used for transmitting power from electric motor to the cutting disc. The operating capacity and efficiency were 50.7 g/s and 95.97 %, respectively.

The slicing timefora finger of raw plantain was between 2 to 3 seconds,compare to existing machine which takes between 30 to 40 seconds to slice a finger of plantaindepending on the length of plantain ranging from 200-300 mm and diameter between 30-70 mm.The time taken to slice1,200 fingers of raw plantain into chips was 46 minutes. Results showed that ten fingers of raw plantain were weighed to be 1,176.6 g, the weights of the whole round and broken sliced plantains were 1131.1 g and 45.5 g, respectively.Also, 710 plantain slices were produced by ten plantain fingers and 630 slices out of 710 slices indicated (88.7%) uniform slice thickness of 2.9-3.20 m, while49 slices (7.04 %) and 31 slices (4.22 %) out of 710 slices were half and quarterly broken respectively. During operation, the machine was noise free and no vibration was observed.The slicing blade rotated without wobbling, the output of motorized slicer was quite encouraging and saved time. This is an indication that the ability of the machine to slice efficiently depends on the mass of the plantain and the power rating of electric motor. The slicing mechanism achieved the intended function, it sliced the plantain very well because the physical nature of the specimen (the sliced plantain) produced showed that the slicing blade and cutting chamber had no negative effect on the colour of the sliced plantain, this impliedthat there was no contamination, the plantain retained its colour and round shape plantain chips of uniform size were obtained. This indicates that the machine's functional requirement is achieved.

Advantages of modified machine over existing one

Based on the results of the test obtained, the machine proved to be a better design than the existing on in the following ways;

i. The slicing timeofplantain is reduced.
ii. It is cheap to maintain since the machine
iseasily assembled and disassembled;
and only lubrication of moving partsis required.
iii. The materials used for the construction of the machine are locally available.
iv. The machine is ergonomic; operation of the machine does not require special skill.
v. Energyfor loading and unloading is reduced since tray for loading and discharge outlet for unloading are large.
vi. The machine can slice both ripe and unripe plantain.
vii. No discoloration of the sliced chips produced with provision of stainless blade and air outlets on the frame.
viii. Safety is ensured, all rotating parts are shielded and electric motor casing is insulated.

CONLUSIONS

The plantain slicing machine has been modified and evaluated.With this modified plantain slicer, the problems of safety, quality and quantity of sliced plantain associated with manual slicing and existing slicer has been eliminated.The modified plantain slicer is user friendly and does not require and special skill to operate. The slicing efficiency of the modified slicer has been determined to be 95.57 %. In addition, the equipment is required to be properly maintained and kept clean to provide a more reliable and longer service life. This plantain slicer is recommended for small and medium scale production.

ACKNOLEDGEMENTS

Acknowledgement is hereby accorded to my final year project students of Agricultural Engineering Department, LAUTECH, Ogbomoso and Abiola Electrical Installation, Osogbo for their support during this project work.

REFERENCES

Anonymous (2008): About plantain nutrition and processes. http://www.plantain.be/nutritional=valves.of.plantain.php

Anonymous (2008): About plantain nutrition and processes. Retrieved March 2009 from http://www.plantain.be/nutritional=valves.of.plantain.php.

Arisa, N.U., Adelekan A.O., Alamu, A.E. and Ogunfowora,E. J. (2013).“The effect of pretreatment of plantain (*Musa Paradisiacal*) flour on the pasting and sensory characteristics of biscuit”, International Journal of Food and Nutrition Science. 2013; vol. 2(1), pp 10-12

Awoliyi, O.O. (2003): “Design and construction of plantain slicer” unpublished thesis dissertation in Department of design and fabrication. Federal Institute of Industrial Research, Oshodi, pp 20-21.

Brenna, J.G., Bulters J.R., Cowell, N.D. and Lilley, A.E.U (1990): Food Engineering Operation, third edition London, Elsevier science publisher limited,pp 69-85.

Earle, R.L. and Earle, M.D. (2004): “Unit Operations in Food Engineering”. The New Zealand Institute of Food Science and Technology, (Inc.), Web Edition, 2004, pp 287.

Fellow P.J. (1988): Food processing technology, principles and practice, England, Ellis Horwood Limited,pp 92-95.

FIIRO Federal Institute of industrial research (2008)

Fabricatedmachines, available at http://www.fiiro.org/engineering/projects/plantain-details

Food and Agricultural Organization of United Nation (1990); “root tubers, plantains and banana in human nutrition series, 24, Rome-Italy.pp 37-45.

Khurmi, R.S. and Gupta J.K.(2004): A text book of machine Design, Eyrasia Publishing House (put) LTD. Ram Nagar, New Dehil.pp 1096.

IITA (international institutes of tropical agricultural (1996): a research report edited and produced in the publication of IITA unit of the information service program IITA Ibadan, Nigeria pp 20-22.

Kachru R.P., Balasubrmanna D and Nchiket K (1996): Design, Development and Evaluation of rotary slicer for raw banana chips. Journal of Agricultural Mechanization.Pp 61-64.

Khurmi, R.S. and Gupta, J.K. (2010): “Theory of Machines”, Eurasia Publishing house, New Delhi, India.

Nwanekezie, C and Ukagu, J.C. (1999).Nigeria food Journal, Vol. 17 pp. 55.

Obeng, G.Y. (2004): Design and fabrication and testing of a mechanized plantain and carrot slicer. Technology consultancy center kwameNkrumahUniversity of science for WestAfrican schools, Ghana, vol. 24, (2), pp126-133.

Odekunle O.I. (1986): Design and construction of a mechanical yam slicer,unpublishedB.Sc (Hons) project. Department of Agricultural Engineering, University of Ibadan.

Okafor, B.E. and Okafor, V.C. (2013): Design of a plantain chips slicing machine, International Journal of Engineering and Technology, vol 3 (10) pp 928-932.

Saheed, O.A. (2001): Design and construction of rotary plantain slicer, Unpublished B.Tech (Hons) project.Department of Food Engineering,LadokeAkintola University of Technology,Ogbomoso.