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Performance Evaluation of a Power Rotary Slicing Machine

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Abstract: ***This paper presents the performance evaluation of a power operated rotary slicer capable of slicing plantain, cocoyam, cassava among others. The machine is designed and fabricated to aid production of chips in plantain, cassava, cocoyam and other related farm products for frying and as well drying for immediate consumption and storage purposes. The machine is made up of two blades cutter and operated at speed of 1440rpm to overcome drawbacks of existing hands or power operated slicer and to meet the demand of small scale processing industries. Samples was taken for plantain, cocoyam and cassava to evaluate the efficiency and capacity of the machine. The machine has 83% efficiency and capable of producing 22.9kg/h***

Keywords: Rotary Slicer, Plantain Chips, Cocoyam Chips, Cutting Rate, Mean Thickness.

I. INTRODUCTION

Plantain (Musa spp.) occupies a strategic position for rapid food production in Nigeria. It is ranked third among starchy staples [1]. Nigeria is one of the largest producers of plantain in west Africa with an annual production of 2.4million metric tons [2]. It is an important dietary source of carbohydrate in the humid tropical zones of Africa, Asia and South America. It is rich in vitamins A, C and B group as well as minerals such as calcium and iron [1]. All parts of the plantain plant are useful and consumed by human in one way or the other; especially in medicinal applications, animal feed and craft works such as table mats, handbag and ropes. As a result of poor storage facilities, substandard transportation network and high standard of exportation requirements, leading African plantain producing countries like Nigeria and Ghana, lost lots of tons of plantains to inadequate post-harvest handling and management practices [3].

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In an effort to prevent poor harvest losses, many works had been done to process plantain for longer storage. Plantain chips is one of the way of making plantain available for longer period through drying and frying, of which in turn can be made into powder/flour for other preferred purposes. Traditional household knives had done much in a primitive way to produce plantain chips in large quantities in small, medium and large scale industries but these resulted in low speed, fatigue, too many staff and low income generation, hand injury high productive time and energy consumption. Plantain slicing is a size reduction process that involves the application of shearing force on plantain with the aid of a cutter blade or knife to shear through the plantain to obtain a minimum deformation and rupture of the cell wall. The cutter blade could either be on a reciprocating or rotary motion. In some rare cases, the blades are made stationary while materials travel against it and gets sliced in the process (Yusuf and Abdullahi, 2007; and Sonawane et al., 2011).

This research focused on design and fabrication of motorized / power operated plantain slicer to meet the raising demands for plantain chips in Nigeria. The objectives of this research was met as the machine has the capacity to produce plantain chips of uniform size in shorter time and a greater slicing efficiency of up to 96.84% while keeping the cost of the machine at an affordable price [4].

The slicer was designed for medium and small scale industries but can also be used for domestic purpose. The slicer works on the principle of cutting to reduce plantain and potato size. The slicer used between 5-8 second to slice a finger of an average- size plantain into chips at 0.78 mm thickness. The slicer achieves 93.93%, 90.26%, and 62.90% efficiency, for slicing unripe, semi-ripe and ripe matured plantain pulps respectively. The capacity for unripe, semi-ripe and ripe was calculated to be 64.3 kg/hr, 61.5 kg/hr and 60.3 kg/hr, respectively. The percentage moisture content for unripe, moderate ripe and ripe plantain was calculated to be 48%, 50% and 56% on wet basis, respectively.

Sonawane et al., worked on an electric power operated plantain chipping machine with efficiency of 93% and a mean thickness of 20mm. The machine has an efficiency of 93% and a mean thickness of 2.0mm [5].

Okafo and Okafo designed a plantain slicer for small scale industries. It is made up of a cutter chamber, an electric motor and a feed and discharge mechanism. The machine was developed to slice a single plantain in 4 seconds during a single revolution of the input shaft. The machine efficiency is 73.8% [6].

Adesina et al. developed an automated electric powered plantain slicer.

The machine has the ability of slicing a plantain for about 20 seconds, depending on the plantain length. The major machine components are; the cutter plate, a 2 horse powered electric motor, belt, bearings and pulleys. Plantain is fed through the collector into the cutting chamber of the machine. The motor supplies rotary motion through the belt and pulley drive to the cutter plate. This performs the cutting action that slices the plantain into chips of relatively uniform sizes [7].

A similar slicing machine was fabricated at the department of Agricultural Engineering, Federal Polytechnic, Ado-Ekiti supervised by Engr. Oyedele, 2017 which has a big pulley and mode of operation looks tedious and it is not economical.

M.B Usman and I.T Bello developed an automated plantain slicing machine. The machine is made up of a support mechanism, a cutter mechanism, a feeder mechanism, an outlet chute and an electric motor. The cutter mechanism comprises the blade, blade housing, connecting rod and crank. The blade is a removable 0.5mm thick stainless steel sheet, of 300mm wide and 70mm high, bolted firmly to the blade housing. Its basic function is to slice plantain, loaded on the conveyor, by reciprocation. The blade housing is pair of hollow cylindrical pipe of 30mm diameter and 100mm long. The feeder mechanism consist of a conveyor belt mounted on two rollers. This act both as feeding and discharge mechanisms. The conveyor was designed to travel at a speed of 80rpm [8].

Chilakpu, K. and Ezeagba, A. C develop and made Evaluation of a Motorized Plantain Slicing Machine. The machine has three stainless blades mounted on upper end of the power shaft rotating at a speed of 360 rpm slicing of the products. The peeled plantains were manually fed vertically through the feeding hole to the rotary blades. A stainless steel base with an adjustable height is placed below the cutting blades to prevent the products from passing through without being cut, and also to ensure uniform thickness of the sliced products [9][10][11][12][13][14].

II. EVALUATION PROCEDURE

The plantain slicer was tested under no load condition for 15 minutes to ensure all part are working perfectly without malfunctioning, then the evaluation of the machine was done with selected fingers of plantain and pairs of Cassava. The clearance between the cutting blades and the restriction base which determines the thickness of the plantain slice was varied between 2.5 - 6mm in line with the thickness of the manually cut slices in the open market which has an average of about 6 - 7 mm. The plantain fingers were peeled manually, before feeding into the hopper. They were manually fed into the machine feed hole while the machine was running; the time taken to completely slice each plantain finger was recorded. This experiment was repeated five times and the average results recorded.

III. RESULT AND DISCUSSION

The slicing time for a raw plantain was between 5 to 7 seconds, compare to manual and other existing machine which takes between 30 to 40 seconds to slice a plantain depending on the length of plantain ranging from 150 to 400 mm and diameter between 25 and 50 mm.

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 implied that 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 was achieved.

Table 1: Plantain Slice Chart

Sample	Weight (Kg)	Length of Plantain	Time Taken (s)	No of Chips	Chips Dia	Min Chip Thickness (mm)	Max Chip Thickness (mm)	Average Thickness (mm)
1	0.046	200	8	90	23	2.5	6	4.25
2	0.043	160	6	60	25	2.5	6	4.25
3	0.029	170	5	70	20	2.5	6	4.25
4	0.039	170	6	70	23	2.5	6	4.25
5	0.046	170	8	65	25	2.5	6	4.25
6	0.036	170	7	80	22	2.5	6	4.25
7	0.068	250	10	90	25	2.5	6	4.25
8	0.05	300	13	108	20	2.5	6	4.25
9	0.092	270	11	100	28	2.5	6	4.25
10	0.074	320	15	130	23	2.5	6	4.25
11	0.084	200	7	95	31	2.5	6	4.25
	0.61		96	958				

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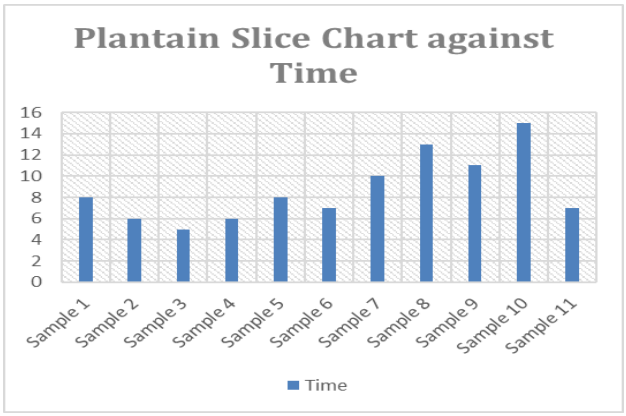
Table 2: Cassava Slice Table

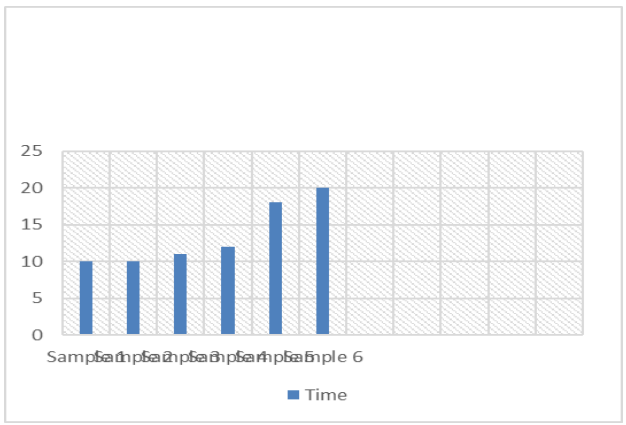
Sample	Weight (Kg)	Length of Plantain	Time Taken (s)	No of Chips	Chips Dia	Min Chip Thickness (mm)	Max Chip Thickness (mm)	Average Thickness (mm)
1	0.67	200	10	110	70	2.5	7	4.75
2	0.369	150	10	70	60	2.5	7	4.75
3	0.65	170	11	76	75	2.5	7	4.75
4	0.37	180	12	70	55	2.5	7	4.75
5	2.21	400	18	150	90	2.5	7	4.75
6	0.88	230	20	110	75	2.5	7	4.75
	5.2		81	586				

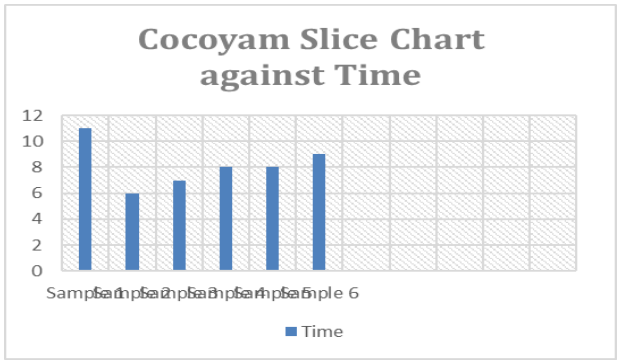
Table 3: Cocoyam Slice Table

Sample	Weight (Kg)	Length of Plantain	Time Taken (s)	No of Chips	Chips Dia	Min Chip Thickness (mm)	Max Chip Thickness (mm)	Average Thickness (mm)
1	0.079	120	11	90	30	2.5	6	4.25
2	0.018	60	6	60	20	2.5	6	4.25
3	0.032	70	7	70	25	2.5	6	4.25
4	0.040	50	8	70	33	2.5	6	4.25
5	0.060	80	8	65	32	2.5	6	4.25
6	0.090	100	9	80	35	2.5	6	4.25
	0.321		49	435				

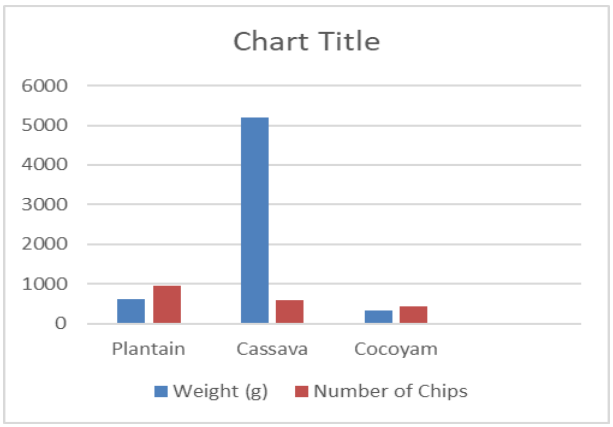
IV. SAMPLE AGAINST CUTTING TIME FOR PLANTAIN, COCOYAM, CASSAVA

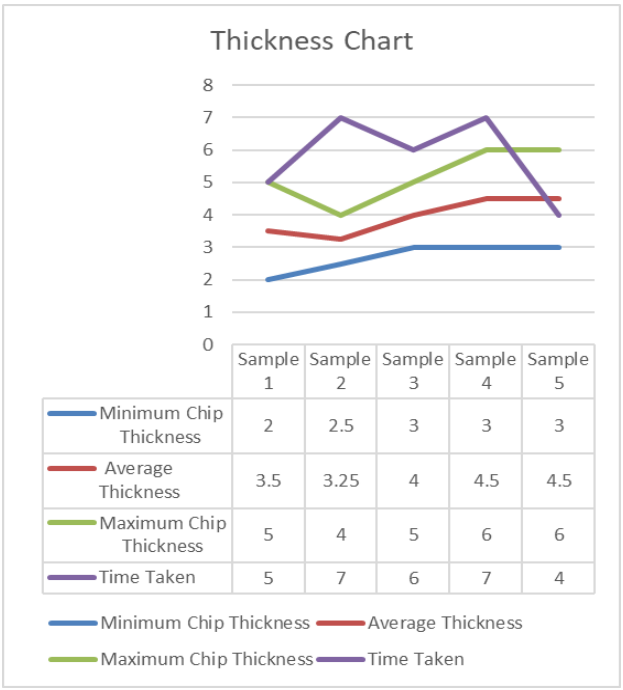


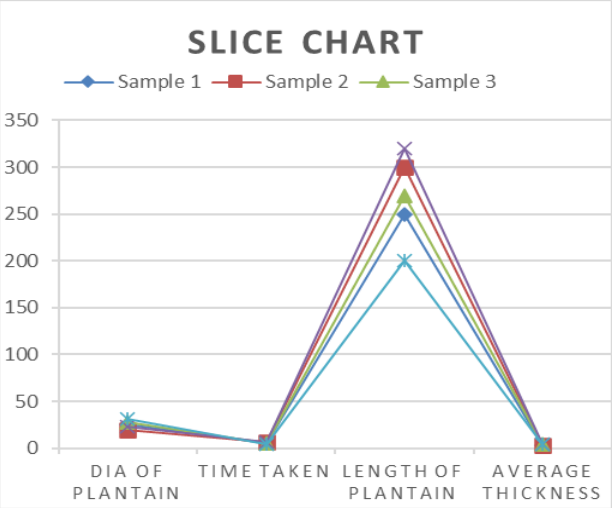




A. Weight Against Number of Chips







B. Cutting Rate

Since the machine produce 0.61kg of plantain in 96seconds in an hour it will produce 22.8kg

The cutting rate per hour of the machine is calculated to be 22.8Kg/ Hour.

C. Capacity of the Machine

During the performance evaluation it was noted that an average length of 25mm plantain was not slice by the machine and the chips produced from 6 fingers of plantain within 2minutes of operation is range 500 chips.

If all length of plantain is slice the actual number of chips to be produced from 6 fingers of plantain is 600 chips.

Efficiency of the machine is calculated by number of chips produced/actual number of chips to be produced.

Efficiency = (500/600) x 100 = 83%

V. CONCLUSION

A power operated rotary slicing machine was developed with locally available materials for the slicing of freshly harvested farm products (plantains). Though this machine was designed for medium scale industries for raw plantain chips production, it can also be used for domestic purposes.

The develop machine in addition to slicing peeled and unpeeled plantain can also be used to slice other agricultural products such as; banana, cassava, cocoyam among others. Based on the results of the test obtained, the machine proved to be a better design than the existing in that the slicing time of plantain is reduced. In addition, the use of stainless materials in area in direct contact with the product ensured that there was no discoloration of the sliced chips produced.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been sponsored or funded by any organization or agency. The independence of this research is a crucial factor in affirming its impartiality, as it has been conducted without any external sway.
- **Ethical Approval and Consent to Participate:** The data provided in this article is exempt from the requirement for ethical approval or participant consent.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Authors Contributions:** The authorship of this article is contributed equally to all participating individuals.

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