DEVELOPMENT OF A MOTORIZED YAM SLICER

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ABSTRACT

A motorized yam-slicing device was designed and developed to improve drying by increasing the surfaces area of yam tubers. It consists of rotary blades, feeding chutes and electric motor. The operating power was obtained from 1.5 hp electric motor (1400 rpm) and, using pulley and belt with complete drive. The device is manually fed with one tuber at a time. Performance of the device was evaluated using the following parameters: slicing efficiency, throughput and percentage of non -uniform slices. The slicing efficiency, throughput and non–uniform slices obtained was 52.3 %, 315 kg/hr and 47.65 % respectively. Making the chute adjustable to different tuber thickness would eliminate wobbling and further reduce the percentage of non–uniform slices.

Keywords: Yam tuber, development, Slicing device, performance Evaluation.

1. INTRODUCTIION

Yams (*Dioscorea* spp) is a major source of carbohydrate in west and central African countries. Among the numerous species, six are economically useful and are cultivated in Africa. They are D. rotundata (white), D. cayensis (yellow), D.alata (water), D. esculenta (Chinese), D. dumetorum (bitter) and D. bulbifera (aerial) (Onwueme, 1978 and Asiedu, 1992).

They also contain ash, protein and vitamin, and are used as human diet. Yams can be prepared and eaten in various forms of baked yam as supported by Bell and Favier (1981), who reported that yams baked at 200 ^{o}C for 30 minutes usually retain their nutrients. Eaten fried (Osajie, 1992), mechanically pounded into glutinous dough Makanjuola (1974) or turned into flakes thin film in a drum dryer and baked into flakes, (Steele and Sammy, 1976).

Yams can also be processed into flour for making bread, biscuits and for preparing beer (Grenand, 1980). They are also fed to domestic animals either fresh or boiled and as a result, they serve as a valuable food for the conversion of such animal product as milk, meat and eggs. Some species have chemical, pharmaceutical and cultural values for making insecticides, steroid and for social events.

The world production of yam is 3.9 tones and West Africa accounts for 90-95 % of total production (Gebremeskel and Onyewole, 1987). Ezeh, (1992) and FAO, (2005) reported that Nigeria is the single largest producer of yam, accounting for about 71 % of total world production.

The methods of harvesting, processing, storage and marketing of yams are poorly developed resulting in a lot of post–harvest losses. FMARD (2001) reported that 30 % of root and tuber crops cultivated annually got lost due to deterioration. At harvest, yam tubers contain about 60 - 80 % moisture depending on the specie. High moisture content encourages sprouting and high rate of deterioration such as rottening, which reduces the shelf life and food value of yam tubers also documented in Obetta et al. (2007).

Farmers sell their yam tuber at farm gate prices to the middlemen to avoid spoilage and thereby achieving very poor returns. Low profit discourages farmers and production per head is greatly reduced. To overcome this, yam farmers peel, blanch and dry their yams either in lumps or slices and store them for a better profit.

Some further process them into yam flour for elubo (*Local yam flour*). This flour is highly cherished by the Yorubas, especially in Ekiti, Ondo and Oyo States of Nigeria (Onyekere, 1987). Oleniyi (1973) stated that *Dioscorea rotundata* is usually preferred to other species for mass flour production which may be due to its moisture content being lower than others and better colour of the flour after processing.

Yams, being a perishable crop, need to be processed into a more suitable form such as chips, flour, starch and glue so as to improve their shelf life, reduce or eliminate toxic alkaloid and improve the palatability of the food products. To achieve this and reduce bulkiness, losses, cost of transportation and drudgery in production, high moisture content of yam tuber could be maximally reduced with appropriate technologies, especially for Nigerian small-scale yam farmers who produce most of these yams. Drying is an appropriate option for preserving yam. Drying of yam could be enhanced by increasing the surface area of the tubers.

Slicing involves using sharp blades to reduce the yam tuber into smaller thicknesses purposely meant to increase the surface area of the product for faster drying. Akomas and Otti, (1988) stated that sharp knife could be used during slicing to reduce damaging the yam tissue. The physical properties of yam tuber relevant to slicing are shape, size, length, weight and moisture content.

Shape and length, these depend on their variety, genetic make-up and species (Coursey, 1967 and Watt, 1961). Environmental factors such as soil structure, soil density, presence or absence of rocks and roots, also affect the physical characteristics of yam tubers (Onwueme, 1978). Nwadikom and Mittal (1988) in their work, determined the shape of yam tubers by taking linear measurements at various points on the tuber. Most yams are more or less cylindrical in shape with pointed or round lower end.

The weight of yam tubers depends on their moisture content. Degras, (1993) reported that yam tubers contains less than 40 % dry matter. Asiedu (1992) stated that the weight of individual yam tuber may range from 200 gm – 50 kg. Yam tubers loose most of these weights during storage especially in an open-air traditional barn. Mozie (1981) found that

yam tubers stored in barns usually loose 50 % of their weight. This affects the appearance and texture of the yam tuber, hence requiring more force for slicing.
The protective corky periderm of the tuber is smooth, brown and thin skinned usually less than 3 mm (Degras, 1993). The colour of the ground (inner) tissue depends on the yam variety and specie. The flesh of D. rotundata for example is white, moist and firm. The starch grains in the tubers are large and void (Asiedu, 1992).
Farmers slice their yam tubers conventionally by placing the tuber on the table or ground and force a sharp kitchen knife through the desired thickness. This method is injurious, laborious, and unhygienic and produces non–uniform slices and thereby giving poor end products.
In recent times, some slicers have been developed for reducing the size of agricultural products such as electrically operated ginger slicer (Gegede 2000); rotary draw banana slicer (Kachru et al, 1996); Cassava Chipper (Gyuse, 1997); Potato slicer (FAO , 1991) and foot operated yam slicer (Ehiem, 2000). The above technologies are for different applications except the foot operated yam slicer, which uses human energy. It is slow and labor intensive. The development of a motorized yam slicer will provide a relief of human labor speed up slicing and produce uniform slices for a better end product.

This study therefore aim at developing a motorized yam-slicing device to produce a uniform yam sizes that will enhance further processing and storage of yam.

2. MATERIALS AND METHODS

2.1 Components of the yam slicer

The followings are the components of the yam slicer (fig 1 & 2).
(a). Feeding Chute: The chute serves as the hopper and provides means of feeding yam tubers to the device. It is made of galvanized steel. Its length and diameter were based on average length and diameter of the tuber. This helps to prevent wobbling.
(b). Blades: The blades are made of galvanized steels coated with aluminum. They are used for effecting slicing. To prevent tuber damage, easy maintenance and replacements, the blades were sharpened and bolted to the bearing shaft.
***(c). Blade Housing**:* The blades housing shields the rotating blades during and after operation to prevent accident. A door way was provided to facilitate easy access to the blades by the side of the housing
(d). Bevel Gears: **Bevel gears** were angled at angle 90° to each other so as to transfer the horizontal speed of the driving gear to the driven gear.
***(e). Pulleys**:* Larger pulley was used to reduce electric motor speed in the design.
***(f). Bolts and Nuts Selection**:* For all the attachments made, 5 mm bolts and nuts were used.
The thickness of the slices considered was 7 mm. This was essential in determining the speed of the blades.

2.2 Description and Working Principle of the Yam Slicer

The yam slicer reduces tubers of yam into smaller thickness for faster drying. It consists of powered shaft, bevel gears, blades and feeding chutes. The powered shaft is of diameter 30 mm and 130 mm long with 8-tooth bevel gears (∅ 60 mm) at its end. The blades are 270 mm long and 40 mm wide. Each of the blades has holes of ∅ 5 mm at one end to facilitate bolting it to the blade's bearing shaft of diameter 30 mm. Blade's bearing shaft with bevel gears at its end was angled, 90˚ to that of power shaft. The blade housing is of diameter 60 mm and 250 mm high. The mainframe base is 1000 mm by 600 mm. The standing legs were angled at 65˚ to the base frame to ensure stability in operation. The assembly and isometric drawing of the slicer are shown in Fig. 1 and 2. Feeding chute is ∅ 92 mm and 310 mm long. It is opened through the top of the blades housing.

The slicer is operated by an electric motor and power transmitted to the blades through the shaft via the pulley's v-belt. It is manually fed with one tuber at a time through the chute. The whole tuber falls vertically as it is manually fed by the operator against the rotating blades and become sliced. The thickness of the slices is predetermined by the feed rate pressure on the yam tuber and this is greatly enhanced by the rotating speed of the blade. The slices are collected through the channel into the receptacle below the blades housing.

2.3 Experimental Procedure

The experimental procedures for the laboratory tests are as follows:

(a) Determination of the feeding chute of the slice.

The weigh (kg), length (L) and circumference (C) of different sizes of yam tuber were taken. The mean of the circumference was used to determine the average diameter (d) of the yam tubers as:

$$\pi d = C \quad \text{...} \quad (1)$$

and

$$d = \frac{C}{\pi}$$

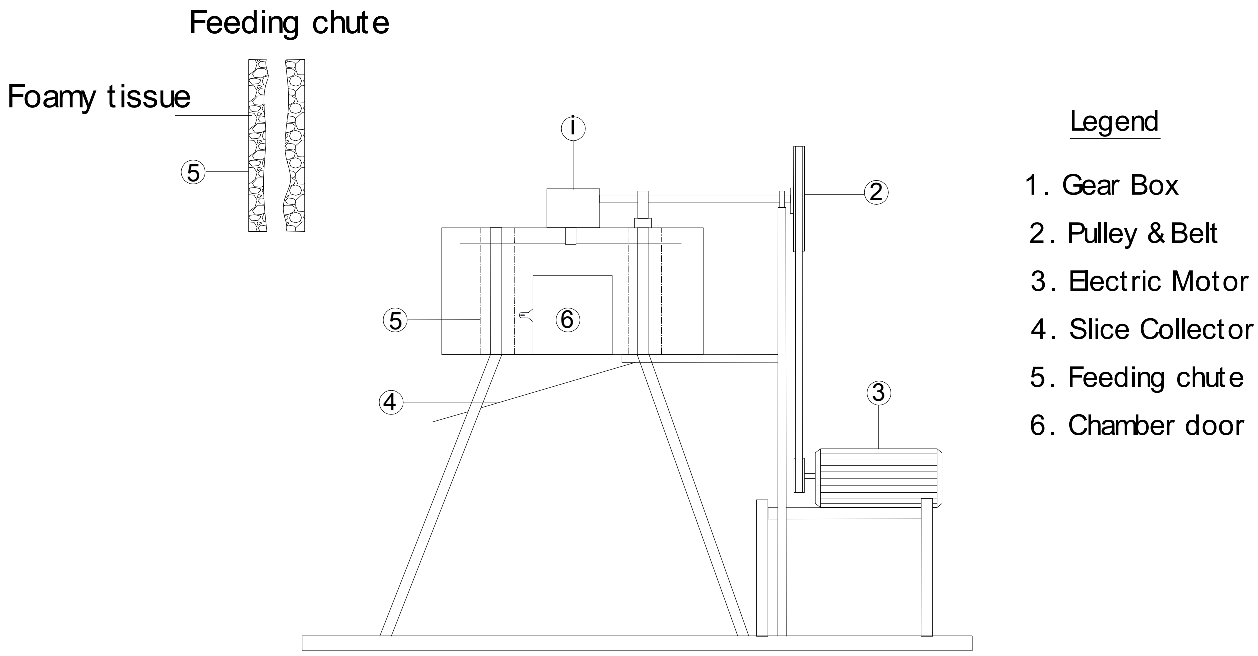

Figure 1:Side Elevation sketch of the Yam Slicer

where; C = mean circumference of yam tubers

d = diameter of the yam tubers

$$\pi = \frac{22}{7}$$

The diameter (d) becomes the diameter of the slicer chute.

(b) Determination of dynamic frictional coefficients (blades and yam)

When two bodies in contact move relatively to one another, resistance occurs between them. This is due to friction that opposes their motion. Different sizes of yam slices were individually placed on a neat weight-carrying pan. Weight (F) was added to the pan until the slices begin to move at uniform velocity. The thickness and weigh of each slice (R) were measured using micro–meter screw gauge and weighing balances respectively to determine the coefficient of dynamic friction (μ) as shown below.

$$\mu = \frac{F}{R} \quad \text{...} \quad (2)$$

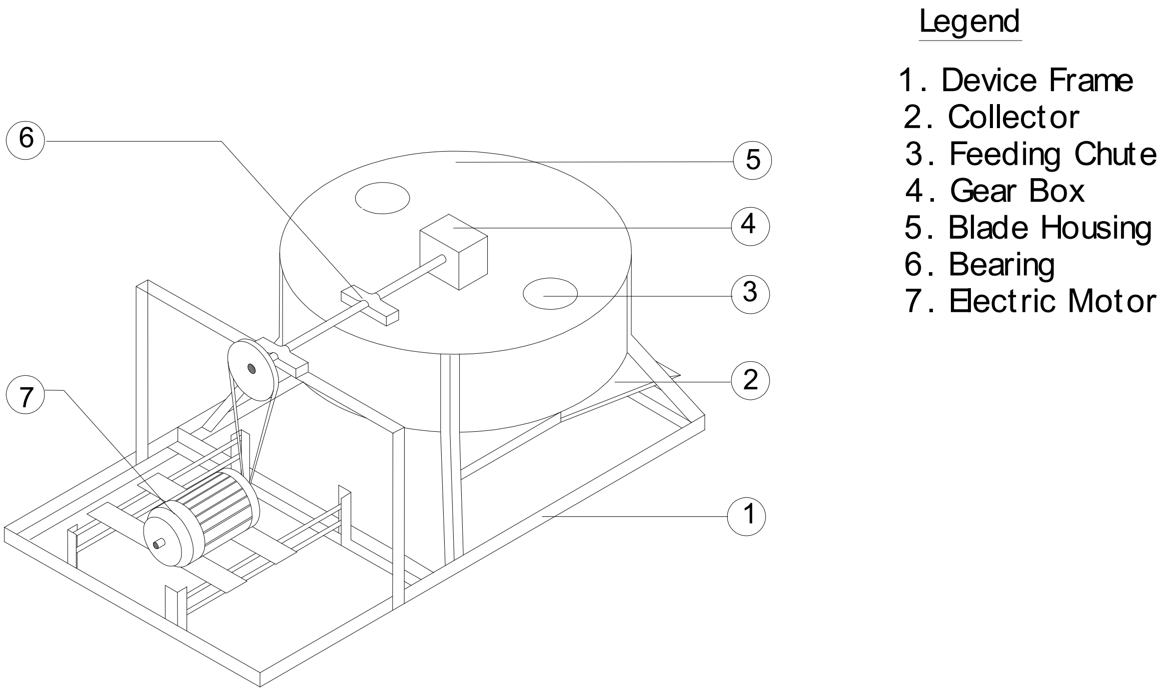

Figure 2: A Perspective view of the Yam Tuber Slicer

The knowledge of the coefficient of dynamic friction helps to obtain the dynamic frictional force which is important in determining the shear force that must be applied to the blades to effect shearing of tubers.

Therefore, the shear force (P_t) of the device is given as:

$$P_t = \frac{T}{R} \quad \text{...} \quad (3)$$

where; P_t = shear force

T = torque

R = resistance

(c) Determination of the number of revolution of the shaft

Linear velocity (V) is equal to the angular velocity (ω).

$$V = R\omega \text{..} (4)$$

Linear velocity $(V^2) = U^2 + 2as$

$$U = 0$$

$$V^2 = 2as$$

$$V = \sqrt{2as}$$

but $\omega = \frac{2\pi N}{60}$

$$\therefore \sqrt{2as} = \frac{2\pi RN}{60}$$

$$N = \sqrt{\frac{60^2 as}{2\pi^2 R^2}} \qquad \text{..........(5)}$$

where:

s = thickness of the yam slices
R = length of the blades
a = acceleration due to gravity

3. PERFORMANCE EVALUATION

Slicing efficiency (η_s). This is defined as the ratio of weight of uniform sliced yam (Q_u) to the weight of the yam tubers fed (Q_f).

$$\eta_s = \frac{Q_u}{Q_f} \times \frac{100}{1} \qquad \text{..........(6)}$$

Slice capacity (S_C). This is the quantity of yam tubers sliced (Q_t) in a given time (T).

$$S_C = \frac{Q_t}{T} \qquad \text{..........(7)}$$

Percentage non–uniformity of the sliced yam (%) which is the ratio of weight of non-uniform sliced (Q_n) to the total fed (Q_f) into the slicer is given by:

$$\% = \frac{Q_n}{Q_f} \times \frac{100}{1} \qquad \text{..........(8)}$$

4. RESULT AND DISCUSSION

Table 1 represents the performance parameters of the yam slicer. From the table, the slicer has an average slicing efficiency of 52.3 %, while the throughput and percentage of non–uniformity cutting of slices are 315 kg/hr and 47.65 % respectively.

These parameters were tested with six yam tubers of varying diameter. It was observed that tubers of diameter close to that feeding chute have higher slicing efficiency than tubers of lower diameter. For instance, yam tubers diameter of 89.5 mm and 87 mm have efficiency of 89.11 % and 71 %. This could be due to reduced wobbling effect of the tubers with the chute walls as the tuber diameters are close to that of chute wall.

High percentage of non- uniform slicing efficiency was observed for tubers of low diameter. For example, tuber diameter of 68 mm had non–slicing efficiency of 72 %. Besides, slicing efficiency of 74 mm diameter is greater than that of 78 mm and that of 53 mm is greater than 68 mm. All these could be as a result of rocking effect of the yam tubers and chute walls resulting in wobbling as slicing is in progress.

Table 1: Weight of uniform and non–uniform slices, and efficiency of sliced yam

Diameter of yam tubers (mm)	Weight of yam tubers (kg)	Weight of uniform sliced yam (kg)	Weight of non-uniform sliced yam (kg)	Slicing efficiency	% non-uniform sliced yam
89.5	1.01	0.90	0.11	89.11	10.86
87	1.05	0.75	0.30	71	29
78	1.25	0.50	0.75	40	60
74	1.00	0.45	0.55	45	55
68	1.60	0.45	1.15	28	72
53	1.10	0.45	0.65	41	59
Average				52.3%	47.65%

5. CONCLUSION AND RECOMMENDATION

The following can be concluded from the development of a motorized yam slicer.

(1) The mean slicing efficiency obtained from the slicer was 52.3 % with average capacity of 315 kg /hr.
(2) The thicknesses of the uniform slices were of the neighborhood of 7 mm.
(3) The six test carried out showed that slicing efficiency increases as the tuber diameter moves closer to the feeding chute.

For further study, it is recommended that the feedings chute be made adjustable to accommodate tubers of different sizes. Timer should be incorporated to the slicer so as to regulate the free fall of the yam tuber to the blade.

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