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DESIGN AND CONSTRUCTION OF A YAM POUNDING MACHINE

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ABSTRACT

Yam is a daily nutritional food requirement for man and in order to facilitate the processing of yam for consumption, a yam pounding machine has been developed using mainly some locally sourced materials. The machine consists of a shaft, pulleys, belt, bearings, electric motor, yam beaters, bowl and the frame. The machine was developed to enhance the hygienic processing of yam for both domestic and commercial consumption, while eliminating the tedious and laborious indigenous process of preparing pounded yam.

Keywords: Yam, pounding machine, hygienic processing, yam beaters

INTRODUCTION

Yam is one of the oldest known recipes to man. It is a tuber crop, which belongs to the class of carbohydrate and has been a part of the African meal for centuries. Its starchy nature allows yam to form a bond, when it is beaten in a mortar, which is then consumed as meal with a choice soup. Pounded yam is a staple food consumed by almost every tribe in Nigeria. The indigenous process of production is very laborious. It requires physical pounding by two or more men or women, depending on the quantity, in mortars with pistols.

The word yam comes from Portuguese name or Spanish name, which both ultimately derive from the Wolof word nyam, meaning "to sample" or "taste". In other African languages it can also mean "to eat" e.g. yamyam and nyama in Hausa (Mignouna *et al.,* 2003). Also yam is the common name for some species in the genus and they are perennial herbaceous vines cultivated for the consumption of their starchy tubers in Africa, Asia, Latin America and Oceania. They are used in a fashion similar to potatoes and sweet potatoes, (Brand–Miller *et al.,* 2003). Yam products generally have a lower glycemic index than potato products (Kay, 1987), which means that they will provide a more sustained form of energy, and give better protection against obesity and diabetes (Walsh, 2003).

The world production of yam was estimated at 28.1 million tonnes in 1993. Out of this production, 96% came from West Africa, the main producers being Nigeria with 71% of world production; Côte d'Ivoire 8.1%; Benin 4.3% and Ghana 3.5%. In the humid tropical countries of West Africa, yams are one of the most highly regarded food products and are closely integrated into the social, cultural, economic and religious aspects of life. Traditional ceremonies still accompany yam production, indicating the high status given to the plant (Food Information Net, 2008).

In order to facilitate the processing of yam for consumption, a yam pounding machine was been developed using mainly some locally sourced materials.

MATERIALS AND METHODS

Parts and operation of vegetable slicing machine: The yam pounding machine was designed and developed to hygienically process yam and it was designed to pound from kilograms to kilograms weight of cooked yams for both domestic and commercial consumption. The machine consists of the following major components: the shaft, pulleys, belt, bearings, electric motor, yam beaters, bowl and the frame. The yam beaters or blades were located on the upper edge of the shaft which was connected to the electric motor via a V – belt and pulley system. During the pounding operation, the slices of already cooked yam are loaded into the pot-like pounding chamber and covered with the pounding chamber cover. The electric motor transmits power through the V - belt to shaft, as the shaft rotates it actuates the yam beaters, which start pounding the yams in the yam pounding chamber. The pot or pounding chamber bears the bigger pulley so as to reduce the speed of the electric motor to a desired pounding speed of 100 rpm.

The operational stages in yam pounding include; washing the yam tuber, peeling, slicing, parboiling and pounding using the pounding machine before packing the pounded yam as shown in figure I.

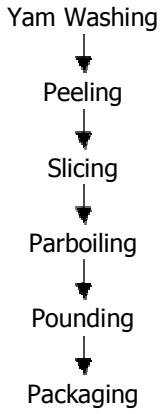

Fig. I: Flow diagram for yam pounding

The shaft: The shaft which is made of mild steel was designed to transmit power to the yam beaters in the bowl to perform the yam pounding operation.
Pulley: The primary function of the pulley is to reduce the original speed of the electric motor to the required speed. The material selected for this pulley is mostly cast iron.
The yam beaters: The yam beaters are two blades made of stainless steel material and they are the main components that do the real pounding of the yam. These are two bars designed and joined together at angle 90^0 to each other at the centre and they rotate together through angle 360^0 while pounding the cooked slices of yam.
The bowl: The bowl consists of the yam beaters which perform the pounding operation in a chamber of the bowl. It is made of stainless steel material with a volume of 0.018 m^3.
The frame: The frame forms the housing of the whole components, including the electric motor. It has to be rigid to withstand all the forces generated in the components during the pounding operation.
Design specification:
The pulley system: To reduce the motor speed to the desired speed, we select;
(i) the ratio of transmission to be 3 : 1.
(ii) Coefficient of friction is 0.35
(iii) Angle grooving of the pulley, is 40°, for the best performance of belt.
(iv) diameter of small pulley, D_s =50mm.
From the relationship,
$D_l = 3D_s$ ----------(1)
$\therefore D_l = 3\times50=150$mm
Where D_l =150mm is the diameter of the large pulley, and D_s is the diameter of the smaller pulley.
The centre distance, C between the two pulleys is taken as the larger of the value between $\frac{3D_s}{2}+\frac{D_l}{2}$ and C = D_l, (Deutschmann and Aron, 1985).

Therefore C = max ($\frac{3D_s}{2}+\frac{D_l}{2}$ and D_l),

That is C = ($\frac{3(50)}{2}+\frac{150}{2}$ or 150),

therefore C = (150 or 150) = 150 mm.
From Fig. III we have,

$$\theta_1 = 180° - 2\sin^{-1}\left(\frac{\frac{D_l - D_s}{2}}{C}\right) = 180^0 - 2\sin^{-1}0.3333 = 141.06°$$

$$\theta_2 = 180° + 2\sin^{-1}\left(\frac{\frac{D_l - D_s}{2}}{C}\right) = 180^0 + 2\sin^{-1} 0.3333 = 218.94°.$$

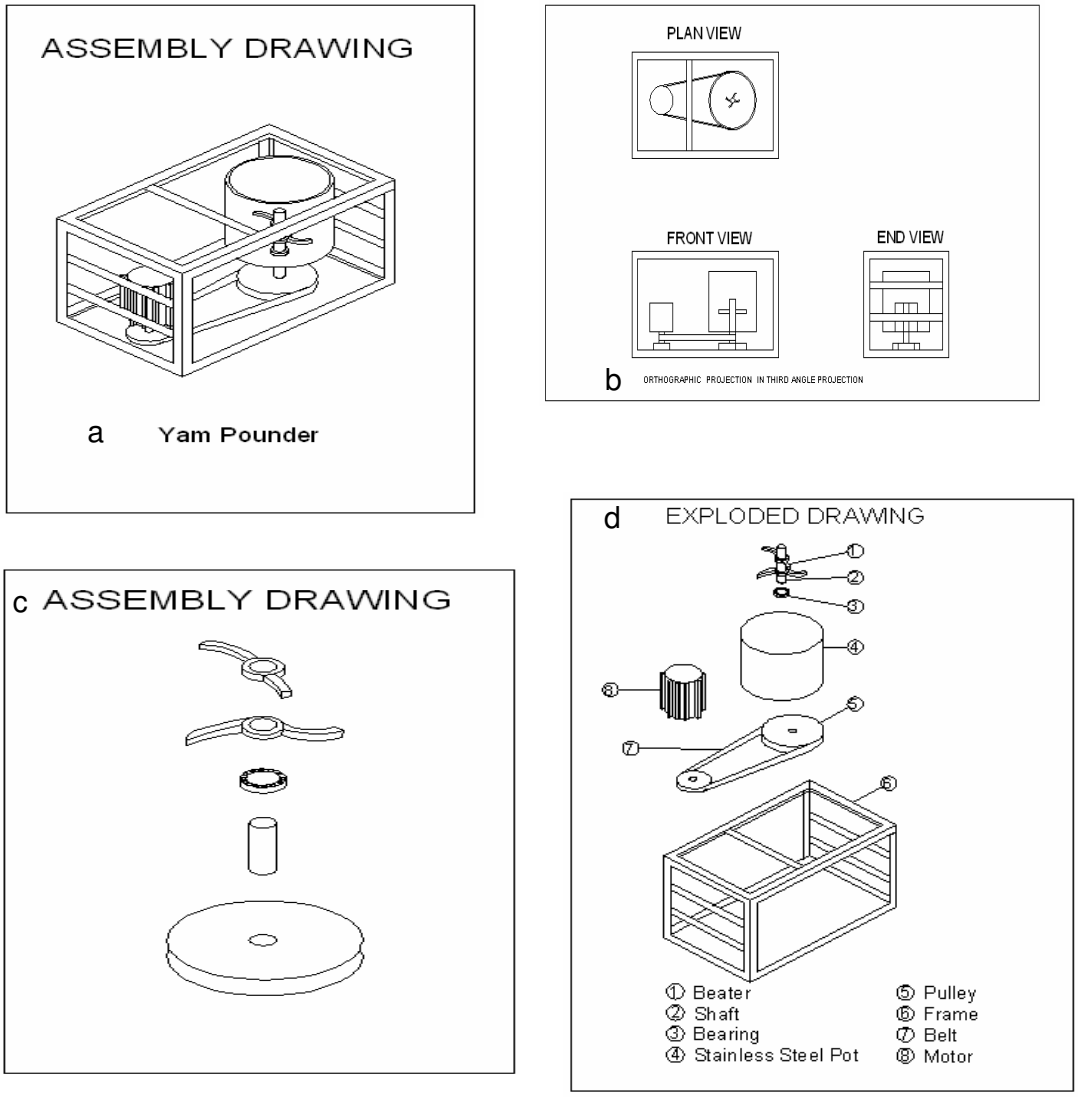

Fig. II: Component Elements of the Yam Pounding Machine

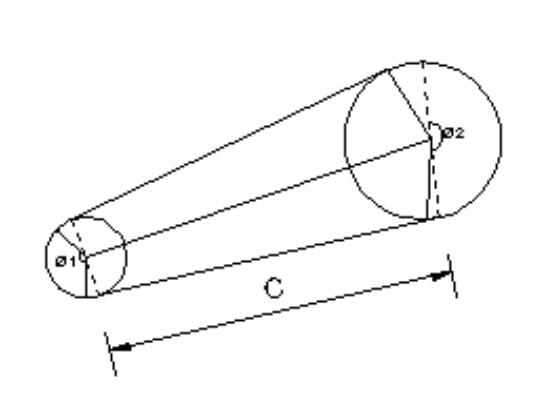

Fig. III: The Pulley System.

Shear stress on the shaft: The shaft is subjected to a torque or twisting moment and as a result a shearing stress is produced in the shaft. The shear stress varies from zero in the axis to a maximum at the outside surface of the shaft.
The shear stress produced in the solid circular shaft is given as:

$$\sigma = \frac{Tr}{I_p} \quad \text{----------(2)}$$

where
σ = shear stress (MPa)
T = twisting moment (Nm)
r = distance from center to stressed surface in the given position (mm)
I_p = "polar moment of inertia" of cross section (mm^4)
3.3: The Maximum Moment on the Shaft.
The maximum moment in the circular shaft can be expressed as:

$$T_{max} = \frac{\sigma_{max} I_p}{R} \quad \text{----------(3)}$$

Where
T_{max} = maximum twisting moment (Nm)
σ_{max} = maximum shear stress (MPa)
R = radius of shaft (mm)
The polar moment of inertia on the shaft: The polar moment of inertia of the circular solid shaft can be expressed as

$$I_p = \frac{\pi R^4}{2} = \frac{\pi D^4}{32} \quad \text{----------(4)}$$

Substituting for I_p in Equation 3 gives:

$$T_{max} = \frac{\pi R^4 \sigma_{max}}{2R} = \frac{\pi R^3 \sigma_{max}}{2} = \frac{\pi D^3 \sigma_{max}}{16} \quad \text{---------- (5)}$$

Diameter of a solid shaft: The diameter of the shaft can be calculated by the formula

$$D = 1.72\left(\frac{T_{max}}{\sigma_{max}}\right)^{1/3} \quad \text{----------(6)}$$

Torsional deflection of the shaft: The angular deflection of a torsion solid shaft can be expressed as

$$\theta = \frac{584LT}{GD^4} \quad \text{----------(7)}$$

where
θ = angular shaft deflection (degrees)
L = length of shaft (mm)
G = modulus of rigidity (Mpa)

RESULTS AND DISCUSSION

The constructed yam pounding machine was tested by pounding three different types of cooked yams with the machine. In this case, each yam specimen was washed, pealed, cut into small slices and cooked for a period of 45 minutes. The cooked yam slices were then packed into the bowl or pounding chamber of the machine. The machine was then operated to pound the cooked yam slices for a stipulated time which was not the same for the different yam specimens.
Test for hardness was conducted on each specimen to know if it was necessary to add water to the pounded yam, in order to achieve a desired texture. The text results are presented in Table 1.

Table 1: Test results on different yam specimens.

S/No.	Yam Specimen	Pounding Time (Min)	Test For Hardness Time (Min)	total pounding time (min)	Quality
01	White yam	3	1	4	Starchy
02	Yellow	4	1	5	Starchy
03	Water yam	2	1	3	Semi – starchy.

It was however observed that while the water yam took a period of 2minutes for pounding and 1 minute for hardness testing, the white yam took a period of 3minutes for pounding and 1 minute for hardness testing while the yellow yam took the longest total time of 5 minutes for pounding. It was also observed that the fabricated machine also eliminates the tedious and laborious indigenous process of preparing pounded yam. The breakdowns of the cost estimate for the various materials used for the construction of the yam pounding machine are presented in Table 2. Actually, most of these materials were locally sourced.

Table 2: Material cost estimate

S/No.	Description of Item	Quantity required	Unit Cost (N)	Total Cost (N)
01	Shaft	1	750.00	750.00
02	A big pulley	1	800.00	800.00
03	A small pulley	1	500.00	500.00
04	V – Belt	1	180.00	180.00
05	Bearing	1	280.00	280.00
06	Electric motor (1 hp)	1	10,000.00	10,000.00
07	Yam beaters	3	500.00	1,500.00
08	Bowl	1	750.00	750.00
09	1 inch angle bar for frame work	1½ length	540.00	810.00
10	¾ inch angle bar for frame work	2½ length	450.00	1,125.00
11	Galvanized sheet for the casing	1 length	2,500.00	2,500.00
10	Welding electrodes	40	6.50	260.00
	Labor Cost			9,457.75
	Total Cost			N28,912.75

CONCLUSION

Pounded yam is a staple food, which is consumed by almost every tribe in Nigeria. The indigenous process of producing pounded yam is very laborious. It requires physical pounding by two or more men or women, depending on the quantity, in mortars with pistols. As a result, a mechanical yam pounding machine has been developed for both the domestic and commercial consumers. In addition to the fact that this machine gives more hygienic pounded yam, it also eliminates the tedious and laborious indigenous process of preparing pounded yam. The development of the yam pounding machine demonstrated the fact that such food processing equipment helps in producing large quantities and keeps cost under control.

The development of the yam pounding machine involves the design and fabrication of some principal components which include the shaft, pulleys, yam beaters, bowl and the frame. It was discovered from the machine performance that it takes 5 minutes to pound a full bowl of cooked yam cooked red yam, 4minutes to pound white yams and 3 minutes to pound cooked water yam.

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Keywords: Yam, pounding machine, hygienic processing, yam beaters. Abstract. Yam is a daily nutritional food requirement for man and in order to facilitate the processing of yam for consumption, a yam pounding machine has been developed using mainly some locally sourced materials. The machine consists of a shaft, pulleys, belt, bearings, electric motor, yam beaters, bowl and the frame. The machine was developed to enhance the hygienic processing of yam for both domestic and commercial consumption, while eliminating the tedious and laborious indigenous process of preparing pounded yam. Keywords Design construction yam pounding machine, pounding machine design.Â However, if you are among those that have been searching for answers to [design construction yam pounding machine, design and fabrication of yam pounding machine, literature review on yam pounding machine, pounded yam machine amazon, pounding machine design, pounding machine price, national yam pounding machine, yam pounder machine amazon, How Yam Pounders Are Designed To Work | Design & Fabrication Of Yam Pounding Machine]. , then you can see that you are not the only one. Nonetheless, you shall get all this information right here on this blog. How Yam Pounders Are Designed To Work | Desi... Construction of canals requires different types of machineries and equipments, the selection of which depends on many factors. These types of canal machines.Â That is why different canal construction machineries and their selection criteria for any given project are explained in this article. Fig.1: Canal Construction Equipment. Fig.2: Canal Construction Machines. Contents: 1 Factors Considered for Selection of Canal Construction Machineries.