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Design and Fabrication of a Garri Sieving Machine Using Locally Available Materials

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ABSTRACT
Garri is the most popular cassava food derivative in Nigeria. In Nigeria, most of the garri production is done locally using manual labor. This exposes the garri to contamination and limits the quantity that can be produced. Garri sieving machine is a machinery used in garri production for separating garri according to various sizes. The garri sieving machine in this report was made using locally available materials sourced from Osogbo, Ikirun and Iree. Materials used are Mild steel plate, 40mm angle iron, metal sieves (40x20)mm, 1hp electric motor and cam linkages. The fabricated machine was tested and found satisfactory. Experimental test was conducted on the sieving machine and the result showed the variation between the weight of the cassava starch and the garri sieved.The garri sieving machine would greatly increase the quantity of garri that could be produced, reduces drudgery and improves the hygiene of the food produced.

Keyword - contamination, processing, garri sieving machine, hygiene, mild steel.

I. INTRODUCTION.

Garri sieving machine is used in garri production for separating garri according to various sizes. In garri production, garri sieving machine is not the only machine used, other machine used include garri frying machine and garri presser. However, currently in Nigeria, garri production is done mostly manual. The processing techniques include peeling, boiling, steaming, slicing,grating, soaking, grinding, fermenting, pounding, roasting,pressing, drying, and milling. (Ozigbo E. S., Bamgboye A.I., Adunoye F.O. & Murphy K.M., 2020)

Garri is the most popular cassava food in many West African countries. Due to its convenience and multiplicity of use, garri is gradually gaining a foothold in the international food market. Ghana and Nigeria appear to be the principal producers, consumers, and exporters of garri. In Ghana, garri exports grew by 23.2% annually from 2001−2007 (FAO, 2018). Nearly 75% of cassava produced in Nigeria is processed into garri powder. Garri is a relatively recent introduction in East and Southern Africa. In Mozambique, garri is traditional to the people of Inhambane Province of Mozambique, where it is known as rale (Adeniji,Ega, Akoroda Ugwu et al, 2023).

The product is currently promoted in West, Central, East, and Southern Africa largely through the work of international agricultural development organizations (e.g.,International Institute of Tropical Agriculture) and NGO's supported by donor agencies (e.g., United States Agency for International Development, Common Fund for Commodities/Colony forming units) who worked to increase food security in the countries. (Amadi, J.E, Adebola ,S. E. , ,2008)

In Nigeria, Garri is a staple food consumed in Nigeria by all. Garri is consumed either soaked in cold water orstirred in hot water to make a stiff paste (calledeba in Southwest Nigeria). It may be consumedwith sauces or stews. (Sanni, L. O, Adebowale, A. A., Awoyale, W. and Fetuga, G.O., 2009).Garri sieving machine can be used in this sieving process to speed up the grating process(Akinnuli et al.,2012). With the motorized garrisiever, appreciable quantities can be sieved over a short period of time resulting in an increased production.

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Frying of the garri takes place against the hot surface of a pan that must be scraped quickly and stirred constantly to keep the material moving to prevent it from burning until frying is completed. (Gbasouzor Austin Ikechukwu, Anthony Maduabum, 2022). Garri sieving machine can also be used after the frying process. Depending on the sieving size used,Ovat&Odey(2018), classified garri into extra fine grain, fine grain, and coarse grain garri. Generally in making eba, the fine grain or coarse grain garri are usually used.

The objectives of this paper work are, to design a garri sieving machine that is portable, to increase the production of garri. The scope of this work is limited to the construction of a garri sieving machine and testing the efficiency.

II. MATERIALS AND METHOD

The garri sieving machine is constructed to sieve garri hygienically (hands- free operation) which will not make the garri susceptible to contamination (Ovat, F. A., Nyong, O. E., Adie, J. A. & Onabe Patrick, 2021). The machine utilizes the principle of slider-crank mechanism in its operation. There is a disc (crank) mounted on driven shaft which is driven by 1-horsepower (0.745 kW) electric motor. Whenever the shafts rotates, the rotational motion is converted to the reciprocating motion of the sieving tray. This reciprocating action of the sieving tray separates the particles.

2.1. MATERIALS SELECTION.

In Engineering design materials selection are very important factor which were put into consideration(Olanipekun K.A.,& OluwadareB.S., 2016).

This machine consist of:

i. The frame: This is the main unit of the machine in which every other component is supported.
ii. Sieving tray: Its function is to sieve or separate the granular substance on the tray. Garri inlet
iii. Top cover: This is to prevent the contamination of the garri being sieved in the chamber
iv. Drive pulley: These are mechanical drivers that are fixed to transmit motion or power from one shaft to another. Fine grain outlet: this is where the fine sieved grains are collected.
v. Shaft outlet: this is where the remaining un-sieved shafts grains are collected
vi. Bolts/nuts: Are mechanical fasteners used to hold components together.

Development and application of Garri Sieving Machine

2.2 GARRI PROCESSING.

Ovat&Odey(2018) reported in their thesis that traditional garri processing involves these steps:

i. Fresh cassava tubers are peeled, washed and grated.
ii. The grated pulp is put in sacks and pressed using a hydraulic jack or stones to release excess liquid from the pulp as it ferments. This step takes about 4days.
iii. The dewatered and fermented lumps of pulp are then broken up by hand.. Fibre and other hard parts are also removed.
iv. The remaining mass is sieved either traditionally or with a machine to separate out the fine pulp and ready it for frying
v. The sieved fine pulp is then fried in an iron pan or earthen pot over a fire. If the sieved pulp is too wet, it takes longer time to roast resulting in a finished lumpy product.
vi. The roasted garri is then sieved into different particle sizes and sold

In some locations, Palm oil is added to prevent the pulp from burning during roasting and to give a light yellowcolor to the garri. This yellow garri is 10-30 percent more nutritious therefore more expensive than white garri [Augustine et al., 2019].

2.3 DESIGN CALCULATION AND ANALYSIS

2.3.1 WEIGHT OF HOPPER PART

The volume of the hopper pot is given as:

$$Vp = \pi \frac{(D_b)2 - (d_b)2}{4} \times L_b$$

$$V_p = \pi \times \frac{(0.28)^2 - (0.275)^2}{4} \times 0.25 = 5.449 \times 10^{-4} m^3$$

Since ρ = density of stainless steel = 7880 kg/m³, then

Wp=Weight of pot = ρ x V x g

=

$$7880 \times 5.449 \times 10^{-4} m^3 \times 9.81 = 42.12 \text{ N}$$

2.3.2 WEIGHT OF SIEVING TRAY

Tray dimension:

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Length, l= 0.425m, Thickness, = 5mm = 0.005m,
Height, h = 50mm = 0.05m^t
Volume of each side of the tray, = l x h xV_b
(Agbetoye, 2024)
= = 3.375 x100.135 x 0.05 x 0.05^{-5}
The volume of the two sides of the tray =3.375x10^{-5}
=6.75x10^{-5}
Since ρ = density of stainless steel = 7880 kg/m^3
Mass of tray, $m_{bl} = \rho V$
= 7880 = 0.266kg x 3.375 x10^{-3}
Weight = mg where g = 9.81kg/m^2
= 0.266 x 9.81 = 2.61N
Ring dimension:
D = 19mm = 0.019m, d = 17.5mm = 0.0175m,
width, w = 50mm = 0.05m
Weight of each ring, = $w_r \rho \times A \times w \times g$
=
$$7880 \times \pi \times \frac{(0.019)^2 - (0.0175)^2}{4} \times 0.05 \times 9.81 = 0.166\ N$$
Total weight of trays = 3(2 x weight of each side of the beater + weight of each ring)
= 3(2 x 2.51 + 0.166) = 15. 558 N

2.3.3 WEIGHT OF DRIVE PULLEY.

$$w_s = \rho \times \frac{\pi D^2}{4} \times h \times g$$
$$= 7880 \times \frac{\pi(0.02)^2}{4} \times 0.089 + 0.015^2 \times 0.003 + 0.01^2 \times 0.038 \times 9.81 = 2.983\ N$$
=7880 x π/4 (4.0075) x 9.81
=2.433 N

2.3.4 WEIGHT OF TRANSMISSION SHAFT OR CONNECTING ROD

$V_1 = \pi(HR_1^2 - hr_1^2)$
$V_1 = \pi H (0.015^2 - 0.008^2)$
$= \pi \times 0.003 (0.015^2 - 0.008^2)$
$= 1.517 \times 10^{-5} m^3$

$V_2 H (R = \pi_2^2 - hr_2^2)$
$= \pi \times 0.055 \times 0.015^2$
$= 3.888 \times 10^{-5} m^3$

$V_3 H (R = \pi_3^2 - hr_3^2)$
$= \pi \times 0.04 \times (0.015^2 - 0.008^2)$
$= 2.023 \times 10^{-5} m^3$

Total volume of shaft =
$1.517 \times 10^{-5} + 3.888 \times 10^{-5} + 2.023 \times 10^{-5}$
$= 7.428 \times 10^{-5} m^3$

Weight of shaft $= \rho \times V \times g$
$= 7880 \times 7.428 \times 10^{-5} \times 9.81 = 5.742\ N$

2.3.5 DESIGN OF THRUST BEARING

P = W/A = w/πR^2
Where;
W = load transmitted over the bearing surface
R = Radius of the bearing surface (or shaft)
A = cross – sectional area of the bearing surface
P = bearing pressure per unit area of the bearing surface between rubbing surface
N = speed of the shaft in rpm
W = Total load = Wb+Wbl+Ws
= 42.12+16.158+2.433
= 60.711 N
R = Radius of bending surface = radius of shaft = 30 mm = 0.03 m
P = 60.711/π (0.03)^2 = 21472.124 Nm^2
= 21.47 KNm^2

2.4 DESIGN OF THE MACHINE

The machine was design using Autocad 2016 software and the assembly drawing can be seen below in figure 2.1.

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PART NO	PART NAME	QTY	MATERIAL
1	Gaari Inlet	1	MILD STEEL
2	Top Cover	1	MILD STEEL
3	Sieving Tray	1	MILD STEEL
4	Drive Pulley	1	MILD STEEL
5	Fine grain Outlet	1	MILD STEEL
6	Frame	1	MILD STEEL
7	Shaft Outlet	1	MILD STEEL

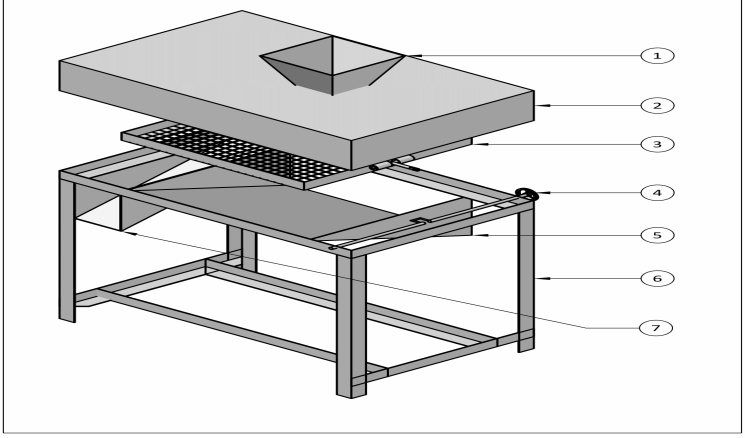

Figure 2.1: Assembly Drawing of TheGaari Sieving Machine

2.5 FABRICATION PROCEDURE

The materials were procured from Ikirun, Osun State, Nigeria.The angle irons and sheet metal were cut to the desired sizes and welded together with an arc machine. The fabrication of the frame can be seen in figure 2.2.

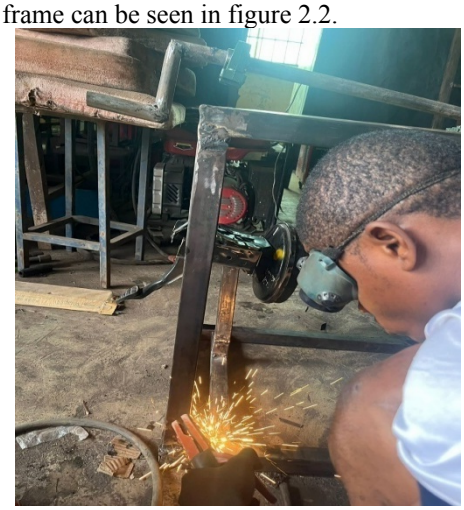

Figure 2.2: Welding The Metal Frame

The sieving tray was constructed with wood and sieve cloth and wire mesh. This was constructed to specification.

After the frame was constructed, the sieving tray, the cover and outlet trays were added to the construction. The electric motor was added and v-belt fitted. This can be seen in figure 3.1 below.

III. RESULTS AND DISCUSSION

3.1 RESULT

After the fabrication of the garri processing machine, the machine was painted blue. This can be seen in figure 3.1 below. The garri processing machine was tested and found to be satisfactory.

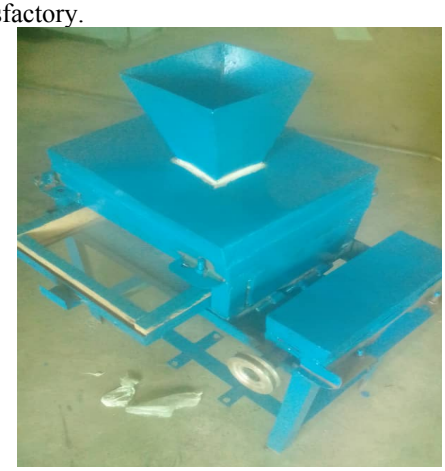

Figure 3.1: The Completed Garri Sieving Machine

3.2 TESTS AND RESULT

The fabricated garri sieving machine was tested with varying quantity of cassava starch. Time taken to sieve and quantity of garri produced were measured and recorded. In order to test the efficiency of the machine, the same quantity of cassava starch was done using the traditional method. Results were recorded and compared as can be seen in Table 1 below.

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Table 1:Testing The Garri Sieving Machine

SN	Cassava starch (kg)	Hand Sieving Time (mins)	Machine Sieving Time (mins)	Qty of Sieved Garri by Hand (kg)	Qty of Sieved Garri by Machine (kg).
1	2	5	2	1	2.4
2	5	10	5	3	6
3	10	15	8	8	12.1
4	15	20	14	11	15
5	20	25	20	13	20

It was observed that as the weight of cassava starch increases, this lead to increase in quantity of sieved garri and also rate of sieving.

This result was good and showed that the machine was much more efficient than the traditional method. The use of this machine will help increase quality as well and quantity of garri produced.

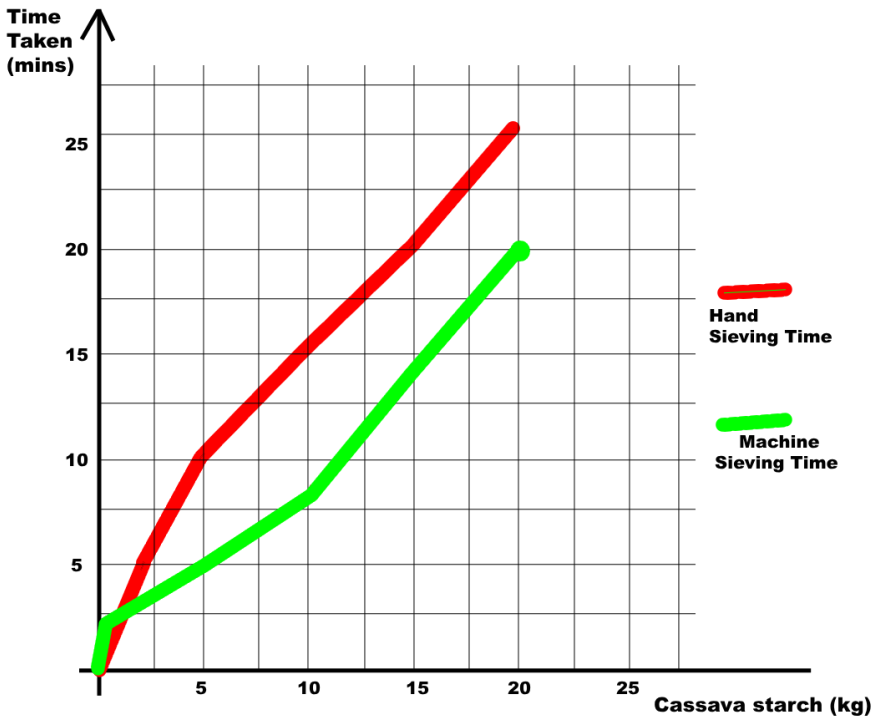

Figure 3.2: Graph of Time Taken To Sieve by Hand and with Machine

The graph shows a significant reduction in time taken to sieve the garri using the machine compared with sieving by hand.

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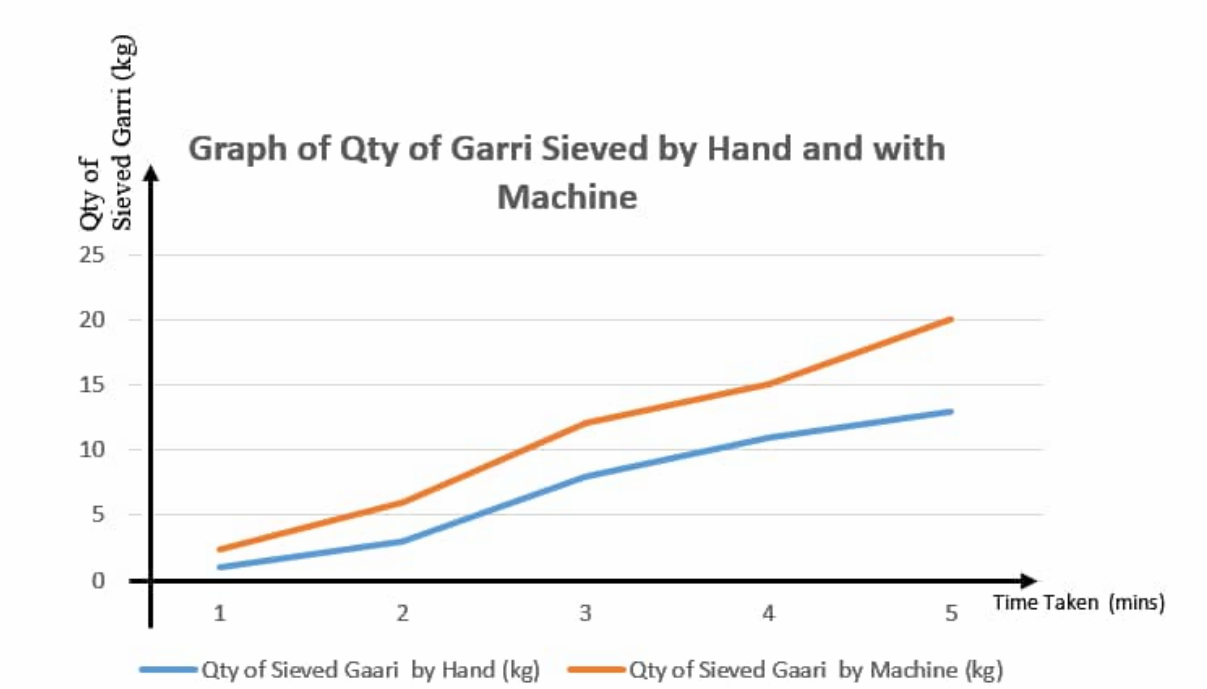

Figure 3.3: Graph of Quantity of Garri Sieved by Hand and with Machine

IV. CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The garri sieving machine worked as intended. It runs on a 1horse power electric motor. The rotating motion of the motor is translated to reciprocating motion of the sieving tray. The garri put into the sieving tray is separated into fine particles and coarse particles (shafts). The garri sieving machine will help farmers and garri processing plant to separate garri to different particles faster and more hygienically.

4.2 RECOMMENDATIONS

Based on the above conclusion, the following recommendations are made:

i. The garri processing machine can be included into a garri production train between frying stage and packaging stage.
ii. The garri processing machine can be modified to use lesser horse power, than 1 horsepower motor, and still have same efficiency or higher.

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