International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 01 Jan. 2025, pp: 308-314 www.ijaem.net ISSN: 2395-5252

Development of a Gas-Powered Garri Fryer

*Bankole, Yakub O; Odunukan,Risikat O ; Dare Bisola T ; Lamidi Sheriff B and Tanimola A. Olanreaju

Department of Agricultural and Bio- Environmental Engineering, Lagos State University of Science and Technology Ikorodu. Lagos State, Nigeria. +2347088587194,

Date of Submission: 10-01-2025 Date of Acceptance: 20-01-2025

ABSTRACT
A gas powered garri frying machine was designed, fabricated and tested at the department of Agricultural and Bio-system Engineering, Lagos state University of Science and Technology, Ikorodu Lagos, Nigeria to fry cassava mash using locally sourced materials. The main components of the machine are the machine frame, frying compartment, stirrer shaft, delivery chute, burner, heating source (gas), gas cylinder, gear and paddle. The result obtained from the performance evaluation of the developed machine accounted for throughput capacity of 23. 99kg/hr, functional efficiency of 88.03%, moisture loss of 11.9% and the final moisture content of the fried garri of 11.9% within frying time of 0.37 hour. The result obtained showed that the machine can effectively fry cassava mash into garri following the performance indicators outlined. The smoke hazard attributed to the traditional garri frying was eliminated while heat loss was also controlled. The machine is user friendly and it requires no skilled labour.

Keywords: Gas powered, Garri fryer,Cassava mash, Development

I. INTRODUTION

Garri, a product from cassava roots, is a staple food consumed in Nigeria as well as inmostcountries in West Africa and in Brazil.Nutritionally, Garri is a carbohydrate food which symbolizes that it is an energy giving food. Garri processing follows a sequential operation starting from cassava uprooting, peeling,washing,grating,dewatering,fermentation,sieving, frying and cooling. Historically, frying of Garri manually with minimum crude mechanization. Garri frying is a simultaneous cooking and dehydrating operation. The garri is first cooked with the moisture and then dehydrated (Egba, 1987). The heat intensity during frying affects the quality of theproduct. The moisturecontent of dewatered and sieved cassava mash is between 50% to 65% that has to be reduced after the frying (Gbasouzor and Maduabum, 2012). Traditional methods of processing cassava roots can result in poor quality products that contain unacceptable levels of cyanide, as well as being contaminated by foreign matter and disease-causing agents. If people eat these kinds of products, they can suffer from acute cyanide poisoning, goiter, and a nerve-damaging disorder that makes them unsteady and unable to walk properly. Traditionally, garri is fried by women in shallow earthen-ware of cast-iron pans (Agbada) over a wood fire. Women use spatula-like paddles of wood or calabash to press the sieved mash against the hot surface of the frying pan and turn it vigorously to avoid caking. The operator sits sideways by the fireplace while frying. The discomfort due to heat and the sitting posture of the operator have been of concern to researchers and this has led to the advent of the mechanized method of frying garri . A mechanized system of frying and drying usually appear in the form of a stainless steel drum with rotary conveyor and paddles fixed along the conveyor to a slower rotation in the same axis of the drum.It is observed that quality mechanized garri processing plant are few, hence it is highly imperative to design and construct a garri frying machine that will assist in solving the major challenges faced by the local garri processing industries and to produce quality garri at commercial quantities. However, this study aimed at designing and construction of an economical garri fryer machine using gas as a source of energy.thereby the developed machine can be utilized in rural areas where electricity supply is a major challenge.

II. MATERIALS AND METHOD

Material Selection

Material selection is the most important aspect of this work to ensure that the components to be fabricated have the desired performance requirement.

Materials selected were considered based on their strength, availability, durability and corrosiveness to prevent the machine from damage, ease of construction and maintenance hence, mild steel angle iron was used for the machine frame while stainless steel sheet was used for the frying compartment based on the aforementioned properties. The designed and fabricated garri fryer is automated with gas as the heat source of energy.

Component Parts of the Machine and their Functions

Highlighted below are the components of the garri fryers and their functions

- **Frying compartment** - It is the separate section in the machine where the frying of garri takes place.
- **Delivery chute** - It is the sloping channel of the machine that conveys the fried garri to a lower level for further processing.
- **Delivery chute cover** - It is the part of the machine that covers the delivery chute to avoid escape of the garri when frying.
- **Rotary system** - It helps in appropriate turning of the garri during frying operation to avoid caking.
- **Bolt and nut** - They are used to fasten the component parts of the machine together.
- **Machine frame** - It is the structural system that supports other components of the machine. Other components are tightly fixed to it.
- **Heating compartment** - This is the unit or section where the source of heat is fixed for adequate frying of the garri.
- **Gear motor** - It is the mechanism that rotates the paddle when frying garri.

Machine Analysis and Design Calculation.

The Frying Chamber Design.

The volume of the frying chamber of the machine can be obtained using equation (1) Prescribed by Nwadinobi et al. (2019).

$Vc = \pi r^2 h$ 1

Where,d= diameter of the cylinder =0.457m ; r = radius of the cylinder $\frac{0.457}{2}$ = 0.2285m ; h = cylinder height = 304mm = 0.304m, π = 3.142

V_c = 3.142 x 0.2285^2 x 0.304= 3.142 x 0.457 x $0.304m^3$

$V_c = 0.436m^3$

Determination of the Maximum Weight of Garri.

The maximum weight of the garri the chamber can contain in a single batch of production can be obtained in equation (2) as given by Nwadinobi et al, 2019.

$M = \rho$ x Vc 2

Where,ρ = Density of garri = $1509kg/m^3$ (IJFST, 1989).

M = mass, kg; Vc = volume = $0.436m^3$

M = ρ x Vc= 1509 x 0.457= 689.6kg

Determination of Maximum Weight of Garri that can be Fried in the Garri fryer.

The maximum weight of garri that can be fried in the fryer is calculated using equation (3) as reported by Nwadinobi et al, 2019.

W = mg 3

Where,W = weight of garri, N; M = mass of the garri, kg; g = Acceleration due to gravity = $9.81m/s^2$

W= 689.6 x 9.8 = 6758.8N

Volume of Cassava Mash in the Cylinder.

Note: For the effective garri frying, one-third of the cylinder will be required, assuming the cassava mash in the cylinder (Nwadinobi et al, 2019) then,

$V_m = {}^1/_3 V_c$ 4

Where,V_m = Volume of mash in the cylinder, m^3

$V_m = \frac{1}{3}$ x 0.457= 0.153 m^3

Mass of cassava mash in the cylinder.

The mass of the cassava mash in the cylinder is calculated using equation (5) given by Nwadinobi et al, 2019.

$M = \frac{\rho}{Vm}$ 5

Where,ρ= density of cassava mash = $1509kg/m^3$

V_m = volume of mash in the cylinder =$0.153m^3$

M= 1509 x 0.153 = 230.8kg

Heat Required for the Drying.

The quantity of heat required to cook and dry the cassava mash during the garri frying process was determine using the relationship in equation (6) given by Nwadinobi et al. (2019).

$Q = MC\Delta T$ 6

Where,Q = Quantity of heat required; M = mass of cassava mash in the cylinder, kg
C = The specific heat capacity of cassava mash at moisture content 45% wb, given as 4.14J/kgk (Oyerinde and Olalusi, 2011).
ΔT = Temperature change = T_1-T_2 = 60^0C
T_1= Initial temperature of Trough (60^0C).;T_2 = Maximum Temperature attained by the frying (100^0C).
Q = 230.8 x 4.14 x 6 = 57330.7KJ

Determination of Output Speed of the Gear.
A gear consists of toothed wheels attached to shafts. (Claire, 2020). To calculate the speed ratio otherwise known as gear ratio, the number of teeth of the input gear is divided by the number of teeth of the output gear.
Speed ratio of the gear = $\frac{\text{Numbers of teeth of the output gear}}{\text{Numbers of teeth of the input gear}}$
Gear ratio = $\frac{50}{19}$ = 2.63
Equation (7) prescribed by Claire, 2020 can be used in calculating the output speed of the gear.

$$\frac{T_2}{T_1} = \frac{N_1}{N_2} \qquad 7$$

Where,T_1 = Number of teeth of input (driven) gear = 19;T_2 = Number of teeth of the output (driven) gear = 50
N_1 = Input speed of the gear (rpm) ;N_2 = Output speed of the gear (rpm)

$$T_1N_1 = T_2 N_2 \qquad 8$$

N_1 = 130 rpm
$N_2 = \frac{19X130}{50}$ rpm ; N_2 = 49.4 rpm
The output speed of the gear = 49.4 rpm

Determination of Power to Drive the Shaft.
The calculation can be obtained in equation (9) given by Nwadinobi et al, 2019.

$$P = \frac{2N_2T}{60} \qquad 9$$

Where,P = Power; T = Minimum torque to drive maximum volume of the garri; N_2 = Speed of the driven gear (output speed of the gear (rpm)
The power required in conveying the mash is obtained in equation (10) as given by Nwadinobi et al. (2019).

$$P = \frac{2N_2T}{60} \qquad 10$$

T = f x r

$$T = (W_{cr} + W_f)x\, r_f \qquad 11$$

F = force (N)
R = radius of driven gear
W_{cr} = Weight of the connecting rod (shaft)
W_f = Weight of the driven gear.

Machine Description and Principle of Operation
The garri frying machine (See figure 1) consists of a geared electric motor (Prime mover) chain and sprocket, frying compartment, mixing paddles system, delivery chute, delivery chute cover, stirrer shaft, machine frame, heating chamber, and bearings. The cylindrical frying chamber is made of stainless-steel metal sheet of 2mm thickness, 350mm diameter, and depth of 135mm. The frying chamber is attached to the base where the heat source is located (cooking gas cylinder and burner). The burner was connected to a gas cylinder through a hose and a regulator. The burner has a control valve for regulating the temperature to a desire temperature. The fried cassava mash (garri) discharge chute was located on one side of the frying chamber. An electric motor (2hp) fitted with a reduction gear of variable speed. This was used to propel the paddles shaft and paddle to allow for the slow and gradual movement of the garri within the frying chamber. The paddles were attached to one side of the shaft which was connected to the chain and and sprocket. The machine frame was made of 2mm (thick) mild steel angle iron. The sieved cassava mash is fed into the frying chamber. The electric motor is engaged and the power from the motor produce a rotation which is transmitted in the paddle shaft with the aid of the chain and sprocket system. The paddles connected to the shaft rotates thereby preventing the cassava mash from getting burnt and sticking together during the frying operation. The paddle rotates around the frying surface, thereby pressing and agitating the cassava mash thus preventing sticking, burning, and formation of lumps during gelatinization. This operation continues until the garri frying is completed. After frying, the discharge chute gate is opened, the machine is tilted and the fried garri is discharged into a receiving bowl. The garri frying machine was designed to use cooking gas as its energy source.

Machine Performance Evaluation
Cassava mash was used for the machine testing. The cassava roots were obtained from

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 01 Jan. 2025, pp: 308-314 www.ijaem.net ISSN: 2395-5252

Lagos state university of science and technology farm. The harvested cassava roots were cleaned, peeled, washed, grated, and pressed using cassava grating and pressing machines available in the crop processing unit of Agricultural and Bio- Systems Engineering Department of Lagos State University of Science and Technology in Ikorodu, Lagos State, Nigeria. Gravitational method was used to determine the moisture content of the cassava mash (AOAC, 2005). The final weight of the cassava mash was taken after the product has been cooled. inside the desiccator. The moisture content determined was on wet basis. The moisture content was calculated using the mathematical expressionin equation 12as reported byOdunukan et al., (2022).

$$Mc = \frac{W_o - W_f}{W_o} x\ 100\% 12$$

Where,Mc = Moisture content (wet basis) %;W_o = Weight of wet mash (kg)
W_f = Weight of dried mash (kg)

The cassava mash frying was carried out by pouring the cassava mash of known moisture content and mass intermittently into the fryer. The burner placed at the base of the frying chamber was lit and heat up by the gas flame. As the frying progress, the moisture content of the cassava mash reduces some small lumps developed and were broken down by constant pressing and agitation. The heat was then increased to further cooked and dehydrate the garri. The extent of drying depends on the rate of the heat utilized and frying time.The test parameters used in evaluating the performance of the machine are the fryer throughput capacity $(TP)_C$ and functional/drying efficiency **(η_f).**

Determination of Throughput capacity of the garri fryer

$$(TP)_C = \frac{M_f}{t} 4$$

Where,
$(TP)_C$ = Throughput capacity, kg/hr
M_f = Mass of garri collected
T = time taken, hr

Determination of the Functional/ Drying Efficiency.

$$(\eta_f) = \frac{m_f}{m_i} x\ 1005$$

Where,
(η_f) = Functional/ drying, %
M_f = Mass of mash introduce into the fryer, kg

2.5.3 Determination of the Material Loss

$$M_L = \frac{m_i - m_f}{m_f} \quad 6$$

Where, M_L= Material loss during frying operation %
M_i = Mass of cassava mash fed into the frying chamber during each operation (kg).
M_f = Mass of garri obtained after frying, (kg)

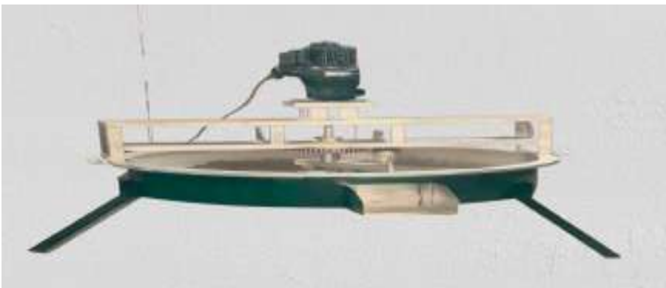

Figure 1: The Garri Fryer

Figure 2: The Fried Garri.

III. RESULTS AND DISCUSSION

3.1 Results

Three replicates of the cassava mash were used in carrying out the performance test on the constructed machine and the samples were labeled A, B and C.Presented in Table 1 are the results obtained from the performance evaluation carried out on the machine. Figures 2,3,4 and 5 show the effects of mash moisture content on frying time, mash moisture content on percentage material loss,mash moisture content on throughput capacity and mash moisture content on percentage functional efficiency respectively.

Table 1:Machine Performance Parameters

Experimental Runs	Initial Moisture Content (% w.b)	Final Moisture Content (%w.b)	Mass of Mash Introduced into the Fryer, M_i (kg)	Mass of Garri Obtained, M_f (kg)	Frying Time, t (hr)	Throughput Capacity, (TP)c (kg/hr)	Functional Efficiency, (η_f) (%)	Material Losses M_L (%)
1	44	12	10	8.8	0.37	23.98	88	12.0
2	44	13	10	8.7	0.37	23.71	87	13.0
3	44	10.9	10	8.91	0.37	24.28	89.1	10.9
TOTAL	**132**	**35.9**	**30**	**26.4**	**1.11**	**71.97**	**264.1**	**35.9**
AVERAGE	**44**	**11.9**	**10**	**8.80**	**0.37**	**23.99**	**88.03**	**11.9**

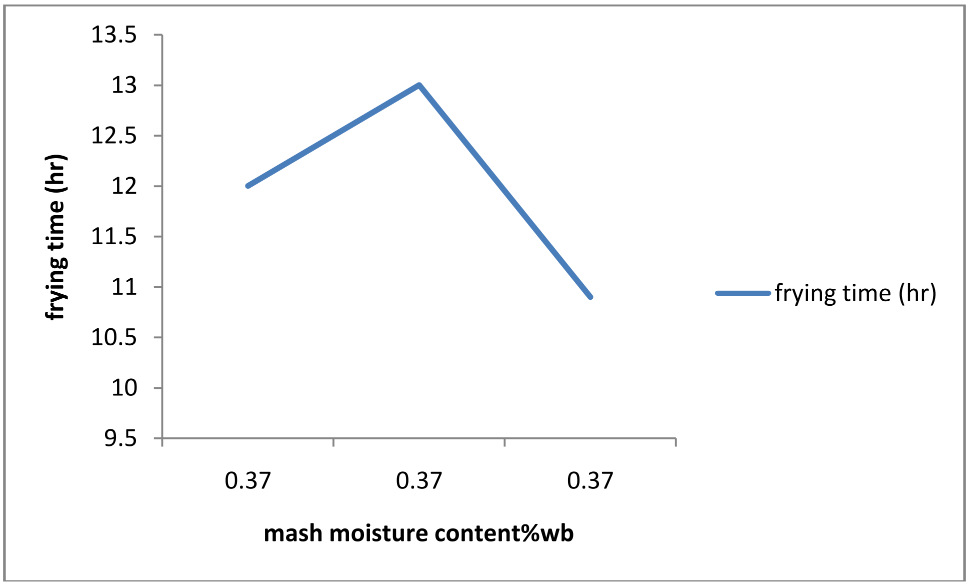

Figure 2: Effect of mash moisture content on frying time

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 01 Jan. 2025, pp: 308-314 www.ijaem.net ISSN: 2395-5252

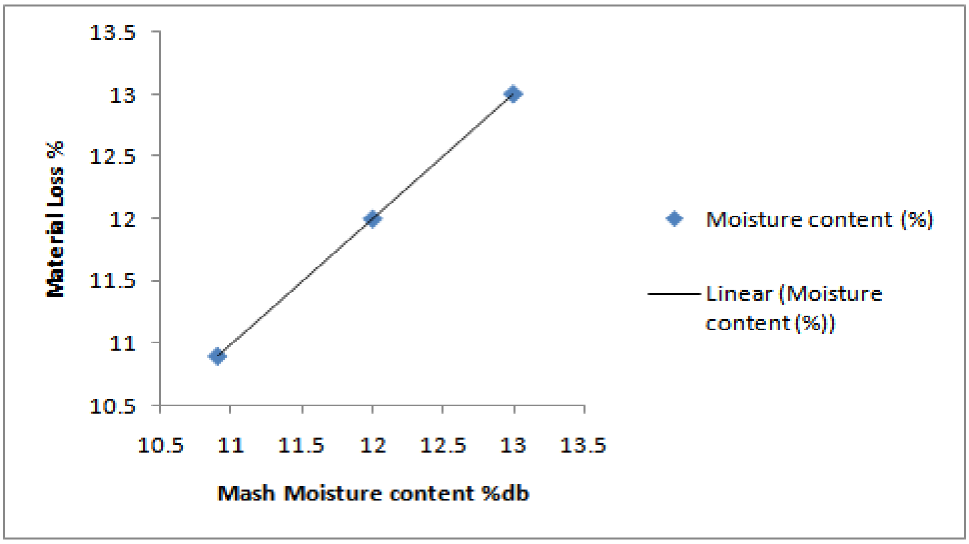

Figure 3: Effect of mash moisture content on percentage material loss

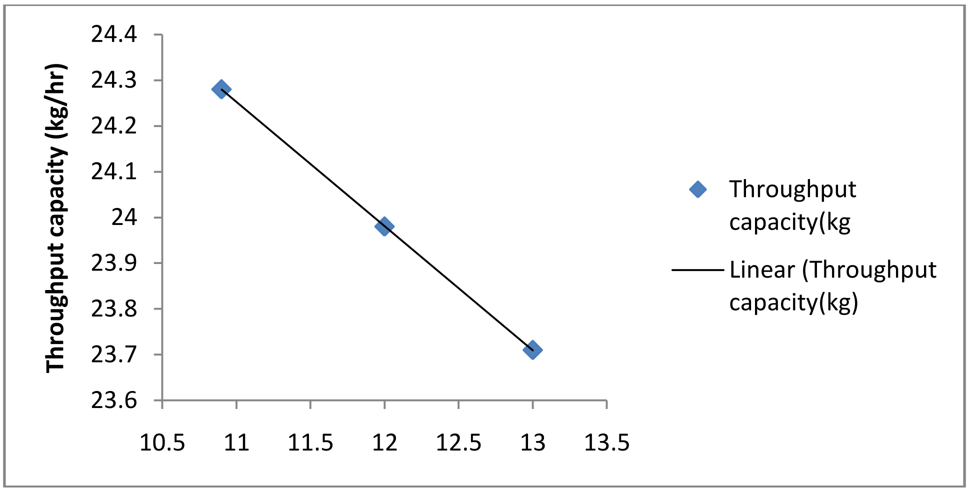

Figure 4: Effect of mash moisture content on throughput capacity.

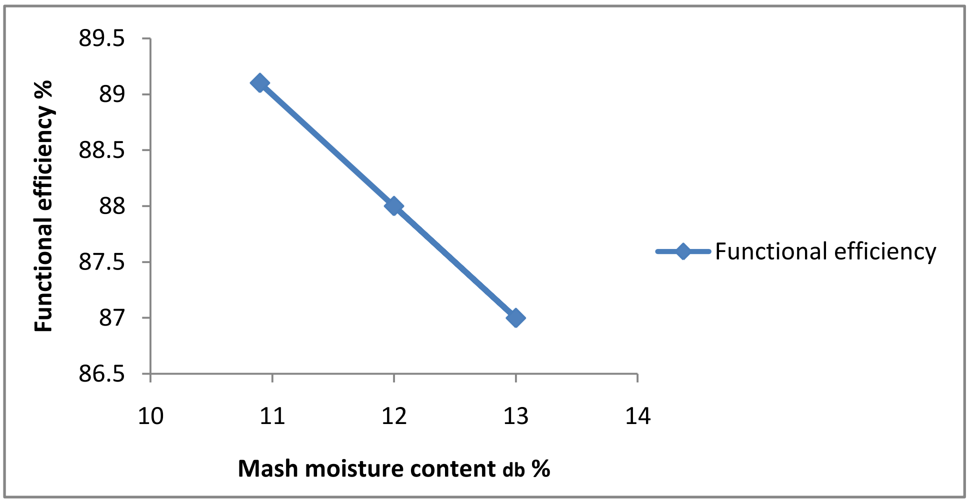

Figure 5: Effect of mash moisture content on percentage functional efficiency.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 01 Jan. 2025, pp: 308-314 www.ijaem.net ISSN: 2395-5252

3.2 Discussion

Frying time

As shown in the Table 1, the frying time was constant throughout the frying period. The cassava mash moisture content initially increased and later decreases as frying progresses as depicted in figure 2. The constant frying time was responsible for the mash moisture content (%) loss. It was also observed from the table that constant frying time of 0.37 hour of the cassava mash was fried to 12, 13, and 10.9%.

Material Losses

As indicated in Table1, percentage material losses are 12, 13, and 10.9%. Garri obtained at 13%. As the percentage material loss reduced the mash moisture constant increased as shown in figure **Throughput Capacity**

The throughput capacity of the machine under the different mash moisture content ranged from 23.71 to 24.28kg/hr as indicated in Table 1. As the mash moisture content reduced, the throughput capacity increased as shown in figure 3. The lowest throughput capacity of 23.71kg/hr which was recorded at 13% moisture content (wet basis), corresponded to the highest percentage material loss, while the best throughput capacity was recorded at 24.28kg/hr.

Functional Efficiency

The effect of mash moisture content on functional efficiency is presented in figure 5, Functional efficiency was observed to increase. The best functional efficiency of 89.1% was observed when the mash moisture content was 10.9% wet basis as indicated in Table 4.1.

IV. CONCLUSION

A garri frying machine was developed in this study. The result obtained from the performance evaluation of the developed machine accounted for throughput capacity of 23. 99kg/hr, functional efficiency of 88.03%, moisture loss of 11.9% and the final moisture content of the fried garri was 11.9% within frying time of 0.37 hour. The result obtained showed that the machine can effectively fry garri following the performance indicators outlined. The smoke hazard attributed to the local garri frying was eliminated while heat loss was also controlled. The machine is user friendly and it requires no skilled labour.

REFERENCES

[1]. Egba, A, (1987). Design and Construction of Garri Fryer for Local use. Bsc

[2]. Project Report, Agricultural Engineering Department Unpublished.

[3]. Association of Official Agricultural Chemists (2005).AnalyticalMethods: Determination of Moisture Content 18th Edition Edition,Arlington,VA,USA

[4]. Gillespie,Claire (2020). How to Calculate Speed Ratio.sciencing .com.Retrieved from https:www.sciencing.com/calculate-speed-ratio-7598425/

[5]. Gbasouzor, N. and Maduabum. U. (20012). Improved MechanizedGarri Frying Technology forSustainable Economic Development in Nigeria. Proceedings of the International Multi Conference of Engineers and Computer Scientist. Vol.2, IMEC. Vol 7: 246-256.

[6]. International Journal of Food Science and Technology (1989). 24(6) 637-645.

[7]. Nwadinobi, C. P., Edeh, J. C. and Mejeh, K. I (2019). Design and Development of a Vertical Paddle Semi Automated Garri Frying Machine.

[8]. **Odunukan, R. O.,** Bankole, Y. O., Tanimola, O. A., and Dare,B.T.(2022).Drying Methods Impact on Physiochemical Properties of Sliced Ginger (Zingiberofficinate).International Journal of Research in Engineering and Science. Vol(10) issue 7 Pp 400-407.

[9]. Oyerinde, A. S. and Olalusi, A .P. (2011)., Thermal Properties of Ground and Fermented Cassava Mash (Garri) During Different Stages of Roasting.