Design and Fabrication of Cassava Processing Machine: The Necessary Aid for Technological Renaissance

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Abstract*- The processing of cassava mash (garri) over the years has been a lucrative business for farmers in Nigeria. Unfortunately, this business has been run in small scale due to the unavailability of the mechanized and industrial machine that will facilitate the production in large scale necessary for export purposes. This paper, is meant to bring to light The automatic controlled garri frying machine incorporated with microcontroller so as to improve on mechanization of the production of gari in Nigeria. The frying machine operates with an electrical heating element of 5kW and a gear motor of variable speed. This makes it an improvement on other machine which operates on charcoal or gas burner for heat sources to fry the cassava mash. And also a programmable controller is used for controlling the operation of the heating element and the gear motor, making it a semi-automatic machine. It has a display interface on the machine control panel that displays the instantaneous temperature of the garri. The machine operates with a peak temperature of 90^0C and it has a vibrator which maintain smooth frying operation, thereby avoiding bunning and caking or clustering of garri grains due to uncontrolled and unstable high temperature. The height of the machine is 920mm with a diameter of 700mm. The material used for the internal frying pan is stainless steel of 1.5mm thickness welded with a thungsten electrode to ensure that the garri is safe from any food poisoning as a result of corrosion. The body is constructed with mild steel of 4mm thickness. The top support frame is constructed with mild steel of 8mm thickness. The machine is supported with a pair of tyre to facilitate movement .After the construction, the machine was tested and it was found that the machine function optimally. The project can be mimicked by both the students of the department of mechanical and electrical engineering of to enhance their knowledge on mechatronics. Furthermore, it can be constructed in larger capacity to process more tons/hour for industrial purposes.

***Indexed Terms*- Technological renaissance, automatic control, microcontroller, casaava mash (garri), industrial purposes.**

I. INTRODUCTION

Cassava which is known biologically as "manihotesculentacrantz" is a crop which has many varieties. Cassava is a perennial woody shrub in the Euphorbiaceous (Spurge family) native to South America, but now grown in tropical and sub-tropical areas worldwide for the edible starchy roots (tubers) which are a major food source in the developing world, in equatorial regions including Africa, South America, and Oceania, is also known as yucca, manioc, and tapioca.

It is a major food crop in Nigeria (Kim, 2009). It supplies about 70% of the daily calorie of over 50 million people (Agbetoye, 1999) and about 500 million people worldwide. It is a basic staple food to more than 70% of Nigerian population and it is consumed at least once every day (Njoku and Muoneke, 2008). It was probably the emancipated slaves who introduced the cassava crop into southern Nigeria as they returned to the country from South America via the Islands of Sao Tome and Fernando Po. At that time there was Portuguese colonies off Nigeria shores (Ekanem, 1962). Cassava, however, did not become important in the country until the end of the nineteenth century when processing techniques were introduced, as many more slaves returned home.The cassava root is long and tapered, with firm, homogenous flesh encased in a detachable rind, about 1mm thick, rough and brown on the outside. Commercial varieties can be 5cm to 10cm in diameter at the top and around 15cm to 30cm long (FAO, 2003).

As a cash crop, cassava generates cash income for the largest number of households in comparison with other staples (Adeniji, *et al*, 2011). Currently, Quality of garri can be enhanced by adding few drops of palm oil. At the end of the frying operation, the product is still hot and a little bit damp. It is then allowed to cool and dry in a cool dry shade, until the moisture content is reduced to 12% (Gbasouzor, *et al*., 2012).

Garri frying (Garification), though a dehydrating process, is not a straight forward dry process (Igbeka, 1995). It is not possible to produce gari from cassava pulp by just passing heated air through it. The product ofGarification is a simultaneously cooking and dehydrating operation. The product is first cooked with the moisture in it and then dehydrated. The heat intensity during frying affects the quality of the product. The moisture content of dewatered and sieved cassava mash is between 40 to 45%, which has to be reduced to around 12% after the frying operation in the village technique, the initial frying temperature is relatively low so as to avoid the formation of many lumps or caking.

As the moisture content reduces and most of the small lumps developed have been broken down by constant pressing and agitation, the heat is then increased in order to further cook and dehydrate the product. The colour and taste of garri can then be enhanced by adding a few drops of palm oil. (Odigboh and Ahmed,1982).

Traditionally garri is fried by women in shallow earthen–ware of cast iron pans (Agbada, Nigerian Ibo) over a wood fire. Women use spatula-like paddles of wood or calabash sections to press the sieved mash against the surface of the frying pan and turn it vigorously to avoid caking. The operator sits by the fire place while frying. The discomfort due to heat and the sitting posture of the operator have been of concern to researchers. Thus, some innovations and improvements have been initiated and carried out in the equipment and the general set-up of the village method so as to alleviate the problems encountered by women.

Fig. 1. Garri frying process

II. METHODOLOGY

2.1 GARRI PROCESSING EQUIPMENT

- Weighing balance
- Peeling machine
- WashinG machine
- Grater
- Presser
- Sifter/pulverizers
- Fryers
- Sieves
- Hammer milling machine
- Sealers

2.2 SOURCE OF POWER

In the processing centers visited Oye-Emene, the major source of power for frying of gari was charcoal/ firewood. Electricity, diesel and petrol were mainly used for lighting and powering of the grating and milling machines.

Table 1.1: Source of Power

Source of power	No. of machines/equipment	% of machine/ equipment
Firewood/coal	20	70
Electricity	5	10.2
Diesel	4	15.5
Petrol	3	4.3

This improved version of garri frying machine is incorporated with some devices which makes it a unique garri frying machine. This includes a built in electronic panel which contains microcontrollers, relays and thermistor for temperature sensing and adequate temperature controller which will reduce burning and caking of garri.

The controller controls the temperature of the frying process through the relay panel which trips off the firing elements to decrease an elevated temperature. The fried garri is discharged through the outlet for another batch to be introduced. The machine consists of an electric motor, rotating shaft and paddle, frying chamber/pan, fan, a.c. element, control panel, exhaust pipe/ chimney, and frame support.In the firing chamber, a chimney is provided to allow escape of excessive heat to the surrounding atmosphere. A fan is also included in the chamber to circulate the heat emanating from the a.c. elements to the frying chamber.The paddle turns the garri in a rotary motion using the power of the electric motor throughout the frying process and stops immediately when a signal is received to stop the rotation after dried garri product is achieved.

2.3 CONSTRUCTIONAL CONSIDERATIONS

The following points should be noted during frying:

- The circulation of heat must be constant and regulated at appropriate timing.
- Adequate pressing and rotation of the garri in the frying chamber to avoid sticking with the base.
- Ensure that the final product is uniformly cooked and dehydrated.
- Ensure that heat is uniformly distributed.
- Ensure the machine is environmental friendly.

2.4 DESCRIPTION OF COMPONENTS USED FOR CONSTRUCTION

The materials used in constructing the machine were carefully selected with regards to the project work to ensure harmony between parts. The major components of the machine include: Frying chamber/pan, electric motor, frame support, the rotating shaft and paddle, exhaust pipe/chimney, control panel and discharge port.

2.4.1 Frying Chamber/Pan

This part of the machine conducts heat generated by the element and uses it for frying the sieved particle within a specific time range. The frying pan is a pot with a height of 300mm and diameter of 700mm. it is made of stainless steel. This is because stainless steel can conduct and disperse heat faster and not buckle under high temperature couple with resistance to corrosion. The paddle is fixed directly inside the frying pan for the turning of the garri in the frying pan as shown in

Fig: 2. Frying chamber

2.4.2 Rotating Shaft and Paddle

The rotating shaft and paddle is connected directly to the electric motor. They are made up of stainless steel. The paddle is attached to the shaft and to the electric motor shown. The shaft is 600mm long with a radius of 35mm. The paddle has a length 660mm.

2.4.3 Support Frame

As shown in plate 3. the support frame is constructed using mild steel U channel (80millimeter with thickness of 8milimeter). This frame supports the electric motor at a height of 310mm from the frying chamber. This is to prevent the heat from the frying pan from touching the electric motor. The frame support extends to the right hand side of the machine to support the control panel, keeping it away from the motor and heat to the comfort of the operator. It has a height of 300mm, length of 800mm and breadth of 320mm.

Plate 3. Frame Support

2.4.4 Gear Motor

The electric motor drives the rotating shaft, which then turns the paddle attached to it. An induction type, three phase electric motor is selected, because of its torque. The motor is made of 1 horse power, The motor turns the cassava mash through the shaft and paddle at variable speeds.

2.4.5 Discharge Port

The discharge port is located at the front of the base of the frying. When a particular batch of cassava mash is fried, the discharge chute is pulled up, the garri discharges as the paddle rotates and a new batch of cassava mash is introduced into the frying pan.

2.4.6 Control panel

The control panel is a control unit where the operator controls the operation of the machine. As shown in figure

Plate 4: Control panel

2.4.7 Picture of complete construction

After the overall constructional procedure, the pictorial view of the equipment before and after spraying is as shown in figure 3.4

Plate 5. Pictorial view of final construction before spraying

2.4.8 Additional features

The additional features include the light indicators, cooling fan, timer, on/off switch and temperature sensor, LCD.

2.4.9 Light indicators: The incorporated panel has three light indicators of different colours; red, green and yellow. The red shows the presence of current, the green indicates heater-on, and the yellow light indicates motor–on.

2.4.10 Cooling fan: The cooling fan is used to circulate the heat generated from the heating element within the system

2.4.11 On/Off switch: It is used to switch on and turn panel which will automatically switch on the system.

2.4.12 Temperature sensor: The temperature sensing device is used with the built in panel to determine the values of the working temperature in degree Celsius (ºC). With the use of a variable resistor, the panel is preprogrammed to work within the temperature range of 75˚C and 95˚C.The element will be automatically switched Offby the microcontroller whenever the temperature value is above 95˚C and starts the system also whenever the value is below 75˚C.

2.4.13 Timer:The basic concept of applying the timer is to ensure that the machine doesn't start operation until there is adequate heat within the system. The timer controls relays that control the two principal working components; the a.c element and the electric motor.

2.4.14 LCD: The display is to provide us a visual data about the instantaneous temperature of the element, and also when turned ON, displays the name of the project and its supervisor.

2.4.15 Components used in the electronic panel.

The component of the electronic panel includes the contactor, relay regulator, circuit breaker, and thermocouple and wire connections.

- Relay: The relay controls the operation of the element and the electric motor.
- It is preprogrammed to work with the display visual basics.
- Regulator: The regulator controls the heat in the system. The rated voltage is 230v and temperature of 75ºC and 95˚C.
- Comparator: The contactor turns off the electric motor when there is too much load.
- Circuit breaker: If there is any fault within the system such as short circuit, the circuit breaker turns off the system to protect the system.
- Thermistor: The thermistor senses the heat in the frying pan and sends the temperature value as an electrical signal to the contractor for comparison between the working temperature value and the heat temperature value measured in degree Celsius (ºC).
- Wire: The electric wires were used to make the right electrical connections and links between components to achieve the objectives of the control panel with the principal working components i.e. the element and motor.

2.4.16 Electrical components

The electrical components are carefully selected to meet specific function of the design objective. The electrical components such as contactor, regulator, relay circuit breaker, thermocouple, electric motor and wire connection used to the electrical designHigh quality types are used for maximum efficiency. Copper wires are used for the wire connection, because of its high conductivity, durability and low cost.

2.5 CONSTRUCTION ANALYSIS AND CALCULATIONS

2.5.1 Determination of Volume of the frying cylinder.

Diameter of the frying cylinder: D=700mm =0.7m

Height of the frying chamber: h= 300mm =0.3m

Therefore, the radius of the frying chamber r= $\frac{D}{2} = \frac{700}{2} = 350mm = 0.35m$

If radius of the frying cylinder, $r = 0.35$m

And the Height of the frying cylinder, h=0.3m

Therefore, the volume V_c=$\pi r^2 h$

V_c=$3.142 \times 0.35^2 \times 0.3 = 0.12m^3$

Therefore, the volume (v) of the frying chamber is $0.12m^3$

2.5.2 Volume of cassava mash

The cassava mash in the frying cylinder is two-third the volume of the cylinder for optimum performance of the gear motor, (Felix and Iweke, 1989).

Therefore, the volume of the cassava mash is as follows:

$$Vm = \frac{2}{3} V_c$$

Where V_m = volume of mash in the cylinder

And V_c(volume of the frying chamber) isV_c= $0.115m^3$

Hence, $V_m = \frac{2}{3} \times 0.12$

Therefore, $V_m = 0.077m^3 \approx 0.1m^3$

2.5.3 Mass of cassava mash in the cylinder.

Since density is ρ=$\frac{m}{V_m}$

And the density of cassava mashρ_c=$1509kg/m^3$ (A. Gevaudan*et al* 1989)

Volume of the frying cylinder is $V_c = 0.115m^3$
Therefore, the mass of the cassava mash is $m_c = \rho \times V_m$
m=1509× 0.115, m= 174.3kg

2.5.4 Permissible mass of cassava mash to be charged into the frying chamber.

Two-third of the total mas of the cylinder is adopted according to (Felix and Iweke 1989). Therefore,
$m_m = \frac{2}{3} \times m_c = \frac{2}{3} \times 174.3 = 116.2kg \approx 116kg$

2.5.5 Heat generated for the drying

Since, $Heat\ Q = MC\Delta T$
Where, M= mass of cassava mash in the cylinder
And C = Specific heat capacity of mash= $1.598J/kg^oC$ (FAO, 2000)
But, ΔT = Temperature ranges from 25°C-95°C (required to fry cassava mash at ambient temperature).
Therefore, $Q = MC\Delta T$
$Q = 116.2 \times 1.59 \times 70 = 12933.1W \equiv 13kW$

2.5.6 Exposed area of cassava mash for heat absorption.

Using Fourier's law of heat conduction,
$$Q = \frac{KA(T_2 - T_1)}{L}$$
Where, K = Thermal conductivity of mash = 0.2 (A.S Oyerinde, 2016)
A= surface area of the frying cylinder
T_1= temperature change = $95^oC - 25^oC$ (95°C is the steaming temperature of the mash)
T_2=95^oC. Therefore $\Delta t = 95^oC - 25^oC = 70$
L= Thickness of the mash in the cylinder = $0.3m$
Area of the mash in cylinder is derived from area of a cylinder,
Thus,A=$2\pi rh + 2\pi r^2 = 2 \times \pi \times 0.35 + 2 \times \pi \times 0.35^2 = 1.3352m^2$
Therefore, Q= $\frac{0.2 \times 1.33 \times 70}{0.3} = 66.1W/m^2$
Relating the heat transfer rate of the mass of the cassava mash to be dried with time Δt.
Where $\frac{\Delta Q}{\Delta t} = \frac{\Delta M l_h}{\Delta t} = 66.1W/m^2$
And, L_h= Latent heat of transformation
Also, $\Delta t = \frac{Q}{m} =$ time required to dry the mash
Therefore,$\Delta t = \frac{Q}{m} = \frac{12933.1W}{66.1} = 195.7secs$
The total time required to fry 116.2kg of mash is: 195.7 X 116.2= 22735.6secs.
≈22736secs.
Converting the value in seconds to hours, $\frac{22736}{60 \times 60} = 6.32Hr$
If the frying pan is filled with 116.2kg of cassava mash, it will take one hour twenty minutes (6hr 20 min) to produce a well refined garri of about 11% moisture content.

2.5.7 Determination of the power required to convey the cassava mash

Since, $P = \frac{W}{t}$, where, W= work done, and t= time
Therefore P=$\frac{F \times S}{t} = F \times V$
But torque (T) = F× $r, therefore\ F = \frac{T}{r}$
In angular displacement, v=ω× r
Therefore, P=$\frac{T}{r} \times \omega . r = \omega . T$
If speed N= 70rpm (Value of 70rpm is the maximum attainable number of rotation of the electric motor).
Angular displacement of the motor shaft:
$\omega = \frac{2\pi N}{60} = \frac{2 \times 3.142 \times 70}{60} = 7.3rad^{-1}$
T= required torque= F× r
D=diameter of shaft→0.03m
If diameter is 0.03m, therefore radius is:
r=$\frac{D}{2} = \frac{0.03}{2} = 0.015m$
The torque can be obtained from the following relationship.
$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$
Therefore,
$$\frac{T}{J} = \frac{G\theta}{L}$$
Where, T= Torque, Ө= Angle of twist, G= Modulus of rigidity of shaft, L= length of shaft,
J= Polar moment.
Therefore,
$$T = \frac{JG\theta}{L}$$
But J=$\frac{\pi d^4}{32}$, (two moment of inertia, 2I)
J= $\frac{3.142}{32} \times 0.03^4$
J= 7.95×10^{-8}
And G, (Modulus of rigidity of mild steel shaft)=78Gpa
$\theta = twistingmoment\ 2 > x < 5(thus, \theta$ =2 is the minimum twist the shaft could accommodate while θ =5 is the maximum value the shaft can accommodate before fracture).

$$\theta = \frac{2+5}{2} = 3.5$$

$$T = \frac{JG\theta}{L} = \frac{7.95 \times 10^{-8} \times 3.5(78 \times 10^{9})}{0.06}$$

$$= 361725N/m^2 \equiv 361kN/m$$

Thus, P=ω×T

P=7.3× $361 = 2640.0\ kW$

2.5.8 Shear stress (τ) experienced by the shaftwhen working

Where shear stress is illustrated as$\tau = \frac{16T}{\pi d^3}$

Therefore,$\tau = \frac{16T}{\pi d^3} = \frac{16 \times 361725}{3.142 \times 0.03^3} = \frac{5787600}{0.0001234} =$ $46.8G\ N/m^2$

Thus, $\tau = 46.8\ GN/m \approx$

2.5.9 Force required to overcome the inertia of the cassava mash in the cylinder.

From formula for friction, F_r= μN

Where, μ =Coefficient of frictionof the cassava mash $=\ 0.47$ (A.S Oyerinde, 2016)

N = Normal force acting on the mash

F_r =Frictional force experienced in packingthe mash, $N =\ Mg$

Where, g is acceleration due to gravity

g= $9.81m/s^2$

$N =\ 39.7\ X\ 9.81\ =\ 389.46N$

F_r= $0.47\ x\ 389.46\ =\ 183.045N$

2.5.10 Determining the factor of safety

This is considered to be calculated since there could be some unanticipated loads that may affect the operation of the machine. This includes wasted power or inertia causing the machine to slip out of the place.

Most documented value for motor selection guide state that in engineering design, safety factor of between 1.2 to 2.5 is appropriate considering the load and the safety of the operator.

2.5.11 Throughput capacity

With the heating element .5kg of cassava mash with 40% moisture content was dried after 60secs and the final product gives 4.55% [partially undesired output] 5kg−4.15 = 0.85($undesired$). $5kg$of cassava was dried manually at same moisture content after 80secs and give 3.6kg approximately.

5kg−3.6kg = 1.6kg .[desired output]

2.5.12 Efficiency

With respect to the above values,

therefore, efficiency(η)= Output×100= $0.85 \times 100 =$ $85\% efficiency.$

Thus, $\eta = 85\%$

Interpolating to determine the throughput capacity

Through put capacity is 0.85 at 60secs;

Therefore, 0.85= 80

X= $3600(1hr)$

0.85×3600= $80 \times X$

3060= $80X$

X= $\frac{3060}{80}$ =38.3kg/hr

Therefore, throughput capacity for eight working hours is 38.3× $8 = 306.4$ kg

This implies that 306kg of garri would be fried in permissible 8 working hour.

2.5.13 Determination of the shaft stirring force.

using the following relation:$\frac{N_1}{N_2} = \frac{d}{D}$

Where $N_1 = speedofthedrivingshaft$ which is 70rpm

And $N_2 = speedofthedrivenpaddle$ which is unknown

$D_1 = diameterofthedrivenpaddle$ which is 70cm

$D_2 = diameteroftheshaft$ which is 30mm

Therefore, $N_2 = \frac{70}{N2} = \frac{30}{30} = 70$

Meanwhile, converting the speed to rpm. $\frac{w\pi}{60} = \frac{2X\pi XN}{60} = 7rad$/s

V= $r \times \omega$ ($angularvelocitytolinearvelocity$).

r= $radiusinmeter.$

ω= $angularvelocityinrad$/s

Therefore, velocity V= $0.15\ X\ 7 = 1.05m$/s

Since, force= $\frac{power}{velocity}$

Therefore force (F)= $\frac{1X746}{1.05} = 497.3N\ \equiv 0.5$ kN

Therefore, the paddle moves at 70rpm with a force of 497.3N

2.5.14 To determine the element energy consumption.

The power rating of the element is 5KW and operated with 240V the resistance of the element is R=PI^2 (Tontechnik-rechner).

To calculate our resistance, the current is needed to be determined

I= $\frac{P}{V} = \frac{5000}{240} = 20.83A$
If I=20.83A, and P=5000W,
Therefore,
R=P$I^2 = 5000X20^2 = 2000000\Omega = 2000k\Omega$
The energy consumed by the element in 10mins is

$$E = \frac{V^2}{R\,X\,t} = \frac{240^2X10X60}{2000} = 17280J \approx 17.3kJ$$

Therefore, the energy consumed in eight (8) working hours is $17.3\times 8 = 136kJ$.
From the above analysis, the unit of energy consumed per day could be gotten

2.6 HUMAN FACTOR IN CONSTRUCTION AND SAFETY

Due to the available resources on ground during the construction, some 1anufacturing defects have been incurred such as losing of generated heat to the environment which proves to reduce drastically, the total time of frying the garri mash.Materials for lagging are not in place during the coupling section which means that the hollow space between the main body mild steel and the stainless steel for the frying pan were not lagged to reduce the temperature of the machine body.The implication of this is that the machine may prove to be extremely hot when used continuously. But, a cooling fan is in place to compensate this flaw by relieving the degree of hotness of the body of the machine.More so, it is designed to be operated indoor that is the reason why the frying chamber is not covered.All these aforementioned production flaws are thereby subjected to developments as this is just a pathway to improving the technology of garri production although; the machined is tested to operate with desired output.

Incorporating mechanical and electronics technology (mechatronics) to achieve an improved method of frying garri to minimize human stress and health hazards is achieved at the end of the construction.

2.7 HEALTH

The healthy living of the citizen in relation to their consumption of food is very vital to the food processing companies and food production regulation agencies. Nevertheless, an engineer is also concern about developing safe devices and machine to facilitate the production of food with the appropriate engineering materials which will not be hazardous to the healthy living of human and animals.

These points were also considered during engineering material selection to suit the design of the machine. This includes consideration of effect of corrosion on the human body among others. Appropriate materials are assumed to be selected for the construction. Garri production involves generating heat to reduce the moisture content of garri from about 50% to about 12% as considered to be healthy for consumption. With the conventional method of frying in the village, the production is subjected to great hazards of contamination and poisoning if sweats and other objects are allowed to be trapped in the frying chamber. Although the process involves heat which may kill any germ of bacterial but meanwhile, some bacterial grows and survives at even a high temperature.

2.8 SAFETY PRECAUTIONS

We recommend the following safety precautions be observed when using or operating the machine:

- The machine must be operated by a technical know-how.
- The machine must not be operated in the rain or muddy place.
- The operator is advised to use a proper hand glove while operating the machine.
- The control panel is programmed based on calculation to control the machine operation; it must not be tampered with as this may lead to break down of the control unit.
- The machine must not be operated by kids in no circumstances.
- The machine could burn an improperly wired domestic installation due to power consumption.
- The machine should not be used with small capacity generator sets meant for domestic purposes.
- The machine should be used with a 3-phase electrical outlet.
- The electrical element must not be tested working with bare hands for risk of electric shock and electrocution.

2.9 DESCRIPTION OF MANUFACTURING PROCESS

A Mild steel of 4milimeter thickness, length of 2420milimeter and breath of 1220milimeter was rolled to form a cylinder shape which will house the frying chamber, alternative current element, electric fan and discharge outlet. The gear is mounted on the surface of the U channel mild steel; other driving gear was attached to the shaft stirring the sieved cassava was fixed to mesh with other gear rotating by the electric motor. The electric motor is bolted on the motor base pointing upwards. The rotating shaft and paddle are connected to the electric motor through a system of pulley and gear meshed together. The motor base is welded on the body frame of the machine maintaining a height of 310mm from the frying pan to the electric motor. The frying pan is located under the paddle with a diameter of 710mm. The heat chamber is located under the frying pan. The space between the inner wall of the frying pan and mild steel is insulated using fiberglass to prevent heat loss and conduction through the body of the machine. The system is enclosed by the body base stand from the edge of the frying pan. A ceramic temperature sensor is connected inside the base stand to compare the temperature or heat around the heating chamber and heat change of the system to the calibrated temperature gauge at the control panel. The control panel is located at the right-hand side of the machine for easy operation. The fan is located at the base of the machine to blow the heated element.

Table1.2: Materials used for the full construction of an industrial Garri frying Machine.

S/N	Name	Engineering Materials used
1	Frying pan/chamber	Stainless steel
2	Discharge port	Stainless steel
3	Motor frame	Mild steel
4	Electric motor	Cast iron with copper windings
5	Bolts	Mild steel
6	Discharge door	Stainless steel
7	Bearings	Cast iron
8	Frame support	Mild steel
9	Industrial Electric element	Stainless steel
10	Paddle and shaft	Stainless steel
11	Fan (for heat circulation)	Aluminum
12	Tyre and frame support	Cast iron and stainless
13	Control panel casing	Rubber
14	Main switch casing	Aluminum

Table 1.3: Bill of Engineering Measurement and Evaluation (BEME)

S/N	Materials	Quantity	Amount (₦)
1	Electronics components	-	16050
2	Industrial element	1 piece	3500
3	A.C fan	1 piece	1200
4	9mm electrical cable	15 yards	5000
5	1mm electrical cable	5 yards	250
6	15 amps plug	1piece	200
7	Mild steel plate 4 x 8 x 4mm	1 piece	24500
8	Electrode	1 pack	2000
9	Tungsten electrode	25 pieces	2500
10	U-Channel 8mm x 18 inches	1 piece	12000
11	Marble chalk	3 pieces	300
12	Iron rod 16mm	1 piece	3900
13	Cutting disk	4	2400
14	Grinding disk	2	1500
15	Stainless steel plate 6 x 4 x 1.5mm	1 piece	25000
16	Tyre	4 pieces	5500
17	Bearing	1	2500
18	Gear motor	1 piece	28000
19	Shaft	1	2000
20	Bolts / Nuts	12	600
21	Body filler	-	1100
22	Processed Cassava	-	1000
23	Spraying	-	2300
24	Hinges for element door	2 pieces	400

25	Programming of microcontroller	-	3000
26	Transportation	-	31930
27	Saw blade	1 piece	300
28	Miscellaneous	-	42070

Sub total	221,000
Grand total	221,000

III. RESULTS AND DISCUSSION

We were able to achieve at the end of these production process, a well refined garri which is edible for consumption. This is achieved by painstakingly going through series of processes which involves machine of the shaft used on the lathe, fabrication of the frame, body among others.

3.1 Results

The cassava mash used in determining the working principle of this machine is based on the already published sentences below. The cassava mash used in testing this machine was collected and processed at Oye-Emene, Enugu. Other experiment and tests were carried out in the Department of Agricultural and Bio-process Engineering laboratory. Samples of cassava mash were tested at different moisture content. The moisture content was determined using gravimetric method, by placing the grit sample in the oven and heating it at 110^{0}c, for 8 hours (ASAE, 1990). Though, we tested this machice flexibility and compatibility with other standards of its kind with a cassava mash gotten from Odofufu in Ilaro, Ogun State.

Table2.1: Samples of cassava mash at 40% moisture content.

Sample	Initial weight of mash (kg)	Initial temp (^{0}c)	Motor time (min)	Middle temp (^{0}c)	Motor time (min)	Final temp (^{0}c)	Motor time (min)	Final weight of product (kg)	Moisture content of product (%)
Batch A	3	70	3	80	3	100	4	2.25	12
Batch B	2	70	3	80	3	100	4	1.2	11
Batch C	1	70	3	80	3	100	4	0.5	10

Table 2.2: Samples of cassava mash at 45% moisture content.

Sample	Initial weight of mash (kg)	Initial temp (^{0}c)	Motor time (min)	Middle temp (^{0}c)	Motor time (min)	Final temp (^{0}c)	Motor time (min)	Final weight of product (kg)	Moisture content of product (%)
Batch A	3	70	3	80	3	100	6	2.15	12
Batch B	2	70	3	80	3	100	6	1.0	11
Batch C	1	70	3	80	3	100	6	0.5	10

After the entire constructional proceedings in the improvements on the construction of this more economic friendly machine, and undergoing a working test running to be sure of its accuracy, we were able to produce a very fine and refined garri produce which is welcoming and attractive in the colour, uniformity and other qualities of a good garri.

The already constructed machine in other parts of the world was thoroughly studied and with these, an improvement is being undertaken in a more robust semi-automatic garri fryer for industrial production of garri in a shorter time consideration, it is semi-automatic in the sense that the discharge is the done by the machine operator, besides that, the temperature device incorporated with relays in the control panel carries out the remaining machine operation. Production of garri is a lengthy process which undergone certain stages from the raw materials stage which is includes: peeling of cassava, washing of the peeled materials, grinding and pressing. The longer the days used in pressing the higher the fermentation rates.

But for healthy purposes, it must be well fermented to get rid of potassium cyanide a water soluble poison. After which sieving is done to the cassava mash produced before it is fully ready for frying.

In achieving our aim in the construction process, it was observed that the garification is achieved at a constant and maintained temperature difference, which does not exceed 90°C. this temperature is monitored by the preprogrammed microcontrollers to ensure the r does not cake or burn during the frying process. The taste of the produced garri could be enhanced also by adding proper amount of palm oil to the frying pan according to the quantity of the garr5, this is meant to also increase the nutritional values of the final garri produced

RESULTS AND DISCUSSION

Various quantity of cassava grits was employed with slight differences in the moisture content. These samples are taken for the reason of determining the best garri with the specific moisture content after finishing the sampling process. With three quarter of the earth crust been covered with water, it is no news that almost everything we touch or eat has some water contents. It is better to study the accurate measurement of water content in every aspect of food production as these constitute the overall quality of the food and shelf life. Important it is also to every owned business private, or government establishments who produces food to be able to give the nutritional values of the foods, and also regulates the level of presence of moisture in the food because it may ruin businesses if food got spoilt in very short time. due to too much moisture in the food.

With us paying good cognizance to the above-mentioned points, it is also mandatory for us to deter the moisture contents of the three different cassava grits gotten from the said location.

There are six methods for determining moisture content of a non-absolutely soluble liquid. (John bogart).

These processes include: primary and secondary methods

Primary methods:

- LOD (Loss on drying)
- Karl fisher moisture measuring method

Secondary methods:

- Microwave moisture method
- Electrical moisture meter
- Near infrared moisture meter.

The method implored in our own determination is the easiest and affordable of all is the LOD (Loss on drying) as it is the most widely used test of moisture presence. A high temperature oven with continuous weighing of samples is optimized for sampling techniques. After the testing procedures, it was observed that the best quality produced cassava mash for frying must be total fermented during the pressing stage and the moisture content approximately to be 40%. And our refined creamy white partially gelatinized roasted free flowing granules was observed to best befitting at 11% moisture content. The three samples hovers along a moisture content 0f 11%-15%.

The other two samples are also good for consumption based on the laid down theory by chemistry experts, they could all be safely stored in a permitted storage system for as long as seven months. The garification process is closely monitored by the programmed microcontroller used (PIC 16F690).Because the efficiency and quality of the final product relies on the ability of the controller and the operator to control and vary the speed of the gear motor between a ratio of 1:15 and regulate the temperature of the garification process. Also, extra care proper care must be taken in this machine, because, the heat element may prove dangerous when operated badly out of specification. This may cause electric shock and electrocution. It is not like charcoal or gas fired sources of heat. The cyanide level of 0f 20mg of Hcn/Kg by the SON (Standard organization of Nigeria) must be adhered to in frying garri to avoid inflicted food poisoning to the society.

CONCLUSION

Automated Mechanised cassava mash processing machine was designed, constructed, tested and analysed. Garri frying is not a straight forward frying operation, but it needs a good understanding of the factors that affect the quality of the final product. Human factors and ergonomics are considered and the quality of the material needed are careful selected. The garri frying machine was observed to perform efficiently at a faster speed of about 72% when compared with local method of frying sieved cassava mash. However, the highest frying efficiency of 75% was obtained at frying speed of 20rpmin 10mins to reduce the moisture content from between 40-50% to 10-12% moisture content. The best product is obtained from the village technique. Based on that, this machine followed the principles and techniques of village method. It was discovered that frying depends on factors such as temperature (heat), moisture content of the mash, and turning of the cassava mash. The tests performed on this machine proved its standard in terms of producing good quality and light efficiency.

RECOMMENDATIONS

The capacity of this machine can be improved by increasing the volume of the frying chamber and proper lagging of the cylinder. This will lead to production of large quantity of the product.The speed of the motor can be reduced or increased. To obtain a product of better quality, the cassava should be relived of moisture to 40% moisture content, before sieving and frying. It is also good to add few drops of palm oil to the cassava mash to increase the nutritive value of the garri. Palm oil contains vitamin A, which is good for the eye.

Government should also do more in assist small and medium scales enterprise (SMEs), by organizing sufficient training and also loans with low interest generation and also with the help of bank of industries, in order to help them purchase machines to facilitate the production of gari, in order to allow them mechanize the entire process there saving cost and reducing production fatigues. Provision of necessary infrastructures such as electricity, water, accessible roads and technical schools in rural areas.

Adequate training on the use of modern machines and technology should be given to machine operators by relevant agencies. This will enable them to increase the production of garri and speed up the production processes, in order to be able to meet the demand of garri by the entire populace.

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