JOURNAL OF ENGINEERING AND EARTH SCIENCES

JEES ISSN: 1897-8680
JEES 2023
VOLUME 16 ISSUE NO 1
PAGE 39 - 45

DESIGN AND FABRICATION OF ELECTRICALLY CONTROLLED GARRI FRYING MACHINE

*,[1]Fatona, A. S., [2]Ojaomo, E. K., & [3]Obaleye, A. A.
[1,2 & 3] Department of Mechanical Engineering, Federal Polytechnic, Ado Ekiti, Nigeria
Corresponding author: awariolakunle@gmail.com

ABSTRACT

The most critical unit of Operation while processing cassava into Garri is the Garri frying which occurs as a result of the simultaneous cooking and de-hydrating of the moisture content by the application of heat. Traditional methods of frying Garri had been established to have been exposing the fryer to various health disorders. This work highlights the design of an electric Garri frying machine which will help to alleviate these health disorders by making Garri frying appealing to the farmers and hygienic for consumption at our various homes. The machine was designed, fabricated, and tested with the initial temperature of 70 ℃ to dry samples of Garri of the initial weight of 2.05kg while varying the time of drying between 14 minutes and 6 minutes at a reducing step of 2 minutes. The result shows an increase in the weight of the Garri which changes between 1.1 kg to 1.8 kg as the drying time reduces therefore showing a higher dehydration value at higher temperature. It was discovered that, with the use of this machine, a continuous operation can be performed with a regulated temperature mechanism to produce smooth, quality, and large quantities of Garri at a reasonable time compared with what is obtainable with the use of the traditional method.

KEYWORDS: Garri; Frying; Electrical; Heat; Machine

INTRODUCTION

Garri is a processed fermented product from cassava and is consumed in Nigeria as well as in most countries on the West African coast and in Brazil. Garri production is a dehydrating process that combines cooking and drying operations but the drying process is the most critical unit operation in processing cassava to Garri because it is not a straightforward drying process (Igbeka, 1995). The heat intensity during frying does affect the quality of the product and at the end of the frying operation, the product is still hot and a little bit damp, which is then left to cool and dry under a cool dry shade until the moisture content is reduced to about 12 %. The process of frying Garri makes the product safe for human consumption. The heat supplied for this process helps in destroying the hydro cyanide acid, thus reducing its content in cassava mash and also reducing the moisture content of cassava in Garri to a safe level for storage and for human consumption. Traditionally, Garri is fried in shallow iron pots, or the traditional earthenware pots, over an open wood fire on mud-constructed support for heat insulation (Igbeka et al., 1992). Garri is fried mainly by women in shallow earthenware or cast-iron pans over a wood fire. The operator sits sideways by the fireplace while frying and this brings discomfort due to heat and the sitting posture. Thus, there arose the need for innovations and improvements to ameliorate the problems encountered during the process. Also, while frying, a piece of calabash is used to press the mash against the hot surface of the pot which must be scraped quickly and stirred constantly to keep the material moving to prevent it from burning until frying is completed. The process takes 30 – 35 minutes, with the moisture content of the final product reduced to about 18 % making commercial production difficult. To produce Garri at a fast rate and eliminate the problems posed by this traditional method, there is a need for a mechanized continuous process fryer. However, earlier designs on Garri production plants did not produce the desired and acceptable cassava product for the consumers, because the designers of those plants did not take into account the specification of the existing local technology, inspired researchers (Codex standard 151, 2013). A mechanized system of frying and drying usually appears in the form of a stainless-steel drum with a rotary conveyor and paddles fixed along the conveyor to a slower rotation in the same axis of the drum.

Traditionally, women use spatula-like paddles of wood or calabash sections 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 has been of concern to researchers. Therefore, the University of Ibadan came up with an improved Garri fryer which was made of a fireplace oven with a chimney and a frying pan (Igbeka, 1995). The frying pan which is 200 cm x 60 cm x 10 cm was designed to have a trapezoidal shape with its side inclined at 60° to the horizontal. The inclination of the sides allows for a gradual gravitational flow of Garri down the sides of the fryer. It is made from a 4mm thick black steel sheet, which is not easily corroded and does not turn black after heating. The frying pan has an opening or chute on one side for discharging the finished product into a receiving pan. The frying pan sits on a rectangular or semi-circular fireplace built of clay which is 60 cm high and has an opening on one side of the breath or width from where firewood is fed into the oven, while the other width carries the chimney. There are two small ventilation openings on one side of the length. The wall thickness of the fireplace is 22.5 cm and the effective volume of the heating chamber of the fireplace is 0.72 m^3. It can use up to 20 kg of wood as a source of heat. The structure is housed under a shed made of corrugated iron sheets.

The fryer is operated by two people sitting on both ends of the fireplace without ventilation. Field tests amongst Garri producers showed that the improved models had the following advantages over the village fryer: The nuisance of smoke was eliminated.

Sweating by the operator was drastically reduced as a result of the improved fireplace. The capacity and rate of frying were increased, for instance, 5 kilogram dewatered and sieved mash took 20 minutes to fry as opposed to l hour, and improved working environment.

Few mechanized Garri processing plants in the market are performing well with regard to the quality of Garri produced. As a result, some new designs and improvements have been made by engineers and manufacturers to solve the problems associated with the models already in the market.

Newell Dunford Company in London jointly designed a model with the Federal Institute of Industrial Research (FIIRO), Oshodi in Nigeria. It is a Garri-producing plant of which the fryer is just one of the components. In the frying section, heat from a gas fire is controlled and regulated by thermostats at various points in the process. The fryer structure is circular stainless steel, heated from the outside with the fryer's curve linearly lined internally. The fryer containing the sieved dewatered cassava mash is rotated in such a manner that the mash granules agitate against the sides of the fryer and move along the paths of the line curves which results in roasting. The product obtained with this model was not very acceptable to the consumers because it did not have the basic characteristics of Garri (Olukunle & Atere, 2009).

The Brazilian model fryer consists of a semi-circular steel plate and operates on a batch process drying. Atop the plate is a large ring gear mashed to an inner annulus which is connected to a vertical shaft with large steel paddles. A specific batch of sieved cassava mash is dropped into the circular plate and the eccentric paddles shift the mass circularly to produce a dry product. An automatic gate is opened at the side of the plate and the dried product falls into a funnel by gravity. This model designed and manufactured in Brazil, seems to be better than the Newell Dunford model and the product obtained from it is similar to Garri in Nigeria, even though it is not the same. In this model, frying was not evenly spread within a given batch and the product looked more like dried cassava mash than cooked and fried Garri (Akinyemi & Akinlua, 2009).

The Fabrico model is a simple continuous process plant and consists of a semi-circular steel plate with rotating paddles. The paddles are eccentrically located in such a manner that their motion compels the frying Garri granules to move from one end of the plate to the other. Drying occurs during this period. Heat is supplied by either wood or gas burners. This model which was designed and manufactured by a Company, FABRICO, in Nigeria, produces an end-product that is closer to Garri that is taken in Nigeria but the product was not cooked and looked more like roasted Garri. This model has been improved upon by the University of Nigeria Nsukka, and the University of Ibadan (Olukunle & Atere, 2009).

The University of Nigeria, Nsukka (UNN) model designed and faithfully simulated the village manual frying operations (Odigboh, 1983). The equipment has a semi-circular 1.7 m long frying trough of 57 cm diameter mounted at an inclination variable from 0 to 20^0 to the horizontal. Sixteen spring-loaded paddles are attached to a 1.75 m long shaft also mounted axially in such a way as to locate the paddles inside and in permanent contact with the trough. The paddles overlap and are angled relative to the axis of the trough to act as a sort of conveyor. They are driven by an electric motor through several speed reducers and linkage arrangements. As the gang of paddles oscillates through 1800 at 40 reversals per minute sieved cassava mash is automatically metered into the trough, once in a cycle of the to and fro motion. Swinging in one direction, the paddles press the mash against the hot surface of the trough while in the opposite direction, they scrape, stir, and move it slightly forward to the exit end of the trough. By appropriate adjustments of the trough inclination, the quantity of mash metered, and the heating rate, the fryer operates automatically to produce a continuous flow of well-fried Garri at 15% moisture content. An average throughput of 66kg of Garri per hour has been reported for this equipment (Odigboh, 1983).

Igbeka and Akinbolade (1986) stated that the UNIBADAN model was designed and manufactured at the University of Ibadan as a continuous flow fryer which is an improvement and modification of the UNN model, hence a modified version of the Fabrico model. The basic differences are in the feeding device, the heat source, and the arrangement of the paddles. The

UNIBADAN model is made up of a fryer plate, feeding hopper, power transmission devices, and shaft with paddles, pulverizers, and an oven on which the fryer sits. The fryer plate, like in the UNN model, is a semi-circular trough open at the top and both ends. It is inclined at an angle of between 5 and 180 with a length of 2.44 m and a diameter of 0.67 m. The hopper contains a metering device which is one of the basic innovations in the design and the rate of metering is crucial to the quality of the final product (Igbeka & Akinbolade, 1986).

Another innovation in this model is in the paddles. Instead of just paddles, as in the UNN model, the central shaft has 28 paddles and pulverizers arranged in such a way that they have a conveyor effect at the same time as they press scoop and agitate. The pulverizers press the sieved cassava mash against the hot pan surface while the paddles scoop and agitate it. The oven is built with red oven-dry bricks and has air vents at specific points and uses wood or coal as fuel. The vent openings can be reduced or increased according to the heat requirements. The power supply to the fryer could either be a petrol engine or firewood. Field tests using this model showed that the final product was acceptable to the public. At 15 rpm, the capacity was 80 kg/hr of finished product (Igbeka & Akinbolade, 1986).

The frying machine produced with this research is fired using electricity with a thermostat connected to regulate the heat required for the process to avoid overheating. The system also provided for the adjustment of the intensity of the fire using the timer regulator.

MATERIALS AND METHOD

Parts and Theoretical Framework

The major components/parts of the machine include Frame support, Heating chamber, Electrical heating element, Frying trough, Discharge funnel, Paddles, Digital thermometer with sensor, Thermocouple, Electrical switch, Electrical control knob, and Electrical contractor.

Design calculation for parts and heat requirement for the project designed volume (V)

Given: Length, l = 490 mm, breadth b, = 100 mm, thickness, t = 4 mm

V =0.000196m^3, Density = 7800**,** m = 1.529kg, Weight = 15N

Determination of stand weight

Length (l) = 500mm, breadth (b) = 100mm, thickness (t) = 4mm

v = volume, m = mass, w = weight, g = gravity

v = 2.24 X10^{-4} m^3, m = 1.7472kg, w = mg = 17.14N

The number of Stand is 4 Pieces

Platform = 4(15) = 60N

Stand = 4(17) = 68N

Determination of heat requirement for the system

The heat requirement for the system was determined using equation (1) below

H = IVT, (1)

$Q = \frac{H}{t} = IV$ (2)

The heat from the electrical heating element, Q = 1000W

Change in temperature

Change in temperature in both the plate and the clay is calculated 399.16K using the following parameters and equation

Area (A) = 774,400mm^2 = 0.7744m^2, and Coefficient of heat transfer (k) = 50w/mK

Change in temperature (δT) = 0.08^{0}C =272.08K

$Q = \frac{KA\delta T}{\delta x}$ (in plate) (3)

δT = 0.08^{0}C =272.08K

$Q = \frac{t_{o-t1}}{\frac{K_1\ A1}{X1}+\frac{K2\ A2}{X2}} = \frac{t_{o-t1}}{R_1+R_2}$ (in clay) (4)

$\delta T = t_o - t_1$, $Q = 1000W$

$\delta T = Q(R_1 + R_2) = 126.16^oC$

$\delta T = 399.16K$

Determination of convective heat transfer

Convective heat transfer was determined using equation 5 as follows

$$Q = hA(\delta T) \quad (5)$$

$Q_{conv} = hA\ (Ta - Ts)$

Ts = Surface temperature, Ta = Temperature of the surrounding of the fluid,

A= Area, and h = convective heat transfer coefficient

$\delta T = \frac{Q}{h_{1\ A}} = 51.65^oC = 324.65k$

The temperature gradient was also determined to -26^oC be using equation 6

$$\frac{\delta t}{\delta y} = -\frac{Q}{KA} \quad (6)$$

RESULTS AND DISCUSSION

Testing

The following components were incorporated into the Garri frying system to make heat distribution easy and controllable: Element Contactor, Temperature Controller, and Thermocouple. The heat content and distribution were tested with a thermometer.

Result

The drying efficiency which is the degree of dryness of a given quantity of Garri produced from the frying machine was determined by setting the machine to an initial temperature of 70^0c at which the heating of Garri commences and it was done for various heating times of 14 minutes, 12 minutes, 10 minutes, 8 minutes and 6 minutes while the initial and the final measurement of the weight of the Garri were taken as shown in table 1 below. It was observed that the thermostat was used to cut off at a temperature of 110^0C when the machine had an initial temperature of 100^0C and moved back to a temperature of 90^0C before picking back to increase the temperature again.

Discussion

It was discovered that with an equal quantity of Garri which is 2.05kg and varying the heating time from 14 minutes on a reduced graduation of 2 minutes to the time of 6 minutes having maintaining the same initial temperature, the weight of the Garri increased from 1.1kg to 1.8kg showing a higher dehydration value at higher temperatures. The Garri Frying Machine has a high degree of productivity when compared to the local method used for Garri frying. Taking the sample weight of 2.05kg Mash into consideration, it was discovered that such weight of mash normally takes between 25 to 30 minutes to complete the frying process with the use of the conventional drying method. This Garri frying machine is designed to produce 20kg of Garri per hour which is of higher productivity when compared to the local or conventional method of Garri frying which cannot produce more than 12kg per hour.

Also, this machine is human-friendly because it does not emit smoke which is a major problem when using the local method. This Garri frying machine has one essential characteristic which is that it can engage or disengage the element with temperature change.

CONCLUSIONS AND RECOMMENDATIONS

Garri frying is an arduous and intricate operation that is not a straightforward frying operation but that needs a good understanding of the factors that affect the quality of the product. The best quality Garri up to date is obtained by the village technique but it is time-consuming and leads to health hazards for the operator.

Development in the processes and equipment has been more on the accurate simulation of the village technique. It has been stated that in developing this mechanized Garri fryer the following features were considered as basic requirements.

i. A continuous operation leading to mass process production of moderate capacity
ii. A regulated temperature mechanism that ensures simultaneous cooking and dehydration, without roasting to a desired moisture content after a specific period
iii. A mechanism that provides both stirring and lump-breaking action so that uniform cooking dehydration in the entire mass is ensured and the desired texture is produced.

An arrangement of paddle produces a stirring effect which will give the product a forward and backward movement during the process. In putting these basic requirements, this prototype has been designed to ensure that the project achieved the goal that using an electric fryer is better, healthier, faster, and neater than the modern method we are used to.

Recommendation

This prototype design is expected to mass produce good quality Garri at moderate capacity and low cost. Though its installation cost is high, this is duly compensated through its extremely low operating cost over a long period. However, efforts should be made to adapt this prototype for large-scale processing of Garri.

REFERENCES

Akinyemi, J. O. & Akinlua, (1999). Design, construction and testing of Cassava Grater. *International Journal of Tropical Agriculture, 17*(1 - 4), 103 - 108.

Association of Official Analytical Chemist, AOAC (1990). Official Method of Analysis.15th edition. Association of Official Analytical Chemist, Washington DC, USA. 95-224.

Codex Standard 151 (2013), Codex Standard for GARRI. Adopted 1989. Revision 1995. Amendment

Igbeka, J. C. (1995). Recent developments in cassava frying operation and equipment used for gaari production in Nigeria. *Transformation Alimentaire du Manioc*, 582-593.

Igbeka, J. C. (1988). Feasibility study on the establishment of a cottage-level Garri processing industry: Unpublished.

Igbeka, J. C., & Akinbolade, J. A. (1986). The development of a continuous flow Garri. Kenya, *International conference NSTI- UNESCO;7,* 246 - 256.

Igbeka, J. C., Jory, M., & Griffon, D. E. (1992). Selective mechanization for cassava processing. *Journal of Agricultural Mechanization in Asia, Africa and Latin America (AMA), 22*(1), 45 - 50.

Odigboh, E. U. (1983). Cassava production, processing, and utilization. In: Chan Jnr., H. T. (Ed.), *Handbook of Tropical Foods*. New York, USA: Marcel Decker Publisher Incorporation, 145-200.

Olukunle, O. J., & Atere, A. O. (2009). Developments in cassava peeling mechanisation. *Proceedings of the International Conference of the Nigerian Institution of Agricultural Engineers, West African Society of Engineers, held at Obafemi Awolowo University, Ile–Ife*

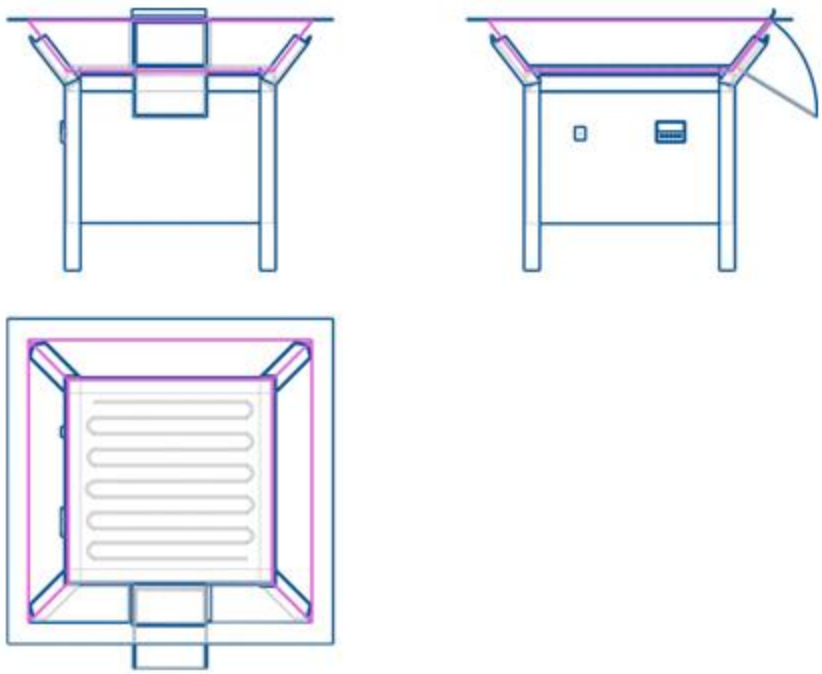

Figure 1. Orthogonal view of the machine

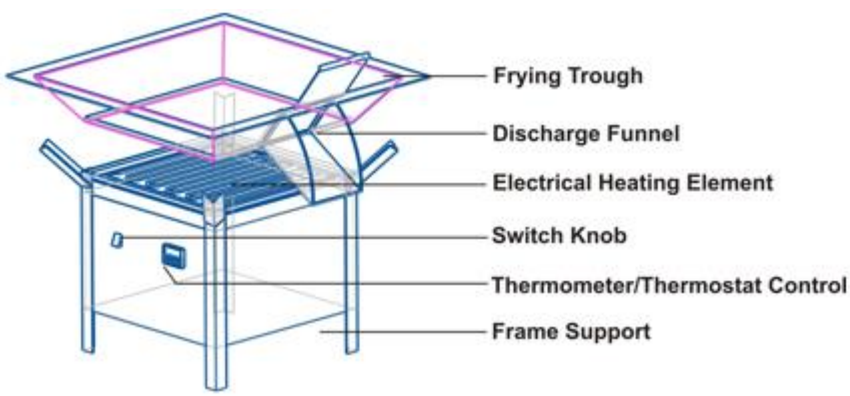

Figure 2. Isometric view of the machine