Original Article

OPTIMIZED DESIGN OF AN AGRO-PROCESSING PLANT FOR RIPE PLANTAIN CAKE PRODUCTION

Ibrahim Olufemi Akinlade

Department of Mechanical Engineering,
Federal University of Technology Akure,
Nigeria.
DOI:https://doi.org/10.5281/zenodo.15471204

Abstract: This study presents the design and analysis of a process plant for the production of ripe plantain cake, commonly known as dodo ikire, with a targeted production capacity of 25 kg/h. The plant is meticulously engineered to ensure efficient processing from the peeling of ripe plantains to the final frying of the product. The process flow designed includes five key sections: peeling, conveying, agitating, moulding, and frying. Each machine was designed to enable productivity and quality of the dodo ikire. The design results demonstrated that the plant meets the necessary criteria for safe and efficient operation.

Keywords: Ripe Plantain Cake, Process Plant Design, Productivity.

1. Introduction

Plantain (Musa paradisiaca) is a tropical natural product that serves as a source of staple food crop in West Africa. Plantain is one of the widely consumed foods in the world due to it nutritional benefit. With an annual production of 2.4 million metric tons, Nigeria is one of the largest producers of plantain in West Africa [60]. In Nigeria and in numerous places in Africa, plantain (Musa paradisiaca) is a significant staple food and is especially wanted for the fluctuation in the phases of ripeness and in cooking stages [72]. As a result of the great tendency for plantain to perish quickly, and relative insufficiency of processing handling, and storage equipment in many nations that grow the crops, about 5 – 50% of the crops are lost after harvesting [3, 76]. Plantain is normally processed into flour, value-added or storable products due to its perishable nature and ease of transportation from one location to another for commercial purposes [77, 82]. Although plantain and cooking bananas belong to the Musa family and are very similar to unripe dessert bananas in exterior appearance, the plantain is often bigger and less sweet compared to cooking banana [36, 38]. The frequent postharvest losses, increasing market demand for plantain and its by-products, necessitated that a plantain peeling machine be developed in Nigeria for the crop [28, 61-71]. Peeling is a vital unit process in the processing of plantain generally. The expanding market interest for plantain and its varieties of products is an indication that it is important to design and subsequently fabricate a machine for peeling plantain efficiently and effectively to satisfy this market need and to lessen or take out the drudgery involved in the peeling process [73-75, 77]. Plantains are highly perishable, with a significant proportion of the harvested crop being lost from the farm gate to the market place. This is due to poor handling, inadequate storage and transportation of the fresh fruits [83, 85]. Additionally, losses may occur in peak production periods when

©2025 AYDEN Journals

farmers do not harvest the entirety of their production because of saturated markets. Put together, an estimate of 35% loss of the production of bananas was reported for developing countries (FAO, 2006) [78-81]. Post-harvest losses are making Nigeria farmers poorer and for a very long time, Nigerian farmers have lamented the situation without getting meaningful assistance [1, 4-12]. Thus, processing activities are undertaken to provide a greater yield from raw farm produce by either increasing the amount of finished product or to improve the net economic value of the produce. The losses are favored by secondary factors resulting mainly from inadequate technology applications and quality control. A high postharvest loss caused by inadequate and inefficient postharvest handling practices is reported to be one of the major problems limiting the expansion of banana/plantain production in Africa [13-21]. Similarly, lack of postharvest and marketing infrastructures such as packaging, cold storage, prepackage and distribution, postharvest treatment and washing facilities together with production constraints are reported problems leading to low productivity and considerable postharvest loss of banana/plantain in Nigeria [22, 97]. This snack is popularly called dodo-ikire because the indigenous technology of processing this local snack originated from Ikire community in Irewole Local Government Area (LGA) of Osun State, Nigeria where the enterprise provides full time employment for both young and adult women all year round [84, 87-95]. It was originally made from leftover plantain but today, people prepare it from fresh ingredients which are: over-ripe plantains, pepper, oil and salt. Nutritionally, consumption of banana/ plantain-based products like dodo-ikire promotes weight loss in obese individuals and caters to the calorific need of many developing countries [41-43, 52]. Despite the growing interest in plantain-based products, there is a lack of literature on the process plant design for the production of dodo ikire. This gap in knowledge makes it difficult for entrepreneurs to invest in the plantain processing industry, especially in the Akure South local government of Ondo State [29-35, 44]. Moreover, the few available studies on plantain processing focus mainly on the proximate and functional properties of the flour [40, 45-49, 86], with little emphasis on the process plant design for dodo ikire. Therefore, this research will focus on a process plant design for the production of plantain cake (dodo ikire) by considering factors such as plantain cultivar, processing method, and recipe development. One of the critical factors to consider in the process plant design for dodo ikire is the choice of plantain cultivar [2, 23-27, 51]. Several studies have evaluated the effect of different processing methods on the nutritional and phytochemical properties of plantain products [57, 86]. In addition, there is limited information on the effect of processing methods on the quality of dodo ikire [37, 39, and 96]. Recipe development is also a critical factor in the process plant design for dodo ikire. The functional, pasting, and sensory properties of plantain flour products are influenced by the recipe formulation [40, 53-56, 58, 59].

2. Design Procedure and Material Selection The process plant designed for the production of plantain cake, popularly known as Dodo Ikire, is a sophisticated facility organized into five distinct sections: peeling, conveying, agitating, moulding, and frying. Each section is meticulously engineered to ensure efficiency and consistency in the production process. Peeling Section: The journey of plantain cake production begins in the peeling section. In this section, over-ripe plantains are fed into the machine equipped with sharp circular blades. These blades efficiently peel off the outer skin of the plantains, preparing them for the subsequent stages. The precision of the blades ensures minimal waste and optimal preparation of the plantain flesh. Conveying Section: Once peeled, the plantains are transferred to the conveying section. A conveyor belt is employed to transport the peeled plantains seamlessly from the peeling section to the agitating section. This conveyor system is designed to handle the delicate nature of the plantains, ensuring they are moved without any damage or loss of quality. Agitating Section:

Original Article

In the agitating section, the peeled plantains are deposited into an agitating tank. The primary function of this tank is to mash or grind the plantains into a smooth paste. This process is crucial as it lays the foundation for the texture and consistency of the final product. During this stage, additional ingredients such as blended pepper, salts, onion are introduced into the mixture. The agitating mechanism ensures that these ingredients are thoroughly combined, resulting in a homogeneous plantain paste. Moulding Section: The next stage in the process is the moulding section. Here, the plantain paste is shaped into small, uniform balls. The moulding equipment is designed to form the plantain balls with precision, ensuring each piece is consistent in size and shape. This consistency is essential for the even frying and final appearance of the plantain cakes. Frying Section: The final stage of the production process is the frying section. The plantain balls are deep-fried in hot palm oil or vegetable oil. The frying process is carefully controlled to achieve the characteristic golden-brown color and crispy texture of plantain cake (dodo ikire). The use of high-quality oil and precise temperature control ensures that the plantain cakes are cooked to perfection, with a deliciously crispy exterior and a soft, flavorful interior.

2.1. Materials Selection changes [98-104]. For this reason; plant components Mechanical properties, physical and technological as stated before, material chosen and reasons behind behavior of materials were strongly affected by the choice are summarized in Table 1. Production and joining parameters and microstructural

Table 1: Material Selection and the Criteria for selection

S/N	Components	Material Selected	Reasons for Selection
1	Peeling blade	Stainless steel	Corrosion resistance, non-Reactivity, compliance with food And drug administration
2	Conveyor belt	Polyurethane	Food safety compliance, non-Toxic and odourless
3	Conveying frame	Mild steel	High tensile strength, Machinability, availability
4	Agitating tank	Stainless steel	Corrosion resistance, durability And strength, temperature Resistance, chemical inertness
5	Agitator’s frame	Mild steel	High tensile strength, Machinability, availability
6	Impeller shaft	Stainless steel	Corrosion resistance, non-Reactivity, compliance with food and drug administration
7	Beaters	Stainless steel	Corrosion resistance, non-Reactivity, compliance with food and drug administration
8	Moulding frame	Mild steel	High tensile strength, Machinability, availability
9	Moulding plate	Stainless steel	Corrosion resistance, non-Reactivity, compliance with food and drug administration
10	Press cylinder	Mild steel	High tensile strength, Machinability, availability
11	Frying pan	Stainless steel	Corrosion resistance, non-Reactivity, compliance with food and drug administration
12	Gas stove frame	Mild steel	High tensile strength, Machinability, availability
13	Bolts and nuts	High carbon steel	High strength in shear and tension

2.2. Design Procedure

Growth and ensuring that all regions are available for the following factors were taken into consideration routine cleaning. During plant design:

Scalability: The designed plant also took into account

©2025 ***AYDEN Journals***

Original Article

Workflow Optimization: The plant layout was future scalability by modular components. This is designed to make it easy to move materials from one done to allow easy upgrade or expansion in the future, part to another. To reduce transport time and the risk thereby facilitating increase in production capacity of contamination, each section was strategically without the need for major modifications. Positioned. Compliance: The design also ensures strict Sanitation and Hygiene: All surfaces and components compliance with local and international food safety were designed to be easy to clean and maintain. This standards. This ensures that the manufacturing process involves using materials that are resistant to bacterial meets regulatory requirements and results in safe, high-quality products.

Design of the Peeling Blade

Based on the findings of Ugwueke et al. (2014), the diameter of plantain ranges from 30 – 70 mm and its average diameter was taken to be 50 mm. The thickness of banana peels depends on several factor namely; the type of the banana, ripeness and other factor. The outer layer varies between 0.5 – 1 mm whereas the inner layer is less than 0.5 mm. Hence, the overall thickness of the plantain peels is taken to be 2mm. For effective peeling, the blades have to penetrate into the plantain with penetration equal to the thickness of the peels.

$$Dhole = Dplantain - 2t \qquad (1)$$

Where;

D_{hole} is diameter of hole through which plantain pass $D_{plantain}$ is cross sectional diameter of the plantain

t is thickness of plantain peel

D_{hole} = 50 – 2(2)

D_{hole} = 46 mm

Conveyor design

Length of the belt, L can be expressed using equation (2)

$$L = H \times N \times \pi \qquad (2)$$

Where;

L is the length of the belt (m)

H is the height of the centre core (m)

N is number of wrap of the belt

Hence;

L = 0.955 × 1 × 3.142 L = 3 m

Drum diameter

According to Dunlop (2009), the drum diameter of a conveyor belt system can be determined using equation (3).

$$D = \sqrt{d^2 + (0.001273 \times L \times G)} \qquad (3)$$

Where; D is overall diameter (m) d is the core diameter (m) L is the belt length (m)

G is belt thickness (mm)

Hence;

$$D = \sqrt{76^2 + (0.001273 \times 3000 \times 3.2)}$$

D = 0.134 m or 134 mm

©2025 AYDEN Journals

Original Article

Belt tension determination Load due to idlers $(M_i) = \frac{mass\ of\ a\ set\ of\ idlers}{idlers\ spacing}$ (4)

$(M_i) = \frac{15}{1.2}$= 12.5 kg/m

Load due to belt (M_b) = 30.5 kg/m

$M_m = \frac{C}{3.6 \times V}$ (5)

Where;

M_m is the load due to conveyed materials

C is the conveyor capacity (36.5 tonnes/ hr)

V is the belt speed (0.25 m/s)

Hence;

$M_m = \frac{36.5}{3.6 \times 0.25}$= 40.6 kg/m

Belt tension at steady state:

$T_b = 1.37 \times f \times L \times [2 \times M_i + (2 \times M_b + M_m)s\delta] + H \times g \times M_m$ (6)

Where;

T_b is the belt tension at steady state

f is the coefficient of friction (f = 0.02 according Dunlop (2009))

L is the conveyor length (Conveyor belt is approximately half of the total belt length) g is the acceleration due to gravity

M_i is the load due to the idlers

$M_b$is the load due to belt

M_m is the load due to conveyed materials δ is the angle of inclination angle of the conveyor

H is the vertical height of the conveyor Hence;

T_b = 1.37 × 0.02 × 2× 9.81 × [2 × 12.5 + (2 × 30.5 + 40.6) cos 20] + 0.7 × 9.81 × 40.6

T_b = 343.56 kN

During the start of the conveyor system, the tension in the belt will be much higher than the steady state. Tension during the start is determined as follows

$T_{bs} = T_b \times K_s$ (7)

Where;

T_b is the belt tension at steady state T_{bs} is the belt tension while starting

K_s is the start-up factor Hence;

T_{bs} = 343.56 × 1.02

T_{bs} = 350.43 kN

Determination of power requirement for the motor

The power required at drive pulley is expressed as follows

$P_p = \frac{T_b \times V}{1000}$ (8)

©2025 AYDEN Journals

Original Article

Where;

P_p is the power at drive pulley

is the belt tension at steady state

V is the belt speed Hence;

$$P_p = \frac{343.56 \times 0.25}{1000} = 0.09\ kW$$

The minimum motor power needed to drive the conveyor system is given below

$$P_{min} = \frac{P_p}{\eta} \qquad (9)$$

Where;

P_{min} is the minimum motor power

P_p is power available at drive pulley η is drive efficiency Hence;

$$P_{min} = \frac{0.09}{0.85}$$

$$P_{min} = 0.1059\ kW$$

Acceleration of conveyor belt is expressed as

$$a = \frac{T_{bs} - T_b}{[L\,(2\times M_i + 2M_b + M_m)]} \qquad (10)$$

Where; a is the acceleration of the conveyor belt T_{bs} is the belt tension while starting

is the belt tension at steady state

L is the conveyor length

M_i is the load due to the idlers

is the load due to belt

M_m is the load due to conveyed materials

Hence;

$$a = \frac{350.43 - 343.56}{[2\,(2\times 12.5 + 2 \times 30.5 + 40.6)]} = 0.0271\ m/s^2$$

Belt breaking strength: This parameter decides the selection of the conveyor belt. The belt breaking strength can be calculated as given by equation (11)

$$B_s = \frac{C_r \times P_p}{C_v \times V} \qquad (11)$$

Where;

B_s is the breaking strength

C_r is the friction factor

P_p is power available at drive pulley

C_v is the breaking strength factor V is the belt speed

Hence;

$$B_s = \frac{15 \times 0.09}{0.75 \times 0.25} = 7.2\ Nmm$$

Design of agitator's capacity

The agitator's capacity can be expressed using the equation (12)

$$V = \frac{\pi {D_a}^2}{4} H_p \qquad (12)$$

Where;

©2025 AYDEN Journals

Original Article

V is the agitator's capacity in m^3

D_a is the diameter of the agitator vessel

H_p is the height of the agitator Hence;

V = $\frac{3.142 \times 2^2 \times 2}{4}$= 6.284 m^3

The gravimetric capacity of agitator is the maximum mass of the plantain that the agitator can accommodate and it is calculated using the density mass-volume

$\rho = \frac{M}{V}$

Where; ρ is the density of the plantain taken to be 1000 kg/m^3

M is the total mass of the plantain

V is the volume of the agitator

Hence;

M = 1000 × 6.284

M = 6284 kg

Design of Beater

According to Obeng (2004), the force require to shear a plantain pulp is 33.15 N and it reduces as the plantain ripens. Therefore, the thickness of the beater require to crush the plantain can be calculated from equation (13)

F = P × A = P × t^2 (13)

Where;

F is the crushing force exerted by the beater

P is the crushing pressure (0.0804 MPa according to Afuwape et al, 2012)

A is the cross sectional area of the beater t is the thickness of the beater

Hence;

33.15 = 0.0804× 10^6 × t^2 t = 0.020 m = 20 mm

Motor Power Requirement

The grinding operation is powered with a one horsepower (1 h.p.) electric motor at the speed of 1,400 rev/min (adapted from Ayodeji, 2016) The torque transmitted to the shaft is calculated as follows

$T = \frac{P \times 60}{2\pi N}$ (14)

Where;

T is the torque transmitted to the shaft

P is the power required to drive the electric motor

N is the number of revolution per minute of the shaft Hence;

$$T = \frac{746 \times 60}{2 \times 3.142 \times 1400} = 5.0878\ Nm = 5087\ Nmm$$

Design for the Shaft of the Agitator

According to Khurmi and Gupta (2005), the polar moment of the shaft can be expressed using equation (15)

©2025 AYDEN Journals

Original Article

$J = \frac{TL}{G\theta} = \frac{\pi d^4}{32}$ (15)

Therefore;

$$d = \sqrt[4]{\frac{32 \times T \times L}{\pi \times G \times \theta}}$$

Where:

d is the diameter of the shaft T is the torque transmitted

L is the length of the shaft (2m)

G is the modulus of rigidity of stainless material (77.2 GPa)

θ is the angle of twist (0.25°)

Hence;

$$d = \sqrt[4]{\frac{32 \times 5.0878 \times 2}{3.142 \times 77.2 \times 10^6 \times (\frac{0.25 \times 3.142}{180})}}$$

$d \cong 0.0235\ m$ or 23.5 mm

Therefore a 25 mm diameter was chosen

Determination of the beater's weight

$W_b = N_b m_b g = N_b \rho V g$ (16)

$V = l \times b \times t$

Where;

W_h is the total weight of the beaters m_b is the mass of each beater g is the acceleration due gravity (9.81 m/s)

V is the volume of the beater ρ is the density of shaft (according to khurmi and Gupta (2005), density of steel is 7850 kg/m^3)

Hence;

$m_b = 7850 \times 0.0008 = 6.28$ kg

$V = 0.8 \times 0.05 \times 0.020 = 0.0008 m^3$ $W_b = 6 \times 7850 \times 0.0008 \times 9.81 = 369.641$ N

Determination of the Centrifugal Force Exerted by the Beater

The centrifugal force of the beater can be calculated using equation (17) [50].

$F_b = \frac{m_b \times v_b{}^2}{r} = N_b\ m_b\ r\ \omega_b{}^2$ (17)

Angular velocity of the beater: $\omega = \frac{2\pi N}{60}$

Where;

is the centrifugal force exerted by the beaters

m_h is the mass of beater ω is the angular velocity

N is the number of revolution per min the beaters make

r is the radius of the shaft

Hence;

$\omega = \frac{2 \times 3.142 \times 1400}{60} = 147$ rad/s

$= 6 \times 6.28 \times 0.0125 \times 147^2 = 10.178$ kN

©2025 AYDEN Journals

Original Article

Design Calculation for the Moulding Machine The moulding machine is a crucial component in the production of plantain cake (dodo ikire), responsible for shaping the mashed plantain mixture into uniform balls. The design and operation of this machine involve several key calculations to ensure efficient and consistent performance. This section presents the design calculations for the main components of the moulding machine: the press cylinder, electric motor, and the mould plate. Force Required for the Press Cylinder

Design for the Press Cylinder

To determine the force required to press the plantain paste through the perforated mould plate, we need to consider the properties of the paste and the dimensions of the mould holes. Assuming the plantain paste has a viscosity similar to a heavy dough, we can approximate the required force using a simplified model of extrusion through circular holes. The force required can be determined using equation (18)

$F = \tau \times A_t$ (18)

$A_t = n \times A = n \times \pi \frac{D_b^2}{4}$ (19)

Where;

F is the force required press the plain paste

T is the shear stress of plantain paste (Pa)

A_t is the total cross sectional area in the mould plate (mm^2)

A is the cross-sectional area of each perforated hole n is the number of holes in the perforated plate D_b is the diameter of each holes in the perforated plate (mm)

Thus, $A_t = 100 \times 3.142 \times \frac{0.02^2}{4} = 0.03142\ m^2$

F =0.0804 × 10^6 × 0.03142= 2.526 kN

The power required by the electric motor can be estimated based on the force and the velocity v at which the paste is pressed through the mould plate. The power Prequired by the electric motor can be estimated based on the force F and the velocity v at which the paste is pressed through the mould plate.

$P = F \times v$ (20)

Where;

P is the power required by the electric motor (W)

F is the force exerted by the press cylinder (N)

V is the velocity of the press (m/s)

Thus,

P = 2526 × 0.3 = 757.8 W

Electric motor with 0.9 efficiency is desired

Then, a motor with a power rating,

$P_{motor} = \frac{757.8}{0.9} = 842$ W

Using simple proportion

1 h.p is 746 W
Thus, 846 W will be 1.2 h.p
The quantity of heat required to fry the plantain cake (dodo ikire) can be determined using the basic principle of thermodynamics, specifically from the concept of specific heat capacity. From simple physics, the heat required to raise the temperature of a substance is given by the expression in equation (21)

$$Q = mc\Delta T \quad (21)$$

Where;
Q is the heat required (in Joules) M is the mass of the substance (in kilograms) c is the specific heat capacity of the substance (in
J/kg.°C)
The following assumptions were made during design calculations.
Initial temperature of plantain is taken to be equal to the room temperature
Temperature of the oil is maintained at 170°C
Quantity of plantain to be fried (m) is 30 kg
Specific heat capacity of plantain is 2606.5 J/Kg/K
(According to Imeh et al, 2016)
Hence;

$$q = 32 \times 2.6065(170 - 25) = 12094.16 \text{ kJ}$$

The Fuel consumption is calculated based on heat transfer rate and the efficiency of the gas stove.

$$\begin{pmatrix}\text{Fuel}\\ \text{consumption}\end{pmatrix} = \frac{q}{\begin{pmatrix}\text{Calorific value}\\ \text{of cooking gas}\end{pmatrix} \text{x} \begin{pmatrix}\text{gas Stove}\\ \text{efficiency}\end{pmatrix}}$$

According World Nuclear Association, the calorific value of cooking gas ranges between 46 -51 MJ/kg. For the purpose of this calculation, the average value is taken to be 49 MJ/ kg.
Gas efficiency = 80%
Hence,

$$fuel\ consumption = \frac{12094.16}{49 \times 0.80} = 308.53 \text{ kg}$$

Thus, 308.53 kg of gas is required
Detailed engineering drawing of the plant is shown in Fig. 1.

3. Results and Discussion

3.1. Performance Evaluation of the Design

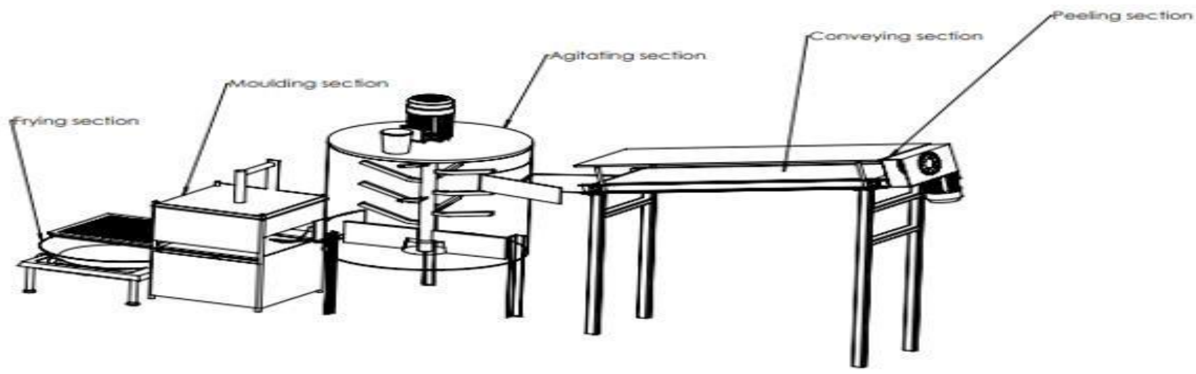
In the efficiency (E_p) of the designed process plant for the production of plantain cake (dodo ikire) was evaluated using percentage ratio of the expected throughput (T_e), 20kg to the designed throughput (T_d), 25kg in the presence of losses (T_o) 5kg as given in equation 22.

$$E_p = \frac{T_e}{T_d} = \frac{T_d - T_o}{T_d} = \frac{20}{25} x100\% = 80\% \quad (22)$$

Peeling Blade Design:
The efficiency and effectiveness of the peeling process depend on the blade design, particularly its ability to accurately peel without damaging the plantain pulp. The design provides a hole diameter of 46 mm, which is calculated to accommodate plantains of average diameter (50 mm) while accounting for peel thickness (2 mm).

©2025 ***AYDEN Journals***

Original Article



This ensures that the peeling process is efficient, minimizing waste and reducing the risk of damaging the plantain pulp.

Conveyor Design:

The conveyor system's performance hinges on smooth material flow, proper tension, and minimal downtime. The calculated belt tension at steady state (343.56 kN) and startup (350.43 kN) ensures that the belt operates within safe limits. The power requirement (0.09 kW) and minimum motor power (0.1059 kW) are adequate for continuous operation. The system is designed to maintain tension and provide sufficient power, ensuring consistent plantain transportation with minimal interruptions.

Agitator:

The agitator's capacity and efficiency are essential for mixing the plantain mixture uniformly. With a volumetric capacity of 6.284 m³ and a gravimetric capacity of 6284 kg, the agitator is well-sized to handle large batches of plantain mixture. This ensures that the mixing process is thorough, leading to a homogeneous mixture and improving the quality of the final product.

Beater:

The beater's effectiveness is critical for crushing and shearing the plantain pulp. The calculated thickness of the beater (20 mm) ensures sufficient force to crush the plantain pulp, and the weight (369.641 N) along with the centrifugal force (10.178 kN) confirm that the beater operates with enough energy to process the plantain without excessive wear.

Motor Power and Shaft:

The motor and shaft must provide enough torque to drive the agitator and beater without failure. The motor power requirement (1.2 h.p.) and torque (5087 Nmm) are sufficient to ensure smooth operation. The chosen shaft diameter (25 mm) is robust enough to withstand the applied forces, minimizing the risk of mechanical failure.

Moulding Machine:

The moulding machine's efficiency is crucial for shaping the plantain cake mixture into uniform pieces. The required force for pressing the plantain paste (2.526 kN) and motor power (842 W) are adequate to ensure consistent operation. The machine is expected to produce uniform plantain cakes with minimal variation in shape and size.

Frying Process:

©2025 AYDEN Journals

The energy efficiency and fuel consumption during frying are key to cost-effectiveness. The heat required for frying (12094.16 kJ) and calculated fuel consumption (308.53 kg) indicate that the process is energy-intensive. The efficiency of the gas stove (80%) is reasonable, but there may be room for improvement in reducing fuel consumption by optimizing the frying process or using alternative energy sources.

Overall System Performance

The design calculations show that the plantain cake production system is capable of handling the required load and operations efficiently. The equipment is designed to operate within safe limits, and the power and material handling systems are optimized for smooth production. However, areas like fuel consumption during the frying process might benefit from further optimization for energy efficiency. The performance evaluation of the plantain cake (dodo ikire) production plant demonstrated the effectiveness of each section in achieving high-quality output. Key highlights include the efficient peeling of plantains with minimal waste, gentle transportation via a polyurethane conveyor belt, successful mashing and mixing in the agitating section, precise shaping in the moulding section, and consistent frying that produced golden-brown cakes with the desired texture. The use of durable, food-safe materials like stainless steel ensured product safety and process efficiency across all stages, underscoring the plant's capability in producing consistent and high-quality dodo ikire.

4. Conclusion

The design and development of a dodo ikire process plant have been successfully executed, integrating various sections including peeling, conveying, agitating, molding, and frying. The plant was designed with careful consideration of material selection, ensuring food safety, durability, and efficiency throughout the process. The stainless steel components, particularly in the peeling, agitating, and frying sections, contributed significantly to corrosion resistance and maintaining product quality. The use of mild steel in the structural components provided the necessary strength, while polyurethane ensured safe and smooth transportation of the plantains between sections. The plant's design focused on achieving optimal workflow, minimizing waste, and maintaining hygiene standards. The result is a process plant that can consistently produce high-quality dodo ikire, meeting both consumer expectations and industry regulations. In conclusion, the developed plant design offers a scalable and efficient solution for dodo ikire production, with potential for future upgrades as market demand grows. The successful integration of engineering principles with food processing needs makes this plant a viable option for industrial production of traditional foods like dodo ikire.

References

Abiodun-Solanke, A. O. and Falade, K. O. (2011). A review of the uses and methods of processing banana and plantain (Musa spp.) into storable food products. Journal of Agricultural Research and Development, 10(2), 85-99.

Adam, K., Nestor, K. K. N. K. K., Denis, Y. N. D. Y. N. and Georges, N. (2015). Plantain (Musa spp., AAB genome) Cultivar Preference, Local Processing Techniques and Consumption Patterns of Plantain Based Foods Mostly Consumed in Urban Area of Abidjan, Côte d’Ivoire. 7, 117–129.

[Adebiyi, O. A. and Oshinowo, O. A. (2017). Effect of replacing concentrates with plantain peels and maize stalk on performance and serum biochemistry of weaned pigs. Nigerian Journal of Animal Production 44 (1), 203-208

©2025 ***AYDEN Journals***

Adegunloye, D.V. (2019). Microbial assessment of street-vended fried plantain in Akure metropolis, Nigeria. Food and Public Health, 9(1), 16.

Adegunwa, M., Alamu, E. and Fasanya, O. (2012). Effects of processing on the physicochemical properties and carotenoid contents of plantain flour. Journal of Food Processing and Preservation, 36, 339– 347.

. Adekomaya, S. O. and Samuel, O. D. (2014). Design and development of a petrol powered hammer mill for rural Nigerian farmers. Journal of Technologies and Policy. 4(4), 65-74.

Adeniji, T. A. and Empere, C. E. (2001). The development, production and quality evaluation of cake made from cooking banana flour. Global Journal of Pure and Applied Sciences, 7(4), 633-635

Adeniji, T. A. and Empere, C. E. (2001). The development, production and quality evaluation of cake made from cooking banana flour. Global Journal of Pure and Applied Sciences, 7(4), 633-635.

Adeoye, I. and Oni, O. (2013). Policy analysis and competitiveness of plantain processing in southwestern Nigeria.

Adepoju, Oladejo Thomas, Sunday, Barine Edwin and Folaranmi, Olubukola Abidemi (2012). Nutrient composition and contribution of plantain (Musa paradisiacea) products to dietary diversity of Nigerian consumers. African Journal of

Biotechnology Vol. 11(71), pp. 13601-13605. [11]. Adesope, A.A.A, Usman, J. M., Abiola, I. O. and Akinyemi, S.O.S. (2004). Problems and prospects of plantain marketing in Ibadan. Proc. 22nd Annual Conference of Horticultural Society of Nigeria. Ibanda, Nigeria 3–6, September. P.142–145.

Adetola, S. O. and Oyejide, A. J. (2015). Development of a bone milling machine with safety hollow and low risk of electrical damage. International Journal of Modern Engineering Research, 5(6), 52-59.

Adewumi, B. A., Ogunlowo, A. S. and Ademosun, O. C. (2009). Investigating potential of plantain wastes as livestock feed in Nigeria. Journal of Food, Agriculture and Environment, 7(3-4), 363-365.

Adewusi, S. R., Ojumu, T. V. and Falade, O. S. (2013). The effect of processing on total organic acids content and mineral availability of simulated cassava-vegetable diets. Plant Foods for Human Nutrition (53): 367-380.

Adeyanju, J., Alabi, B., Abioye, A. O., Adekunle, A. and Oloyede, A. (2021). Effect of Frying Temperature and Time on Thermophysical Properties and Quality Attributes of Deep-Fat Fried Plantain (Dodo). Asian Food Science Journal.

Adeyemi M.M., Bawa MM, Muktar M.

(2018). Evaluation of the effect of calcium carbide on induce ripening of banana, pawpaw and mango cultivated within Kaduna metropolis, Nigerian Journal of Chemistry Society, Nigeria. 2018; 43(2):108 -118.

Adeyemi, O. S. and Oladigi, A. T. (2009). Pakistan Journal of Nutrition, 8(8), 1235-1240.

Afuwape, O. F, Ebikade, G. E., Oguzie, C., Olaye, O. and Osinowo, B. A. (2012). Design and

Fabrication of a Prototype Plant for Processing Unripe Plantain, An unpublished B.Eng Thesis in the Department of Mechanical Engineering, University of Benin, October 2012.

Aiyelaagbe, I.O.O., Odeleye, O.M.O. and Akinyemi, S.O.S. (2001). Effects of plantain population on the productivity of a plantain/cocoyam mixture in Southwestern Nigeria. Nigerian J. Hort. Sci. 5:82–85.

Ajaka, E. O. and Adesina, A. (2014). Design, fabrication and testing of a laboratory size hammer mill. International Journal of Engineering and Advance Technology Studies, 2(2), 11-21,

Alabi, O. O., Olajide, O. P., Dasaolu, O. S. and Ologbosere, Y. D. (2023). Evaluation of The Nutritive Qualities of Ripe and Unripe Plantain Peels as a Potential Feed Ingredient. Journal of Agriculture and Agricultural Technology 12(1). [22]. Alao, O. T., Alabi, D. L. and M. Famakinwa (2020). Profitability of indigenous Banana/Plantain snack (dodo ikire) among processor in Irewolede Local Government Area of Osun State, Nigeria. Technoscience Journal for community development in

Africa 1: 1 (2020) 63-70 ISSN 2659-0573 [23]. Amusan, E., Oramadike, C. E., AbrahamOlukayode A. O. and Adejonwo O. A. (2010). Bacteriological quality of street vended smoked blue whiting (Micromesistus poutasou). Internet Journal of Food Safety, 12,122-6.

Anwaral A. S. Blanger R. and Panis B. (2006). Cryopreservation of banana meristem cultures: effect of vitrification solution on post-thaw survivial in seven cultivars. Global Conference on Banana and Plantain. Bangalore, India, 28-31 October 2006 Pp. 33-34.

Arinola, S. O., Ogunbusola, E. M. and Adebayo, S. F. (2016). Effect of drying methods on the chemical, pasting and functional properties of unripe plantain (Musa paradisiaca) flour. British

Journal of Applied Science & Technology, 14(3), 1-7. [26]. Aslam, M., F., Anwar, R., Nadeem, U., Rashid, T.G., Nadeem, M. (2005). Mineral composition of moringa oleifera leaves and pods from different regions of punjab, pakistan. Asian Journal of Plant Sciences, 4: 417-421

Ayanwale, A. B., Fatunbi A. O. and Ojo, M. (2016). Innovation opportunities in plantain production in Nigeria. Guide Book 1. Forum for Agricultural Research in Africa (FARA); Accra, Ghana.

Ayodeji S. P. (2016). Conceptual Design of a Process Plant for the Production of Plantain Flour. Cogent Engineering, Production and Manufacturing Research Article. 3: 1-16.

©2025 ***AYDEN Journals***

Original Article

Bankole, S. A. and Mabekoje, O. O. (2004). Occurrence of aflatoxins and fumonisins in preharvest maize from south-western Nigeria. Food Additives and Contaminants, 21(3), 251-255.

Cauvain, S.P., and L.S. Young.2007. Microbiological spoilage of bread. In technology of bread making, second edition, Spinger publishers.

Chukwu, J. O. (2011). The Economics of Plantain Marketing in Nigeria: Challenges and

Prospects. Agricultural Economics Journal, 8(2), 45-58

Ebunilo, P. O., Obanor, A. I. and Ariavie, G. O. (2010). Design and preliminary testing of a hammer mill with end-suction lift capability suitable for commercial processing of grains and solid minerals in Nigeria. International Journal of Engineering Science and Technology, 2(6), 15811593.

Ekesa, B., Kimiywe, J., Davey, M., DhuiqueMayer, C., Bergh, I., Karamura, D. and Blomme, G. (2012). Banana and plantain (musa spp.) Cultivar preference, local processing techniques and consumption patterns in eastern Democratic Republic of Congo. International Journal of Agriculture Sciences, 4, 312–319.

Ekesa, B., Poulaert, M., Davey, M. W., Kimiywe, J., Van den Bergh, I., Blomme, G., and Dhuique-Mayer, C. (2012). Food Chemistry, 133(4), 1471-1477.

[35]. Ekunwe, P. A. and Ajayi, H. I. (2010). Economics of Plantain Production in Edo State Nigeria. Research Journal of Agriculture and Biological Sciences, 6(6): 902-905.

Evelyn Serwah Ayeh, Enoch Aryeetey, Ebenezer Quandoh, Abena Boakye, Faustina Dufie Wireko-Manu, James Osei Mensah and Ibok N. Oduro (2023) Economic Impact of Plantain Ripening: A Case Study Among Plantain Traders in Accra, International Journal of Fruit Science, 23:1, 217-228, DOI: 10.1080/15538362.2023.2271993

Falade, K. O. and Oyeyinka, S. A. (2015).

Food Science & Nutrition, 3(1), 70-88. [38]. Falade, K. O. and J. O Okocha (2002). Foammat drying of Plantain and Cooking Banana (Musa spp.). Food Bioprocess.

Falade, K. O. and Oyeyinka, S. A. (2015). Color, chemical and functional properties of plantain cultivars and cooking banana flour as affected by drying method and maturity. Journal of Food Processing and Preservation, 39(6), 816-828.