

DESIGN AND CONSTRUCTION OF A YAM BLENDING MACHINE

BY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF PRODUCTION  
ENGINEERING, INDUSTRIAL ENGINEERING PROGRAMME,  
FACULTY OF ENGINEERING,  
UNIVERSITY OF BENIN, BENIN CITY.

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ENGR. PROF. JOHN A. AKPOBI

A PROJECT SUBMITTED TO THE DEPARTMENT OF PRODUCTION  
ENGINEERING, INDUSTRIAL ENGINEERING PROGRAMME, IN  
PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE  
AWARD OF BACHELOR OF ENGINEERING (B.ENG),

UNIVERSITY OF BENIN, BENIN CITY.

NOVEMBER 2025.

## **DECLARATION**

I, JOSHUA OFURE AKAHOMEN, hereby declare that this project titled DESIGN AND CONSTRUCTION OF A YAM BLENDING MACHINE was carried out by me in the Department of Production Engineering, Industrial Engineering Programme, University of Benin, Benin City, in partial fulfilment of the requirement for the award of Bachelor of Engineering (B.ENG) in Industrial Engineering.

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## CERTIFICATION

This is to certify that this project work on the Design and Fabrication of a Yam Blending Machine was carried out by Akahomen Ofure Joshua with Matriculation number ENG2002337 of the Department of Industrial Engineering, University of Benin, Benin City.

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Prof. John A. Akpobi

*Project Supervisor*

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Date

## **DEDICATION**

This project is dedicated to Almighty God for His guidance, wisdom, and strength throughout the course of this work.

I also dedicate this work to my beloved parents, whose support, prayers, and encouragement have been the foundation of my academic journey.

To my lecturers, supervisors, and friends, thank you for your constant inspiration and belief in my potential.

## ACKNOWLEDEGEMENT

First and foremost, I give all glory, honor, and praise to Almighty God for His infinite grace, wisdom, and strength throughout the course of this project and my academic journey.

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I extend my sincere gratitude to my course adviser Engr. Dr. N.H.M OSADIAYE for his consistent support, mentorship, and academic counsel throughout my studies.

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To everyone who contributed in one way or another to the success of this project, I say a heartfelt thank you.

## ABSTRACT

Yam (*Dioscorea spp.*) remains a major staple and economic crop in Nigeria, where it serves as a vital source of food and income. However, traditional yam processing methods involving manual pounding are time-consuming, labor-intensive, and unhygienic, making them unsuitable for large-scale or commercial production. This study focuses on the design, fabrication, and performance evaluation of an automated yam blending machine with an emphasis on minimizing material leakage—a common limitation in existing models.

The machine was designed using mechanical and food engineering principles to achieve efficient blending through an electrically powered motor, stainless-steel blending chamber, and an effective sealing system that prevents leakage.

Locally sourced materials were used to enhance affordability and promote indigenous technology. Performance evaluation showed that the machine successfully pounded 500 g of boiled yam within an average of 2.7 minutes, achieving an output efficiency of 97% and a throughput capacity of 16.18 kg/hr.

The pounded yam produced exhibited excellent textural qualities comparable to traditionally prepared samples. The developed machine demonstrated improved hygiene, ease of operation, and significant reduction in processing time, thereby offering a viable solution for household and small-scale commercial yam processing. This innovation contributes to Nigeria's local equipment fabrication efforts and enhances food processing mechanization.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

Yam (*Dioscorea spp.*) is one of the most economically and nutritionally important food crops in West Africa, particularly in Nigeria, where it serves as a major staple food and source of income for millions of people. It provides essential nutrients such as carbohydrates, vitamins, minerals, and dietary fiber, contributing substantially to food security and rural livelihoods (FAO, 2021; Otegbayo, Arisa, & Adesanya, 2021). Nigeria is the world's largest producer of yams, contributing over 70% of global production (World Bank, 2023). The high level of consumption and continuous increase in population have led to rising demand for yam and its processed products such as pounded yam, yam flour, and yam-based snacks.

Traditionally, yam processing in Nigeria involves peeling, boiling, and pounding using a mortar and pestle. This manual method, though culturally significant, is highly labor-intensive, time-consuming, and physically demanding. It also limits production scale and consistency in product quality (Adegbite & Oluwole, 2018). In commercial or large-scale settings, manual pounding becomes inefficient, unhygienic, and uneconomical, especially for businesses or restaurants that require large volumes of pounded yam within short periods. The variability in texture and taste that often results from manual pounding further affects consumer satisfaction and market value (Oluwole & Adepeju, 2019).

With the increasing emphasis on mechanization and value addition in agricultural processing, there is a growing interest in developing efficient machines for yam

processing. Mechanized yam blending or pounding machines have been introduced to reduce physical strain, improve product uniformity, enhance hygiene, and increase production output. These machines typically operate by converting mechanical energy from an electric motor into rotational motion that drives blades or beaters to pound boiled yam into a smooth, elastic dough-like consistency (Oniya, Adeboye, & Obasi, 2016).

However, one major issue affecting the performance and durability of most yam blending machines is material leakage during operation. Leakage often occurs around the blending chamber, shaft seals, or discharge outlets. This not only results in material wastage but also creates unhygienic working conditions, increases cleaning time, and may damage electrical components if moisture penetrates into the motor or wiring system (NHK Machinery Parts, 2025; DynaScan, 2025). These challenges have discouraged widespread adoption of local yam blending machines, as many existing designs fail to address the problem effectively.

Therefore, there is a pressing need to design and fabricate a yam blending machine that minimizes or completely eliminates leakage while maintaining high performance, blending efficiency, and hygienic standards. Such a machine would not only improve product quality and safety but also contribute to Nigeria's goal of promoting local fabrication and industrialization of agricultural processing equipment.

This study aims to develop a yam blending machine that integrates effective sealing mechanisms, appropriate material selection, and an ergonomic design capable of delivering uniform, high-quality pounded yam with minimal material loss.

## **1.2 Statement of the Problem**

Traditional yam processing in Nigeria still relies heavily on manual labor. The process of pounding boiled yam using a mortar and pestle is physically exhausting, time-consuming, and inefficient for commercial purposes. Apart from limiting production scale, manual methods often produce inconsistent textures that affect consumer satisfaction and product marketability (Adegbite & Oluwole, 2018; Olagunju & Obasi, 2020).

While mechanized yam blending machines have been developed to address these challenges, their performance has been limited by several operational issues—most notably leakage of yam paste during blending. Leakage leads to:

- Wastage of processed material, increasing production cost.
- Unhygienic processing conditions due to food spillage.
- Frequent machine maintenance and part replacement.
- Shortened lifespan of electrical and mechanical components exposed to moisture (NHK Machinery Parts, 2025).

Therefore, there is a need to design and construct a yam blending machine that incorporates efficient sealing mechanisms and hygienic design features to eliminate leakage and enhance durability, efficiency, and ease of maintenance.

## **1.3 Aim of the Study**

The main aim of this study is to design and construct a functional yam blending machine that integrates effective sealing mechanisms and structural features to

minimize or eliminate material leakage during operation, ensuring efficient, hygienic, and reliable yam processing.

#### **1.4 Objectives of the Study**

The specific objectives of this study are:

- i. To design a yam blending machine that incorporates effective sealing mechanisms and structural features to minimize or eliminate material leakage.
- ii. To construct a prototype of the designed yam blending machine using locally available materials.
- iii. To evaluate the blending efficiency, output consistency, and leakage control performance of the constructed machine.
- iv. To compare the operational performance of the fabricated machine with traditional manual pounding in terms of time, hygiene, and product quality.

#### **1.5 Significance of the Study**

This study holds significant importance for the advancement of yam processing and agricultural mechanization in Nigeria. By focusing on the design and construction of a leakage-free yam blending machine, this research addresses one of the most persistent challenges in mechanized yam processing—material loss and hygiene control.

Mechanized yam blending drastically reduces processing time and human effort, increasing productivity and allowing small-scale processors, food vendors, and households to produce pounded yam more conveniently. In addition, the integration of

a robust sealing mechanism ensures hygienic operation by preventing contamination and reducing cleaning requirements.

The successful development of this machine will:

- Improve food safety and hygiene compliance in accordance with NAFDAC (2019, 2025) guidelines.
- Enhance product uniformity and quality for better consumer satisfaction.
- Encourage local production and adoption of indigenous processing equipment, reducing dependence on imported food machinery.
- Promote small- and medium-scale enterprises (SMEs) involved in food processing, contributing to economic development and employment creation.
- Provide a technical framework for future innovations in similar food processing machines.

## **1.6 Scope of the Study**

This study focuses on the design, construction, and performance evaluation of a prototype yam blending machine. The scope covers:

- Mechanical and electrical design considerations, including material selection, sealing mechanisms, and machine layout.
- Fabrication of a functional prototype using locally sourced components.
- Testing and evaluation of blending efficiency, time, output consistency, and leakage prevention.

The study does not extend to large-scale industrial automation, mass production, or advanced control system integration. However, the prototype serves as a model that can be scaled or improved upon for commercial production in future research.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

A literature review provides the theoretical and empirical foundation on which a research project is built. It critically examines previous studies, innovations, and theories relevant to a particular research problem (Creswell & Creswell, 2018). For the design and construction of a yam blending machine, the review of related literature focuses on understanding the nature of yam, traditional and mechanized methods of processing, relevant engineering designs, material selection, and performance parameters of existing machines.

Over the past decades, researchers and engineers have developed several machines aimed at automating yam processing, particularly the pounding and blending stages. Despite these efforts, challenges such as energy inefficiency, poor product texture, excessive vibration, and most importantly, leakage during operation remain prevalent (Oniya, Adeboye, & Obasi, 2016; Ajibola et al., 2020). This review synthesizes findings from previous works in both mechanical design and food science to provide a comprehensive understanding of the current state of knowledge and identify areas for improvement.

#### **2.2 Overview of Yam and Its Economic Importance**

Yam (*Dioscorea spp.*) belongs to the family *Dioscoreaceae* and is a major root tuber crop cultivated widely in tropical regions, particularly in West Africa. Nigeria remains the world's largest producer of yam, contributing approximately 70% of the global output, with an annual production exceeding 45 million tonnes (FAO, 2022; World

Bank, 2023). The crop plays a vital role in food security, income generation, and cultural practices, particularly in the yam-producing states of Benue, Kogi, Enugu, and Ondo (Otegbayo, Arisa, & Adesanya, 2021).

Yam's economic value extends beyond consumption. It serves as a raw material for several agro-industries, producing products such as yam flour, pounded yam, yam chips, and starch (Okafor et al., 2023). These products have growing export potential, contributing significantly to Nigeria's non-oil sector. The mechanization of yam processing not only enhances efficiency and reduces post-harvest losses but also promotes industrialization and value chain development (Olaoye & Adetunji, 2019).

Mechanized processing equipment such as blenders, peelers, dryers, and milling machines are now seen as essential components of the Nigerian agricultural transformation agenda. These technologies contribute to job creation, improve hygiene, and support small and medium-scale agro-processing enterprises (Ajibola et al., 2020).

### **2.3 Nutritional and Physical Properties of Yam Relevant to Processing**

The design of yam processing machines must be based on an understanding of the **physical, rheological, and chemical properties** of yam. These properties influence how yam responds to mechanical forces such as cutting, blending, and pounding.

#### **2.3.1 Nutritional Composition**

Yam is rich in carbohydrates, primarily starch (60–75%), and contains small amounts of protein (1–2%), fiber (1–2%), vitamins, and minerals (Otegbayo et al., 2021). Its high starch content makes it suitable for forming elastic gels upon heating, which is essential for the characteristic texture of pounded yam (Oluwole & Adepeju, 2019).

Table 2.1 shows the proximate composition of yam as reported in literature.

Component	Percentage Composition (%)	Source
Moisture Content	60 – 70	Otegbayo et al. (2021)
Carbohydrate (mainly starch)	60 – 75	FAO (2022)
Protein	1 – 2	Oluwole & Adepeju (2019)
Fat	0.2 – 0.5	Okafor et al. (2023)
Fiber	1 – 2	Adegbite & Oluwole (2018)
Ash	1 – 1.5	Kumar et al. (2021)

*Table 1 Proximate Composition of Yam (Average Values for Dioscorea rotundata)*

### 2.3.2 Physical and Mechanical Properties

The physical properties of yam—such as size, shape, density, and hardness—affect the design parameters of processing equipment. For instance, yam tubers vary in diameter (5–15 cm) and length (20–60 cm), requiring cutting or size reduction before blending. The density of yam ranges from 0.9 to 1.2 g/cm<sup>3</sup> depending on variety and moisture content (Adepoju & Olaniyan, 2018).

From an engineering standpoint, the most relevant mechanical properties are compressive strength, tensile strength, and shear stress. These parameters determine the energy required to blend or pound yam without damaging the machine components. The hardness of boiled yam drops drastically after heating, allowing mechanical blades or beaters to homogenize it effectively. *Yam (Adapted from Otegbayo et al., 2021)*

### 2.3.3 Rheological and Textural Properties

The desirable texture of pounded yam results from the gelatinization and retrogradation of yam starch. These phenomena depend on processing temperature, moisture level, and the intensity of mechanical shear (Okafor et al., 2023). Rheological

analysis reveals that pounded yam exhibits viscoelastic behavior; it flows like a viscous fluid when blended yet retains elasticity upon cooling (Kumar et al., 2021).

These properties highlight the importance of precise mechanical design in blending machines. A properly designed machine must provide sufficient shear and compression to simulate traditional pounding while maintaining an appropriate temperature to avoid over-gelatinization or lump formation.

## **2.4 Traditional Methods of Yam Processing and Their Limitations**

In most yam-producing communities of Nigeria and West Africa, traditional yam processing methods have been passed down through generations. These processes typically involve peeling, washing, boiling, and pounding (FAO, 2022). While these techniques preserve cultural heritage and produce the characteristic flavor and texture consumers desire, they are increasingly recognized as inefficient for modern food production systems.

### **2.4.1 Manual Pounding Using Mortar and Pestle**

Manual pounding remains the most widespread traditional method of preparing pounded yam. The process involves placing boiled yam in a wooden mortar and repeatedly striking it with a pestle until a smooth, elastic consistency is achieved (Adegbite & Oluwole, 2018). This technique, however, is:

- **Labor-intensive:** It requires substantial physical energy, making it impractical for large-scale production.
- **Time-consuming:** Manual pounding of a single tuber may take up to 15–20 minutes.

- **Unhygienic:** Exposure to dust and human contact increases contamination risk (NAFDAC, 2019).
- **Inconsistent:** The final product depends on the operator’s skill and strength, often leading to variations in texture and quality.

#### **2.4.2 Other Traditional Yam-Based Processing Techniques**

Beyond pounded yam, yam can be processed into products such as yam flour, yam chips, and yam starch. These are traditionally prepared by slicing, sun-drying, and milling the tubers using simple manual tools (FAO, 2022). These methods, though simple, often result in:

- High post-harvest losses due to microbial contamination and spoilage.
- Poor product uniformity and low shelf stability.
- Inefficient labor utilization and low yield (Otegbayo et al., 2021).

These shortcomings underscore the need for mechanization—a shift from traditional labor-based methods to machine-assisted processes that ensure efficiency, safety, and product consistency.

#### **2.5 Mechanization in Yam Processing**

Mechanization represents a key step toward modernization and industrialization in agriculture. In yam processing, it involves the development of machines for peeling, slicing, drying, blending, and packaging (Olaoye & Adetunji, 2019). Mechanized systems reduce drudgery, improve hygiene, and ensure standardization in processing conditions (Ajibola et al., 2020).

### 2.5.1 Evolution of Yam Pounding and Blending Machines

The first generation of yam pounding machines emerged in the late 1990s and early 2000s, largely inspired by domestic food blenders and grinding machines. These devices attempted to replicate the pounding motion of a pestle using rotating blades or beaters. Early models achieved partial success but suffered from mechanical instability, incomplete homogenization, and high energy consumption (Oniya et al., 2016).

Subsequent innovations integrated electric motors, stainless steel blending chambers, and safety covers. However, most designs still experienced leakage at the blending chamber, especially at the shaft-bowl interface, due to poor sealing or misalignment (Okafor et al., 2023).

Generation	Key Features	Limitations	Sources
First Generation (1990–2005)	Wooden body, pestle mimic motion, manually driven or simple motor	Low speed, poor homogenization, unhygienic	Oniya et al. (2016)
Second Generation (2005–2015)	Electric motor with metal chamber, blade or beater mechanism	High vibration, leakage at chamber joints	Adegbite & Oluwole (2018)
Third Generation (2015–Present)	Stainless steel chamber, improved seals, adjustable speed	Expensive, limited local adoption	Okafor et al. (2023); Kumar et al. (2021)

*Table 2 Evolution of Yam Blending and Pounding Machines*

Mechanization has clearly improved processing efficiency, but unresolved issues—especially leakage, wear of components, and safety hazards—remain focal points for further research and innovation.

### **2.5.2 Design Approaches in Mechanized Yam Blenders**

Mechanized yam blending machines typically consist of four main components:

- i. **Electric Motor** – Provides rotational power.
- ii. **Transmission System** – Transfers motion to the blending shaft (usually via a belt or coupling).
- iii. **Blending Chamber** – Contains the blades or beaters.
- iv. **Sealing and Housing Unit** – Prevents leakage and contamination.

The blending efficiency depends largely on the **blade geometry, rotational speed, and clearance between blades and chamber walls**. Higher speeds increase blending uniformity but can also cause overheating, which may alter the rheological properties of yam (Kumar et al., 2021).

### **2.6 Review of Related Machines and Designs**

Numerous attempts have been made by researchers and local fabricators to produce yam blending or pounding machines suitable for household and small-scale commercial use. These machines vary in power rating, blending principle, capacity, and structural material.

### 2.6.1 Review of Local Yam Blending Machines

Local designs in Nigeria often employ **1–2 hp electric motors** and **aluminum or stainless-steel chambers**. They are generally affordable and easy to maintain but suffer from leakage and excessive vibration due to poor balancing (Adegbite & Oluwole, 2018).

Researcher(s)	Power (hp)	Capacity (kg/batch)	Mechanism	Key Features	Limitations
Oniya et al. (2016)	1.0	2	Rotary beater	Simple design, low cost	Leakage at shaft joint
Adegbite & Oluwole (2018)	1.5	3	Blade and pestle mix	Stainless chamber, belt drive	Overheating at high speed
Olagunju & Obasi (2020)	2.0	4	Impact blade	Strong frame, efficient blending	No speed control
Okafor et al. (2023)	1.5	5	Dual blade system	Sealed chamber, improved hygiene	High fabrication cost

*Table 3 Summary of Selected Local Yam Blending Machines in Nigeria.*

### 2.6.2 Imported Yam Pounding Machines

Imported models, primarily from Asia (Japan, China, and South Korea), use advanced blending mechanisms and sealing technology. These devices achieve high efficiency and minimal leakage but are cost-prohibitive and often lack locally available spare parts (NHK Machinery Parts, 2025).

Parameter	Local Machines	Imported Machines
Cost	Low (₦60,000– ₦150,000)	High (₦250,000– ₦800,000)
Availability of Parts	Readily available	Limited
Leakage Resistance	Moderate to poor	Excellent
Energy Efficiency	Moderate	High
Ease of Maintenance	Easy	Difficult
Suitability for Local Conditions	High	Medium
Overall Performance	Fair	Excellent

*Table 4 Comparison of Local and Imported Yam Blending Machines*

While imported models offer superior performance, their high cost and maintenance complexity hinder widespread adoption in rural or small-scale Nigerian settings. Hence, the development of locally designed, leakage-free, efficient, and affordable machines remains a priority in food engineering research.

## **2.7 Theoretical Framework and Design Considerations**

The theoretical framework for designing and constructing a yam blending machine is grounded in both mechanical engineering principles and food processing science. These frameworks provide a structured understanding of how materials, forces, and machine elements interact to achieve the desired blending action while maintaining product quality.

### **2.7.1 Engineering Design Principles**

The engineering design of food processing machines involves applying mechanical energy conversion, stress analysis, and machine dynamics. The yam blending machine transforms electrical energy from an electric motor into mechanical work that homogenizes boiled yam through shear and compression forces (Kumar et al., 2021).

The essential design elements include:

- **Blade Design and Geometry:**

The efficiency of blending depends on the shape, angle, and number of blades.

Curved blades promote uniform shear while minimizing energy loss (Olagunju & Obasi, 2020).

- **Vibration Control:**

Excessive vibration during blending can reduce efficiency and cause structural fatigue. The design must include balancing mechanisms and shock absorbers (Olaoye & Adetunji, 2019).

- **Sealing Mechanism:**

Leakage control depends on selecting the correct sealing materials—such as **food-**

**grade rubber gaskets, shaft seals, or lip seals**—that withstand heat and moisture (NHK Machinery Parts, 2025).

- **Material Selection:**

The choice of materials directly affects machine durability, hygiene, and food safety. As per NAFDAC (2025) and FAO (2022) guidelines, stainless steel is preferred for all food-contact surfaces due to its corrosion resistance, non-reactivity, and ease of cleaning.

<b>Component</b>	<b>Recommended Material</b>	<b>Reason</b>
Blending Chamber	Stainless Steel (Grade 304)	Corrosion resistance, hygienic
Blades/Beaters	Stainless Steel (Grade 316)	High strength, food-safe
Frame	Mild Steel (paint-coated)	Structural support, cost-effective
Sealing Gasket	Food-grade Rubber/Silicone	Prevent leakage, temperature resistant
Shaft	High Carbon Steel	Wear resistance, torque transmission

*Table 5 Recommended Materials for Key Components of a Yam Blending Machine.*

### 2.7.2 Food Engineering Considerations

From a food science perspective, the design must ensure the preservation of texture, flavor, and nutritional quality. Factors influencing these outcomes include temperature, moisture, and shear intensity during blending (Okafor et al., 2023).

- **Temperature Control:**

Excessive heat generation during blending can degrade nutrients and alter texture.

Machines must therefore minimize frictional heating (Adepoju & Olaniyan, 2018).

- **Shear Rate:**

The shear rate must be sufficient to break down yam tissue and form a homogenous paste but not so high that it ruptures starch granules excessively (Kumar et al., 2021).

- **Moisture Retention:**

Adequate moisture must be maintained in the blending chamber to ensure elasticity and smoothness of the pounded yam (Otegbayo et al., 2021).

### **2.7.3 Safety and Ergonomic Design**

Ergonomics plays a vital role in reducing user fatigue and ensuring safety. The blending machine must have user-friendly controls, insulated electrical wiring, and proper ventilation for the motor compartment. The blending chamber cover should include a safety interlock switch to prevent accidental operation (Olaoye & Adetunji, 2019).

Furthermore, noise reduction and ease of cleaning are vital aspects of good design practice in food machinery (NAFDAC, 2019). The overall layout should facilitate easy disassembly for cleaning, reducing downtime and contamination risk.

### **2.8 Summary of Related Literature and Research Gaps**

A review of existing literature reveals significant progress in the design and construction of yam processing machines, particularly in the blending and pounding stages. Various researchers have developed prototypes and improved mechanical configurations aimed at enhancing efficiency and texture quality (Oniya et al., 2016; Adebite & Oluwole, 2018; Okafor et al., 2023).

However, despite these advancements, key challenges remain unresolved, as summarized below:

<b>Identified Gaps</b>	<b>Description</b>	<b>Implication</b>
Leakage during operation	Poor sealing mechanisms and misalignment	Material wastage and hygiene concerns
Inconsistent blending	Uneven blade geometry and speed control	Non-uniform product texture
Overheating	High rotational speed or inadequate ventilation	Nutrient loss, machine damage
Lack of local standardization	Absence of unified design specifications	Difficulty in replication or mass production
High cost of imported machines	Limited affordability for small-scale users	Low adoption rates

The gap in the literature clearly identifies leakage control and machine optimization as priority areas. This research, therefore, contributes by designing a yam blending machine with an improved sealing system to address material leakage while maintaining performance, safety, and hygiene.

## CHAPTER THREE

### METHODOLOGY

This chapter outlines the systematic methodology employed in the design, construction, and evaluation of the automated electric yam blending machine. It details the various stages of the project, including the conceptualization, material selection, fabrication processes, assembly procedures, and the experimental methods used for performance evaluation, with a particular emphasis on assessing the effectiveness of the integrated leakage prevention mechanisms. The approaches described herein are designed to ensure the development of an efficient, hygienic, and reliable yam blending machine that addresses the identified gaps in existing technologies.

#### 3.1 Design Approach

The design of the yam blending machine was approached with a strong focus on functionality, durability, hygiene, user safety, and crucially, the minimization or elimination of material leakage. A user-centered design philosophy was adopted to ensure ease of operation and maintenance. The design process involved:

- **Conceptual Design:** Initial sketching and ideation based on the principles of mechanical blending and an understanding of yam's rheological properties.
- **Detailed Component Design:** As elaborated in Chapter One, each component (motor, blending chamber, blending mechanism, outer casing, control panel, and power supply) was meticulously designed, specifying dimensions, materials, and functional requirements.

- **Leakage Prevention Integration:** This was a core design consideration at every stage. Specific attention was paid to the design of robust shaft seals, secure lid sealing mechanisms, and seamless component interfaces to prevent any escape of yam paste during operation.
- **Safety Features Integration:** Design elements such as safety interlocks for the lid, motor overload protection were incorporated to ensure safe operation.
- **Hygienic Design Principles:** Adherence to principles like smooth, food-grade surfaces, easy cleanability, and avoidance of crevices was paramount in the design of food-contact parts.

### 3.2 Materials Selection

The selection of materials was guided by criteria such as strength, durability, corrosion resistance, food-grade compliance, ease of fabrication, and cost-effectiveness. The following materials were chosen for the primary components:

- **Blending Chamber and Food-Contact Surfaces:** Food-grade Stainless Steel (SS304) was selected for the main blending bowl, lid body, and any internal components directly contacting the yam. This choice is based on its excellent corrosion resistance, non-reactivity with food, ease of cleaning, and durability.
- **Blending Blade and Shaft:** Hardened Stainless Steel was chosen for its high strength, toughness, and ability to retain a sharp edge for effective blending.
- **Outer Casing/Frame:**
  - **Internal Frame:** Welded Square Steel Tubing (e.g., mild steel, painted or powder-coated for corrosion protection) was chosen for the rigid internal support structure, providing a robust base for the motor and blending chamber.

- **External Panels:** 1.5 mm to 2.0 mm thick SS304 sheet metal was chosen for the outer panels to provide a premium finish, corrosion resistance, and facilitate easy external cleaning.
- **Fasteners:** Stainless Steel fasteners were used for all food-contact zones and exterior panels. High-tensile steel bolts (Grade 8.8) were used for motor mounting and structural connections outside the food zone.
- **Electrical Components:** Standard industrial-grade electrical components, indicator lights, wiring conforming to relevant electrical safety standards (e.g., IEC standards for motor and wiring sizes) were specified.

### 3.3. Materials

Materials required for this project are here in categorized as experimental and work tools as listed in Table 3.3

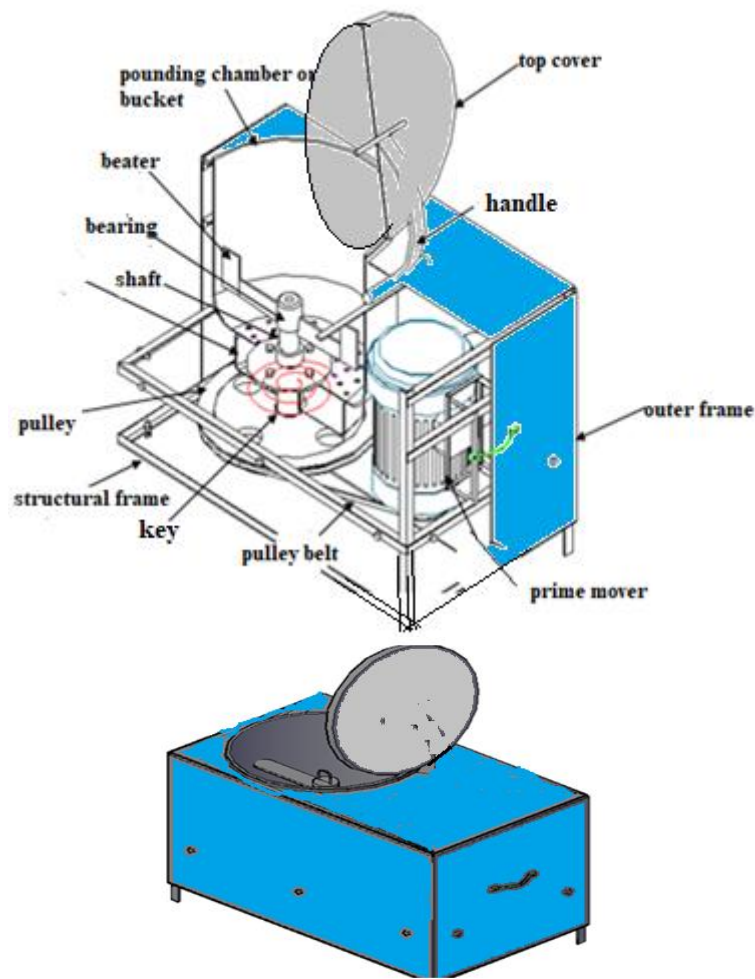
Categories	S/N	Materials	Function
Raw materials	1	Sheet metal	For structure and form of the machine.
	2	AC motor	Prime mover
	3	Pulley and belt	It is used for motion transfer.
	4	Metal hammer	For crushing and tumbling of cooked yam
	5	Angle bar	For building the structure of the machine
	6	Power circuit	For turning and off of the machine.
Information technology tools	1	Math lab, solid works	For computational and graphics analysis respectively.

	2	Intel Core Duo Personal Computer. For typing, CAD designs and program execution.	For typesetting and CAD design.
	3	Desk Jet HP Printer. For printing.	For type setting and printing
Production Tools	1	Drilling Machine	For drilling holes on work piece
	2	Electric/ Oxy-Acetylene Welding Machines	For metal joining
	3	Lathe Machine.	Used for turning of work piece
	4	Welding Electrodes.	It is used with arc welding for joining metal piece
	5	Cutting tools	For material shearing and cutting.

*Table 3.3 Materials Required for the project.*

### **3.4. Conceptual design**

The box type centrifugal yam pounding machine with a cylindrical pounding bowl and metal beaters as shown in Figure 3.1 was proposed. However; the choice of mode of power to energize the machine brought about conflict of choices which were evaluated based on selective criteria with the selection of the most viable concept being selected using a decision matrix.



*Figure 3.1 Proposed yam pounding machine.*

The proposed proof of concept yam pounding machine consists of the following major components:

- **Pot or bowl:** The bowl consists of the metal blade which performs the crushing and tumbling operation inside the bowl. It is made of stainless steel material particularly selected due to its resistance to corrosion and safe for food handling.
- **Metal blade:** This is the member of the machine which does the crushing and turning action of the yam. It is made of aluminum. The ease of casting and shaping of aluminum makes it preferred

- **The shaft:** The shaft which is made of mild steel is designed to transmit power to the metal blade in the bowl to perform the flour tumbling operation.
- **Pulley:** This is used to transmit and alter speed variation via pulley belt during the rotation of the shaft.
- **Motor:** The motor is the prime driver of the shaft.
- **The frame:** The frame forms the housing of the whole components, including the electric motor. It has to be rigid to withstand all the forces generated in the components during the pounding operation.
- **The Electrical wirings:** These are mainly current generating components required to control the machine operation

Two concepts are proposed for consideration and they include the followings;

#### **3.4.1 Concept 1; The Alternating Current (AC) powered yam pounding machine**

The alternating current powered yam pounding machine was considered for fabrication. Owing to the high torque required for pounding of yam and the energy requirement to power such torque, AC power was considered chiefly for its cheap availability and operational cost. The concept comprises of an electric (AC) powered motor as the prime mover, metal hammers or beater, a pounding bowl, belt and pulleys. The beater rotates within a central axis inside the bowl where the pounding action of the yam takes effect.

#### **3.4.2 Concept 2. The Direct Current (DC) powered yam pounding machine**

The direct current powered yam pounding machine concept comprises of an electric (DC) powered motor, a dc battery, charging system for the battery, metal hammers or

beaters, a pounding bowl, belt and pulleys. The choice of the concept is chiefly based on use of alternative energy.

### 3.4.3 Decision Matrix

Decision matrix was used to select the most viable concept amongst the two concepts based on key design considerations as shown in the Table 3.4

Selection criteria	Weighting	Concept 1		Concept 2	
		Score	Total	Score	Total
Low cost of production	35	2	70	1	35
Simplicity of materials selection	25	2	50	1	25
Low weight	20	2	40	1	20
Versatility of use	15	1	15	2	30
Ease of maintenance	5	2	10	1	5
<b>Total</b>	<b>100</b>		<b>185</b>		<b>115</b>

*Table 3.4 Decision matrix for yam pounding machine concepts.*

From the decision matrix in Table 3.4, the concept 1 with AC powered motor had the highest aggregate score total of 185 compared to the concept 2 which had an aggregate total weighted score of 115. The concept 1 with the highest score is therefore selected for detail design and fabrication.

### 3.4.4 Detailed design.

#### I. Sizing of pounding bowls

This is dependent on the amount of cooked yam to be pounded and it is determined considering the number of people required to consume the food per operation. From experimentation 1 kg of yam was enough to make pounded yam for 3 people. Considering the length of metal beater, a bowl of volume of 0.14m<sup>3</sup> was arrived at. An additional allowance of about 0.1mm to 0.2mm on both sides of the blade and wall to avoid contact between the blade and the inner walls of the bowl was also considered.

Considering the length of blade + allowance given =  $0.10 + (0.0002 + 0.0002) = 0.1004\text{m}$

Volume of vessel =  $0.1504 = \pi r^2 h = 3.142 \times (0.1004/2)^2 \times h$

Therefore, height of cylindrical bowl =  $19\text{cm}$

### 3.4.5 Determination of The Torque

The equation used in determining the torque

$$T = P_f \times D \quad (\text{Shigley, 2011})$$

Where;

T = Torque (Nm)

P<sub>f</sub> = pounding force (N)

D = distance of the beater from the center of pivot (m)

$$\text{But } P_f = P_p \times A$$

Where;

P<sub>p</sub> = pounding pressure (N/m<sup>2</sup>)

A = area covered by mastication (m<sup>2</sup>)

Pounding pressure is calculated from the relationship

$$P_p = P_b \times g \times h$$

Where;

P<sub>b</sub> = density of cooked yam (1950kg/m<sup>3</sup>) ( Odior and Orsah, 2008, Osueke 2010)

G =acceleration due to gravity (9.81m/s<sup>2</sup>)

H= Height of the beater (m)=0.06

Therefore;

$P_p = 1950 \times 9.81 \times 0.06$

Pounding pressure =  $1.148 \times 10^3 \text{N/m}^2$

But  $P_f = P_p \times A$

$A = \pi d^2/4$

D=0.05

Therefore,

$P_f = 1.148 \times 10^3 \times 1.9 \times 10^{-5}$

$P_f = 60.4 \text{N}$

Torque =  $P_f \times d$

$T = 60.4 \times 0.11$

$T = 7 \text{Nm}$

### 3.4.6 Determination of Power Requirement

For optimum performance the speed of 500rpm was chosen and a safety factor of 2 was chosen for reliability

$P = T \times 2 \pi N/60$

Where;

P =power requirement (W)

T= torque (Nm)

N =motor speed (rpm)

$$P=7 \times 2 \times 3.142 \times 500/60$$

$$P=367W$$

Considering factor of safety of 2

Minimum power requirement is 367 x 2

$$P =734W \text{ but } 1hp =746W$$

Therefore, an electric motor of 1hp with speed 1440rpm was chosen.

### 3.4.7 Area of sheet metal for casing

The area of the metal sheet for the outer covering of the yam pounding machine include the;

Total Surface area of material of casing – Area of cut out materials

The cut-out materials from the casing are the top circular and rectangular shaped surfaces cut out from the material for final shaping of the casing.

Total surface area of the rectangular casing assuming it is a hollow box material =

$$L_1B_1+L_2B_2+L_3B_3+\dots\dots\dots L_nB_n\dots \tag{3.3}$$

where n = the nth term number of surface of the rectangular casing in arithmetic progression.

$$\text{Area of cut-out circular material} = \pi \frac{d^2}{4} \dots \tag{3.4},$$

where  $\pi=3.142$ ,

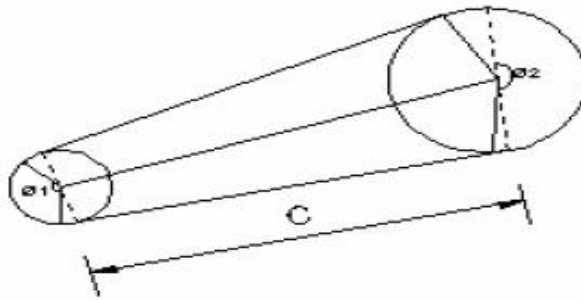
$$\text{Area of rectangular cut-out material} = l \times b \quad (3.5)$$

$$\text{Total surface area of cut-out materials} = \Sigma(L \times B)_n - \left(\pi \frac{d^2}{4} + l \cdot b\right) \quad (3.6)$$

For any cut-out shape profile from the material of casing, the final surface area of material of the casing = Total surface area of all solid casing - (Summation of all Areas of cut out shapes of the material).

### 3.4.8 Pulley design

The pulley system schematic is shown in Figure 3.2., where  $c$  is the center to center distance



*Figure 3.2 Pulley and belt*

The ratio of speed transmission to be  $x : y = 3 : 1$  for adequate speed reduction. This is necessitated for proper sizing of the driven pulley.

Coefficient of friction between belt (leather tanned) and pulley (Cast iron) is  $\mu = 0.35$ .

The combination of the material for the belt and the pulley is necessitated for efficient function

Angle grooving of the pulley, is  $\theta^\circ = 40^\circ$ , for the best performance of belt.

Diameter of small pulley =  $D_s = 50\text{mm}$  (attached to electric motor as supplied)

Diameter of big pulley =  $D_L$

From the relationship, the center distance,  $c$  between the two pulleys is taken as the larger of the value between

$$\frac{3D_s + D_L}{2} \text{ And } c = D_L, [\text{Deutschmann and Aron, 1985}] \quad (3.7)$$

$$\text{Therefore } c = \max\left(\frac{3D_s + D_L}{2} \text{ and } D_L\right) \quad (3.8)$$

From Figure 3.2,

$$\theta_1 = 180^\circ - 2\sin^{-1}\left(\frac{D_L - D_s}{2c}\right) \dots \quad (3.9)$$

$$\theta_2 = 180^\circ + 2\sin^{-1}\left(\frac{D_L - D_s}{2c}\right) \quad (3.10)$$

From the relationship,

$$D_L = 3D_s$$

$$\text{Therefore, } D_L = 3 \times 50 = 150 \text{ mm}$$

Where  $D_L = 150 \text{ mm}$  is the diameter of the large pulley, and  $D_s$  is the diameter of the smaller pulley.

The centre distance,  $C$  between the two pulleys is taken as the larger of the value

$$\text{between } \frac{3D_s + D_L}{2} \text{ and } C = D_L,$$

$$\text{Therefore } C = \max\left(\frac{3D_s + D_L}{2} \text{ and } D_L\right)$$

$$\text{That is } c = \left(\frac{3(50) + 150}{2} \text{ or } 150\right),$$

$$\text{Therefore, } c = (150 \text{ or } 150) = 150 \text{ mm.}$$

From Fig. 3.2 we also have,

$$\theta_1 = 180^\circ - 2\sin^{-1}\left(\frac{D_L - D_s}{2c}\right) = 180^\circ - 2\sin^{-1} 0.3333 = 141^\circ$$

$$\theta_2 = 180^\circ + 2\sin^{-1} \left( \frac{DL-Ds}{\frac{2}{c}} \right) = 180^\circ + 2\sin^{-1} 0.3333 = 219^\circ$$

### 3.4.9 Shaft Design

#### i. Shear stress on the shaft:

Shearing stresses are induced in the shaft due to the fact that it is subject to a torque or twisting moment. The shear stress produced in the shaft is given as:

$$\tau = \frac{Tr}{J} \quad (3.11)$$

where

$\tau$  = shear stress (MPa)

T = twisting moment (Nm)

r = distance from center to stressed surface of the shaft in (mm)

J = "polar moment of inertia" of cross section (mm<sup>4</sup>)

The maximum moment on the Shaft

The maximum moment in the circular shaft can be expressed as:

$$T_{\max} = \frac{\delta j}{R} \quad (3.12)$$

Where;

$T_{\max}$  = maximum twisting moment (Nm)

$\tau_{\max}$  = maximum shear stress (MPa)

R = radius of shaft (mm)

J = the polar moment of inertia on the shaft can be expressed as

$$= \frac{\pi R^4}{2} = \frac{\pi D^4}{32} \text{ for round solid shaft or } \frac{\pi(d_o^4 - d_i^4)}{32} \text{ for hollow shaft} \quad (3.13)$$

$d_o$  and  $d_i$  are the outer and internal diameter of the hollow shaft respectively

Substituting for J in equation 3.12, we have

$$T_{\max} = \frac{\pi R^4 \tau_{\max}}{2R} = \frac{\pi R^3 \tau_{\max}}{2} = \frac{\pi D^3 \tau_{\max}}{16} \dots \quad (3.14)$$

But for a hollow solid shaft, equation 3.14 and 3.15 are expressed in terms of the outside and internal diameter of the shaft as follows,

$$J = \frac{\pi(R^4 - r^4)}{2} = \frac{\pi(d_o^4 - d_i^4)}{32} \dots \quad (3.15) \text{ and,}$$

$$T = \frac{\pi}{16} \chi \frac{\tau_{\max}[d_o^4 - d_i^4]}{d} \quad (3.16)$$

$$R = d_o/2, \text{ and } r = d_i/2$$

Note: D = diameter of shaft and it is given as

$$1.72 \left( \frac{T_{\max}}{\tau_{\max}} \right)^{1/3} \quad (3.17)$$

Allowable shear stress is taken (31 to 47MPa for alloy cast steel and iron)

Then inputting this value of T and  $\tau$  into equation 3.17, it can be computed.

## ii. Torsional Deflection of The Shaft:

The angular deflection of a torsion solid shaft can be expressed as

$$\theta = \frac{584LT}{GD^4} \dots \quad (3.18)$$

where;

$\theta$  = angular shaft deflection (degrees)

L = length of shaft =

T = torque transmitted by shaft in

G = modulus of rigidity (MPa)

D = diameter of shaft

### **3.4.10 Bearing Selection**

The governing conditions for bearing selection used for in the yam pounder for supporting and transferring motion to the rotating shaft of the yam pounder include the followings

- a) The selection of rolling contact bearings over sliding contact bearings due to the former's advantages that were closely desired for the nature of the machine crucial amongst which included; Its low starting and running friction within the desired low speed, its ability to withstand momentary shock loads, accuracy of shaft alignment and low cost of maintenance.
- b) The desired speed to be transmitted from the shaft as supplied from the motor is desired to be low and far less than 2000rpm.
- c) The bearings required needed to have ability to bear load at this speed.
- d) The minimum static and dynamic load rating of the bearing has to exceed the bearing load of the shaft.

Other design considerations such as coefficient of friction and bore diameter of the bearing, which are calculated or matched from reference and manufacturers manual gives the selection of choices from series of potential bearings available in market.

For purpose of this project, the mathematical analysis of the above mentioned parameters are elaborated. The alternative method of reading off from reference manual was adopted.

From SKF bearing manufactures reference catalogues, the appropriate bearing is selected based on output speed, bore size, static load, and dynamic loads and bearing load of shaft.

The Dynamic equivalent load for rolling contact bearings (DEL) was put into consideration. It is the constant stationary radial load (in case of radial ball or roller bearings) or axial load (in case of thrust ball or roller bearings) which, if applied to a bearing with rotating inner ring and stationary outer ring, would give the same life as that which the bearing will attain under the actual condition of load and rotation (Khurmi et al 2005).

Denoted by  $W$  and for the radial and angular contact bearings under combined constant radial load  $W_R$  and constant axial or thrust load  $W_A$  is given by the expression below

$$W = X.V.W_R + Y.W_A \quad (3.17)$$

where;

$V$  = A rotation factor = 1 for all types of bearings when the inner race is rotating

And the values of radial load factor  $X$  and axial or thrust factor  $Y$  for the dynamically loaded bearings may be taken from references or appendix two of this literature.

### **3.4.11 Dynamic Load Rating for Rolling Contact Bearings Under Variable Loads**

#### **DLR**

This denoted by  $C$ , is the constant stationary load (in case of radial ball or roller bearings) or constant axial load (in case of thrust ball or roller bearings) which a group of apparently identical bearings with stationary outer ring can endure for a rating life of

one million revolutions (which is equivalent to 500 hours of operation at 33.3 rpm) with only 10 percent failure. [Khurmi et al, 2005]

It is given as

$$C = W (L / 10^6)^{1/k} \dots\dots\dots 3.18$$

Where

W= equivalent dynamic load

L= service life rating of the ball or roller bearing

The relationship between the life in revolution L and the life in working hours  $L_H$  is given by

$L = 60N.L_H$  revolutions where N is the speed in rpm

k = 3, for ball bearings and 10/3 for roller bearings

Having evaluated all factors from calculated, working condition and references, ball bearings were found suitable and used for the measuring machine. In selecting the most suitable ball bearing, the basic dynamic radial load was multiplied by a service factor ( $K_s$ ) to get the design basic dynamic radial load capacity. After determining the design basic dynamic radial load capacity, the selection of bearing was made from literature and manufacturers reference catalogue. Find reference in appendix three of this literature for the basic static and dynamic capacities of various types of ball bearings. Orthographic drawing and picture of the fabricated proof of concept of yam pounding machine are shown in Figure 3.3 and Figure 3.4 respectively.

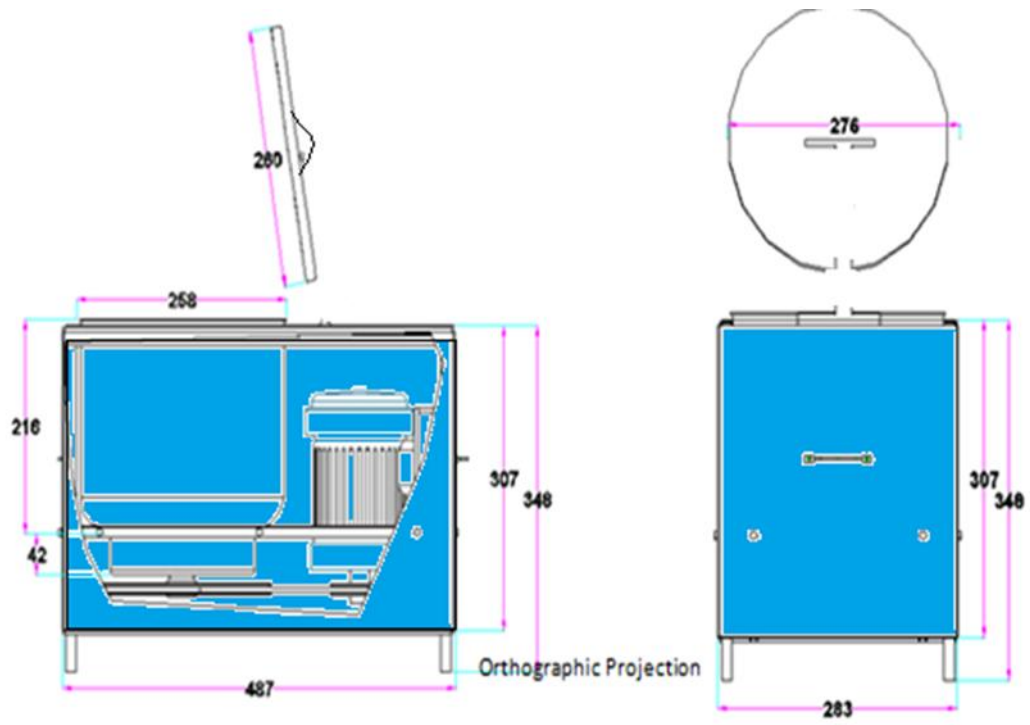
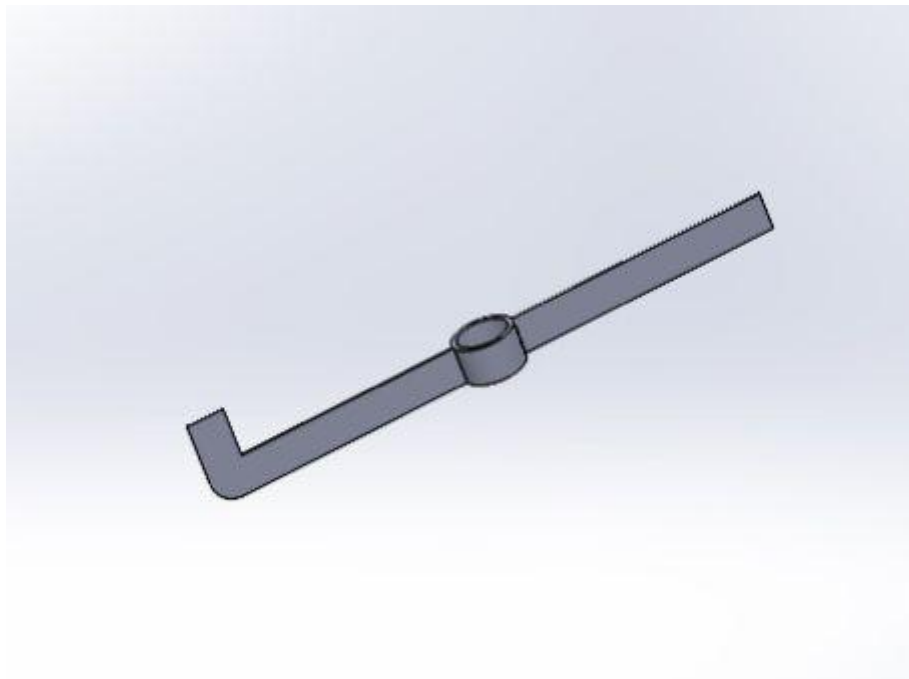
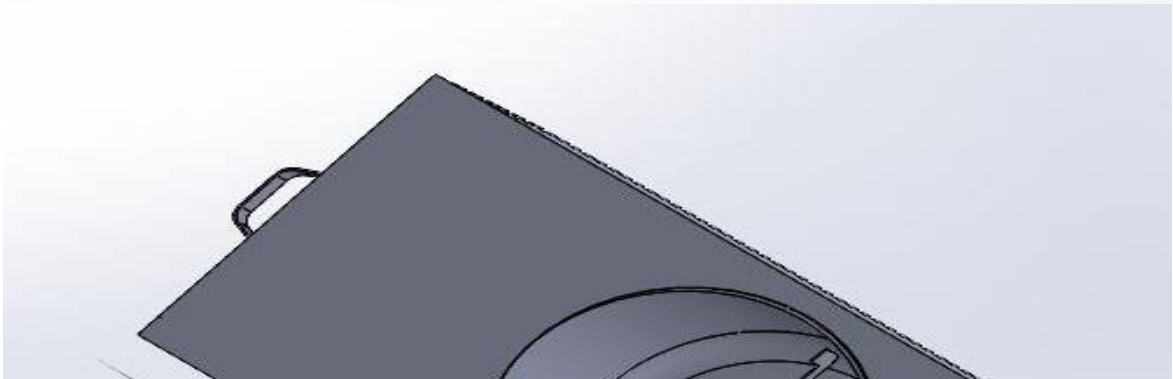
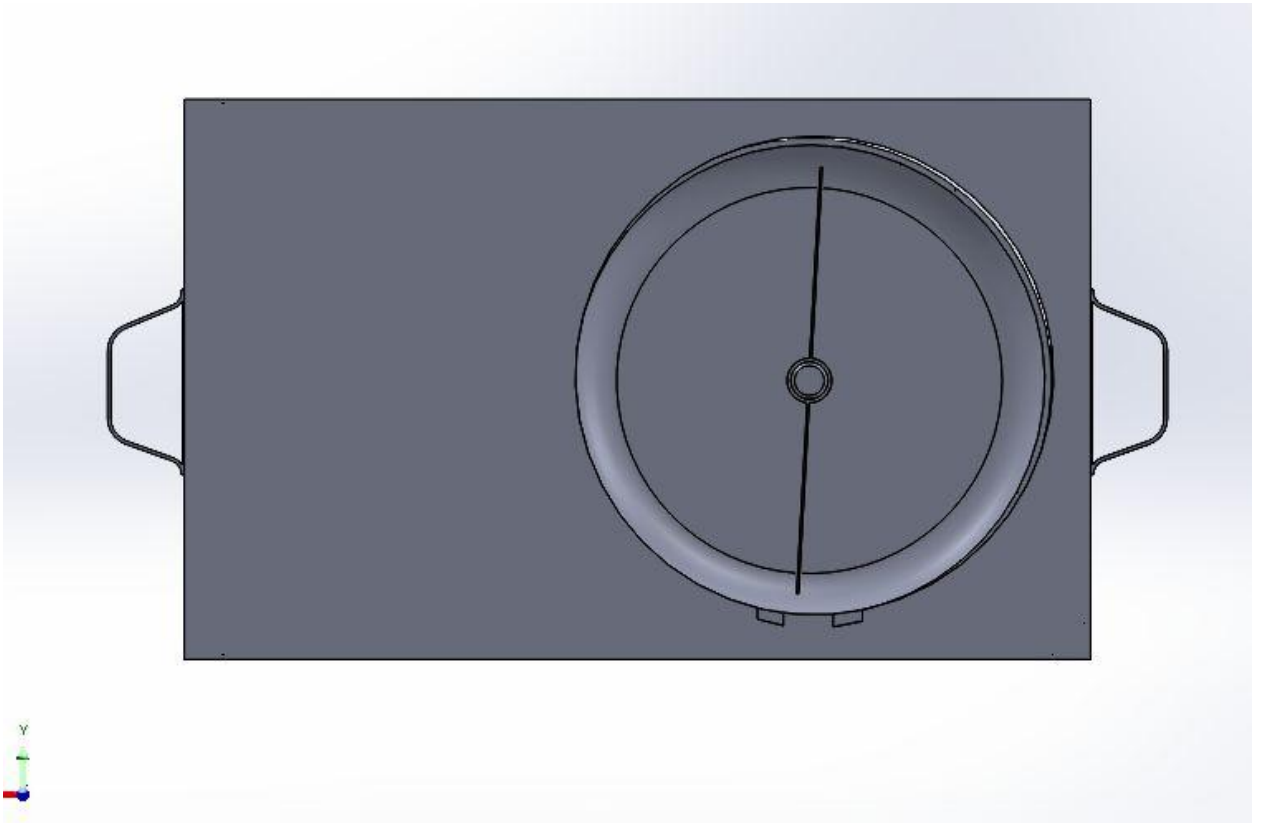
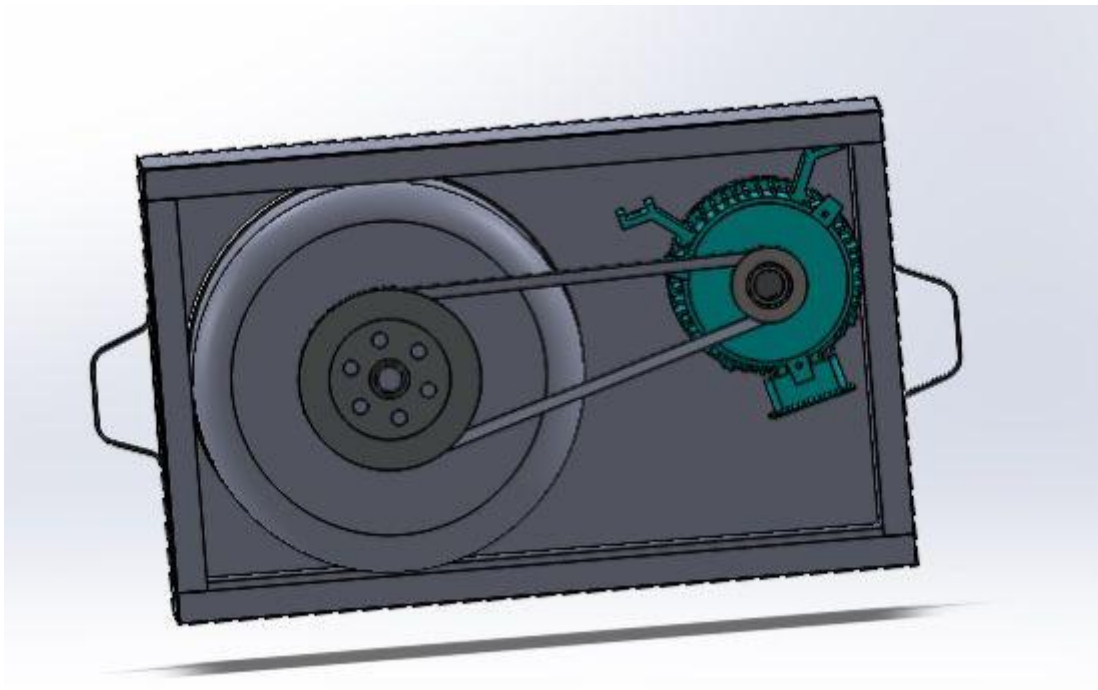
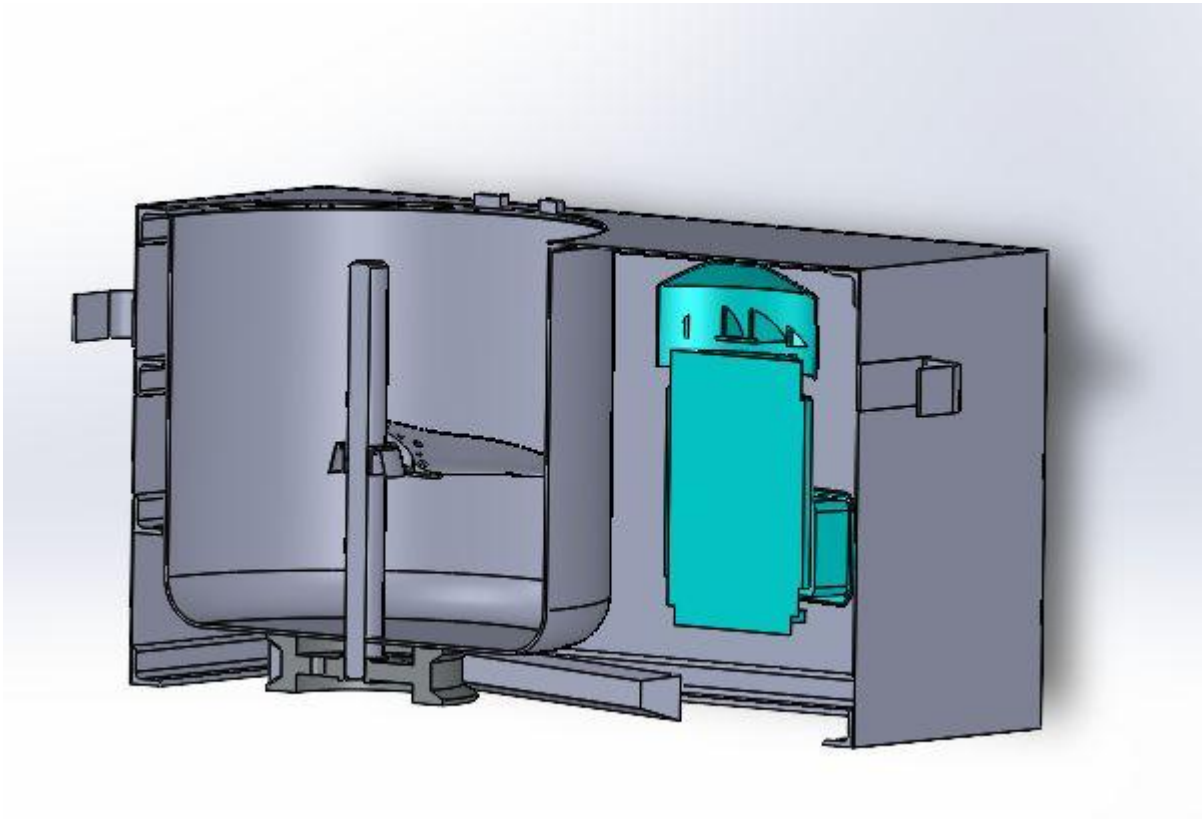
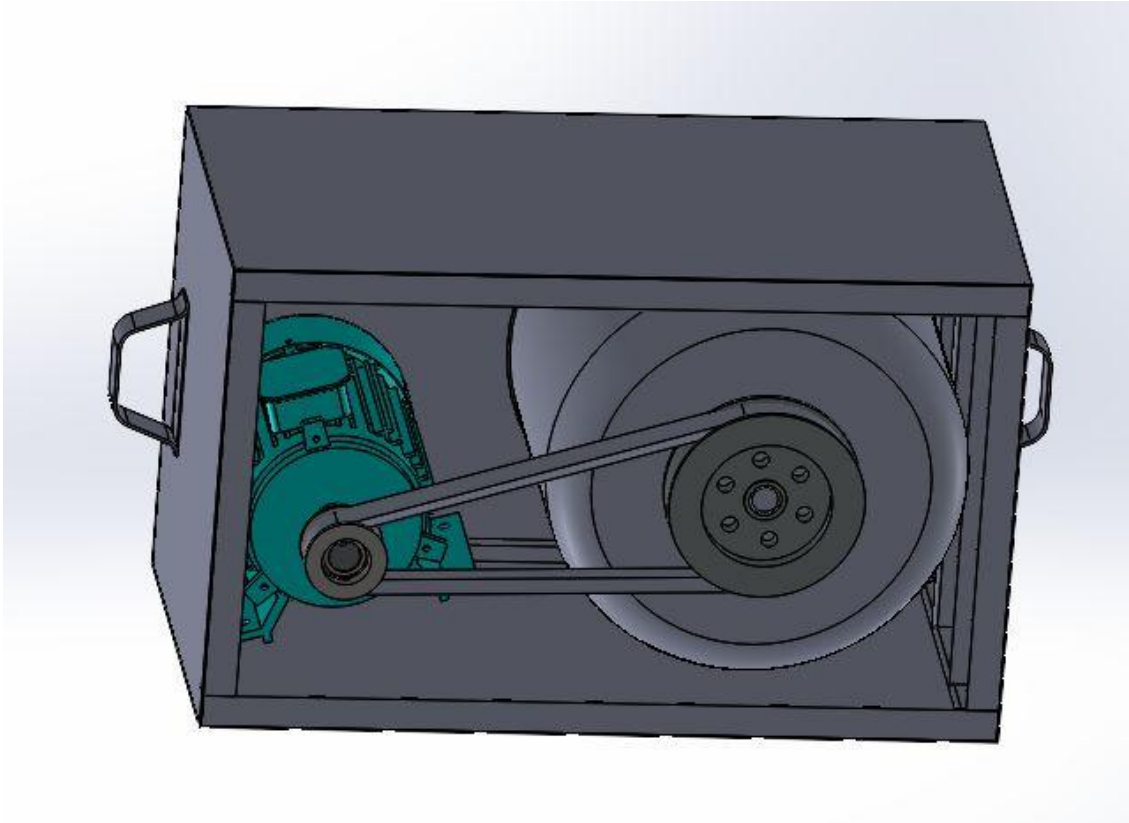


Figure 3.3 Orthographic views of yam pounding machine









*Figure 3.4 AutoCAD Design of the yam blending machine*

### 3.5 Bill of Engineering Materials and Evaluation (BEME)

#### Bill of Engineering Materials and Evaluation (BEME)

The bill of engineering materials and evaluation of the yam pounder is shown Table 3.2 below.

S/No	Component	Quantity	Spec/Capacity	Unit Cost	Total Cost =N=
1.	Shaft	1	ϕ 25mm, 100mm		10000
2.	Big Pulley	1	ϕ 50mm		5000
3.	Small Pulley	1	ϕ 30mm		5000
4.	V-Belt	1	A16		1500
5.	Bearing	1			5000
6.	Electric Motor	1	1hp		80000
7.	Blade	1			5000
8.	Bowl	1			7000
9.	Angle bar for frame work	1.5meter			10000
10.	Spray paint	1.5meter			5000
11.	Galvanized sheet for the casing	1roll			12000
12.	Welding electrodes	40			3000

13.	Wirings/Electricals	sum			8000
14.	Miscellaneous	lump	Sum		20500
15.	Labor				70000
	TOTAL				25000

*Table 3.5 Bill of Engineering Materials and Evaluation of the Fabricated Yam Pounder.*

### 3.6 Performance Evaluation Methodology

The constructed yam blending machine will undergo a rigorous performance evaluation to assess its efficiency, output consistency, and the primary objective of leakage prevention.

#### 3.6.1 Test Parameters

The following key parameters will be evaluated:

- i. **Blending Efficiency (Time and Quality):** The time taken to blend a specific quantity of yam to a desired, lump-free consistency.
- ii. **Output Consistency:** The uniformity of the blended yam paste (texture, smoothness, absence of unblended lumps).
- iii. **Leakage Effectiveness:** The primary assessment will be whether any yam paste or liquid leaks from the blending chamber, shaft seal, or lid during operation.
- iv. **Ease of Operation and Cleaning:** Subjective assessment based on user interaction.

#### 3.6.2 Experimental Setup and Procedure

- **Yam Preparation:** Fresh yam tubers will be peeled, washed, and boiled until uniformly soft, as typically done for pounded yam preparation.

- **Load Preparation:** Batches of boiled yam, standardized by weight (e.g., 300g, 400g, 500g depending on machine capacity) and initial temperature, will be prepared for each test run. A small, measured amount of hot water will be added to facilitate blending, consistent with traditional methods.
- **Machine Setup:** The blending machine will be placed on a stable, level surface. All safety features (lid interlock, E-stop) will be verified for functionality prior to each test.
- **Blending Trials:** A pre-weighed batch of boiled yam will be loaded into the blending chamber.
  - The lid will be securely closed, activating the safety interlock.
  - The blending process will be visually monitored through the transparent lid.
- **Leakage Observation:** During and immediately after each blending run, the machine will be meticulously inspected for any signs of leakage around the lid, shaft seal, discharge points, or any other joints. Any observed leakage will be quantified (e.g., by collecting and weighing leaked material) and documented (location, severity).
- **Blending Time:** The time taken to achieve a visibly smooth and lump-free consistency will be recorded using a stopwatch.
- **Temperature Measurement:** Surface temperature of the motor and external casing will be measured using a non-contact infrared thermometer after a specified operation period (e.g., 2 minutes continuous blending).
- **Output Analysis:** The blended yam will be discharged and weighed to determine net output.

- **Consistency Assessment:** Samples of the pounded yam will be taken for qualitative assessment by a panel (e.g., 3-5 individuals) to evaluate smoothness, elasticity, and absence of lumps on a qualitative scale (e.g., 1-5, where 5 is excellent). Objective texture analysis (e.g., using a Texture Analyzer for properties like stickiness, firmness, elasticity) would be ideal if resources permit.
- **Repeatability:** Multiple trials (e.g., 5-10 runs for each batch size/speed setting) will be conducted to ensure the consistency and reliability of the machine's performance and leakage prevention.

## CHAPTER FOUR

### RESULTS AND DISCUSSION

#### 4.1 Results

The results of the experimental determination of the yam pounding test is shown in section 4.11

##### 4.1.1 Pounding time

The Table 4.1 shows the record of values for the observations made in the experimental determination of time to pound yam.

The following key parameters will be evaluated:

<b>TEST 1 31/10/2025</b>		<b>Mass of yam feed in (g)</b>	<b>Mass of yam feed out (g)</b>
Pound Start Time	0.0s	300	
Pound Stop Time	43.85		297
Total Time for pounding the yam	44s		
<b>TEST 2 31/10/2025</b>			
Pound Start Time	0.0s	400	
Pound Stop Time	1mins.02s		398
Total Time for Pounding	1mins.0.2s		
<b>TEST 3 31/10/2025</b>			
Pound Start Time	0.0s	500	
Pound Stop Time	2mins.43s		470
Total Time for Pounding	2.71min		

*Table 4.1 Time taken to pound given amount of cooked yam.*

From the Table 4.1 it reveals that the time it takes for the machine to pound given amount of cooked yam (500g) was 2 to 3 minutes irrespective of whether it is a new or old yam. A comparison with the manual method of pounding yam using human effort showed that the human effort of pounding takes about 10 or 15 minutes.

On the average, 500g of yam was fed into the pounding machine and it took 2.71 minutes to pound yam with the fabricated yam pounding machine with an average output of pounded yam estimated as:

$$\text{Average output (g) of pounded yam} = \frac{297+398+470}{3} = 388.33\text{g}$$

From the pounded yam output it could be inferred that some negligible amount of pounded yam stuck to the internal walls of the pounding bowl. The stuck amount of pounded yam added to the output in the subsequent test runs.

The cumulative average time it took to pound 400g of cooked yam during the three test runs is expressed as:

$$\text{Average time to pound g of yam} = \frac{44+62+183}{3} = 89\text{s}$$

The average mass of yam fed into the yam pounder before pounding operation is expressed as:

$$= \frac{300+400+500}{3} = 400\text{g}$$

#### **4.1.2 Machine throughput capacity**

The machine throughput was estimated as;

$$\text{Machine throughput capacity (g/s)} = \frac{\text{Average mass of yam feed (g)}}{\text{average time taken to pound (s)}} \quad 4.1$$

Average feed output = 400g in 89sec

Therefore; in 1hr, the machine will pound  $\frac{3600}{89} \times (400) \text{ g} = 16,180\text{g}$  of cooked yam

Therefore machine throughput capacity =  $\frac{16180\text{g}}{1\text{hr}} = 16180\text{g/hr}$

In Kg = 16.18kg/hr

Pounding efficiency = load output  $\frac{\text{Average load output (kg)}}{\text{Load input in (kg)}} \times 100$  4.2

where:

Average Load input = 400g

Average load output =388.33g

Therefore efficiency of pounder =  $\frac{388.33}{400} \times 100 = 97\%$ .

#### 4.1.3 Textural characteristics of the pounded yam made from the machine

Table 4.2 shows the remarks from 10 students who tested and had a touch of the pounded yam. Their remarks were graded on the Rankart's scale of Very poor, Poor, Good, Very good, Excellent

Parameter	Remarks by testers in numbers				
	Very poor	Poor	Good	Very Good	Excellent
Hardness	0	0	1	2	7
Deformability	0	0	0	6	4
Cohesiveness	0	0	0	2	8
Adhesiveness	0	0	1	1	8
Stringiness	0	1	0	2	7
Springiness	0	1	2	2	5
Stickiness	0	0	1	2	7

*Table 4.2 Textural characteristics of pounded yam made with the pounding machine.*

## CHAPTER FIVE

### CONCLUSION AND RECOMMENDATION

#### 5.1 Conclusion

The design and fabrication of a yam blending machine with an effective leakage prevention mechanism was successfully carried out. The project was conceived to address the challenges associated with manual yam pounding and the leakage problems prevalent in existing mechanized yam blending systems. Through detailed design analysis, material selection, and experimental testing, the constructed machine achieved efficient, hygienic, and consistent blending of boiled yam.

Performance evaluation revealed that the machine produced an average throughput of 16.18 kg/hr with an estimated blending efficiency of 97%, confirming its operational effectiveness and suitability for small- and medium-scale food processing. The average time required to blend 400 g of cooked yam was approximately 89 seconds, representing a significant reduction in processing time compared to manual pounding, which typically takes 10–15 minutes for similar quantities.

Qualitative assessment of the pounded yam showed favorable results in terms of smoothness, elasticity, and cohesiveness, comparable to manually pounded yam. The integration of robust seals and an improved chamber design effectively minimized material leakage, which was one of the core objectives of this research. Additionally, the use of food-grade stainless steel enhanced hygiene, corrosion resistance, and durability.

The project therefore demonstrates that locally fabricated yam blending machines can meet modern processing standards when appropriate engineering design principles and

material considerations are applied. The fabricated machine is not only efficient and user-friendly but also promotes the local development of agricultural processing technologies, contributing to food security, employment, and industrial growth in Nigeria.

## **5.2 Recommendation**

Based on the results and observations made during the design, fabrication, and testing phases, the following recommendations are proposed:

### **1. Material Enhancement:**

Future designs should employ higher-grade stainless steel (e.g., SS316) for all food-contact parts to further improve corrosion resistance and long-term hygiene performance.

### **2. Motor Power Optimization:**

Although a 1 hp motor performed adequately, integrating a motor with adjustable speed control would enhance blending flexibility and energy efficiency for different yam textures and quantities.

### **3. Improved Safety and Automation:**

Incorporation of safety sensors, overload protection, and automatic shut-off features would further enhance operational safety and prolong machine life.

### **4. Scaling for Commercial Use:**

The current prototype can be upscaled for industrial applications by increasing chamber capacity, reinforcing the frame, and integrating automated feeding and discharge systems.

**5. Comprehensive Testing:**

Further research should include detailed rheological and thermal analysis of pounded yam to optimize blade geometry, speed, and temperature control for superior textural quality.

**6. Standardization and Local Adoption:**

It is recommended that relevant government agencies (such as NAFDAC and SON) develop standards for locally fabricated food-processing machines to ensure quality, safety, and widespread acceptance.

**7. Training and Dissemination:**

Fabrication workshops and technical training programs should be established to encourage local artisans and entrepreneurs to replicate and improve upon this design for community-level yam processing enterprises.

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