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DESIGN AND CONSTRUCTION OF AN ELECTRIC VEGETABLE CUTTER

BY

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BU/UP/2023/1645

A STUDY REPORT SUBMITTED TO THE DEPARTMENT OF PHYSICS IN PARTIAL FULFILMENT OF THE REQUIREMENTS LEADING TO THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE WITH EDUCATION OF BUSITEMA UNIVERSITY

JUNE/2026

DECLARATION

I, Chemutai Obed hereby affirm that this project work is my own original presentation, and no part has been copied or submitted to any institution of higher learning for any academic award.

Signature: ………………………

Date: 27/8/2026

Chemutai Obed

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APPROVAL

The project work of this candidate has been directly under my supervision and with my approval, it's now ready to be presented to the Board of Examiners and Senate of Busitema University for further Examination.

Supervisor

Signature ………………… Date 27/8/2026…………………

Dr. Michael Robson Atim

Department of Physics.

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DEDICATION

To my beloved parents, Ngatia John Nderitu, Yapsikoria Beatrice. My brothers and sisters Nderitu Shedrack, Mwangi Enock, Wanjiru Janet, Dirango Amos, Chebet Anthoney, Muthoni Winnie, Sande Gifty Ham and Ndirango Mark.

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I thank my fellow physics Students class of 2026 Busitema University and everyone who directly or indirectly contributed to the accomplishment of this work.

Finally, I extend my appreciation to my family members and friends for the prayers and support. May the Almighty God bless you?

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ABBREVIATIONS

AC- alternating current

Eff. – efficiency

Kg - kilogram

RPM- rotations per minute

V - Voltage

(%) - percentage

ABSTRACT

Food preparation in homes, restaurants, and institutions often require cutting vegetables into smaller pieces for cooking. Manual cutting using knives is time consuming, labor intensive and sometimes unsafe. This project focuses on the design and construction of an electric vegetable cutter powered by an AC motor to improve efficiency, reduce preparation time and increase safety. The system consists of feeding inlets, rotating cutting blades, electric motor, housing wooden frame, and an outlet for chopped vegetables. The machine operates by converting electrical energy to mechanical rotational motion, which drives cutting plates. During testing, variables such as cutting speed, motor power consumption, cutting efficiency and size uniformity of vegetables are measured.

The device is suitable for domestic kitchens, school kitchens, restaurants, prison kitchens and small food processing units.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study.

According to Biology, vegetables are essential components of human diets because vegetables provide vitamins, minerals and antioxidants. However, before cooking, vegetables must often be chopped/sliced. Traditional cutting methods using knives require time, skill and can result in injuries (Lehto, 2019).

With the advancement of food processing technology, machines have been developed to assist in vegetable cutting. Mechanical vegetable cutters help increase productivity maintain uniformity in size and reduce physical effort (Uguru-okorie et al., 2021).

Electric vegetable cutters operate using electric motors that rotate cutting blades to slice vegetables rapidly. Such machines are widely used in restaurants, hotels and food processing industries (Uguru-okorie et al., 2021). However, many commercially available machines are expensive and not easily accessible in developing regions. Therefore, designing a low cost locally constructed vegetable cutter using readily available materials can improve accessibility.

1.2 Problem statement

Vegetable cutting is one of the most common activities in homes, restaurants, hotels, and food-processing industries. However, manual cutting of vegetables is labor-intensive, time-consuming, and often results in worker fatigue, especially when large quantities are involved. The use of knives and other sharp cutting tools also exposes users to accidents such as cuts and lacerations, which account for a significant proportion of kitchen-related injuries. In addition, manual cutting frequently produces vegetables of uneven sizes and shapes, leading to inconsistencies in cooking quality, appearance, and food presentation.

Studies on food preparation processes indicate that manual cutting can consume a considerable amount of preparation time and labor, reducing overall productivity in commercial kitchens and small-scale food enterprises. Although electric food processors and vegetable cutters are available on the market, many of them are expensive, costing hundreds of dollars, and are therefore unaffordable for many households, schools, restaurants, and small businesses in developing countries. Furthermore, some commercial machines are complex to operate, difficult to maintain, and not specifically optimized for simple vegetable-cutting tasks.

Therefore, there is a need to design and develop an affordable, user-friendly, safe, and efficient electronic vegetable cutter that reduces labor requirements, minimizes accident risks, improves cutting uniformity, and increases productivity while remaining accessible to local users and small-scale food-processing enterprises.

1.3 Aim and objectives of the study

1.3.1 Aim of the study

This research was aimed at designing and constructing an electric vegetable cutter that can efficiently cut vegetables using an AC motor

1.3.2 Specific objectives

This study was guided by the following objectives.

1. To design the mechanical structure of the vegetable cutter.
2. To construct the cutting mechanism using rotating blades.
3. To integrate an AC motor to drive the cutting blade.
4. To test the performance of the vegetable cutter.
5. To evaluate efficiency of the machine.

1.4 Scope of the Study

This project focuses on the design and construction of a small-scale electric vegetable cutter using an AC motor, cutting blades, a feeding inlet, and an outlet system. The machine is intended for domestic and small-scale commercial applications such as homes, restaurants, cafeterias, and food vending businesses. The cutter utilizes a circular blade carrier mechanism to achieve uniform vegetable slicing and improved operational efficiency.

The study is limited to the use of a single-phase AC motor rated at 0.5 HP (approximately 370 W) operating at 220-240 V. The designed machine has an estimated processing capacity of 20-30 kg of vegetables per hour, depending on the type and size of the vegetable being processed.

The investigation focuses on commonly consumed vegetables that are suitable for slicing and shredding operations, including carrots, egg plants, onions, and Sukuma. Performance evaluation is based on parameters such as cutting efficiency, uniformity of cuts, processing capacity, power consumption, and operational safety.

The scope does not include automated sorting, grading, washing, peeling, or packaging of vegetables. In addition, the machine is not intended for processing hard materials such as bones, frozen foods, or non-food products. The study is further limited to the design, fabrication, testing, and performance evaluation of the prototype under laboratory conditions.

1.5 Significance of the Study

This study is significant because it contributes to improving safety during food preparation and presentation by minimizing direct contact between the user and cutting tools, thereby reducing the risk of injuries.

The electric vegetable cutter also helps to reduce the time required for cutting vegetables, making food preparation faster and more efficient.

In addition, the project promotes local fabrication and technological innovation by encouraging the development of food-processing machines using locally available materials and skills.

Furthermore, the machine enhances productivity in kitchens, restaurants, and small-scale food industries by enabling large quantities of vegetables to be processed within a short period. Ultimately, the project supports the modernization of food preparation processes, improves operational efficiency, and contributes to the growth of small and medium-sized enterprises in the food sector.

1.6 Report organization

The remainder of this report is organized into four chapters.

1.6.1 Chapter Two: Literature Review.

This chapter presents the existing literature, principles of operation advantages and limitations of available systems and the theoretical background of the project.

1.6.2 Chapter three: materials and methods.

This chapter presents the methods and procedures used in carrying out the project. It includes research design, materials and equipment used, system design, circuit diagrams, working principles, construction procedures and testing methods. The chapter further explains how the electronic vegetable cutter was developed and implemented.

1.6.3 Chapter four: Results and Discussion

This chapter presents the results obtained after the construction and testing of the electronic vegetable cutter. It discusses the performance of the system, efficiency of operation, observations made during testing, challenges encountered and interpretation of findings. Relevant tables, figures and photographs are included.

1.6.4 Chapter five: Conclusions and Recommendations.

The summary of the study; conclusions drawn from the findings and recommendations for improvement of the electronic vegetable cutter are presented here. It also suggests possible areas for further research and development.

CHAPTER 2: LITERATURE REVIEW

2.1 introduction

This chapter reviews the literature related to the design and construction of an electric vegetable cutter. The review provides a theoretical and practical foundation for understanding the principles, components, and technologies involved in vegetable cutting systems. It also examines previous studies and existing designs to identify strengths, limitations, and opportunities for improvement that informed the development of the proposed machine.

The chapter begins with a brief history of vegetable cutters, highlighting their evolution from traditional manual cutting tools to modern mechanized and electrically powered systems. It then reviews existing electric and mechanical vegetable cutters, focusing on their operating principles, advantages, and limitations.

Furthermore, the chapter discusses the major components of electric cutting systems, including AC motors, cutting blades, and power sources. Attention is given to the operating principles, construction, types, and applications of AC motors because they form the primary driving mechanism of the proposed vegetable cutter. The functions and characteristics of cutting blades and energy supply systems are also examined.

Finally, the chapter identifies gaps in existing vegetable cutter designs and explores opportunities for improvement in terms of efficiency, safety, cost, durability, and ease of operation. The reviewed literature provides the basis for the design choices and methodologies adopted in this study.

2.2 brief history about vegetable cutter

Vegetable cutting devices have evolved from simple manual tools to advanced mechanized systems**.** Immediate consumption of most vegetables is impossible if their size is not reduced. This has been a problem of agro-processing size reduction of vegetables and as such slicing vegetables is one of the most popular ways to reduce their size. Traditionally vegetables are sliced using bare hands and knives (Lehto, 2019). This method is dangerous and characterized by poor hygiene and low efficiency. The sliced vegetables are of varying sizes and lack the quality appreciated by consumers. To ameliorate this challenge a vegetable cutting machine is important to be designed (Ahmed et al., 2024).

The history of manual vegetable cutters can be traced back to early food –preparation tools used centuries ago (Kubota et al., 2008). Before specialized cutters existed, vegetables were mainly cut using knives and simple chopping tools. As culinary practices developed, people begun creating mechanical slicing tools to produce uniform vegetable pieces more quickly and safely (Aguilera, 2018). Early versions of such devices appeared in Europe where cooks used stationary cutting boards fitted with blades to slice vegetables for large meals and food preservation (Uguru-okorie et al., 2021).

By the 17th to 19th centuries, specialized slicing tools began to appear in European kitchens. One well-known example is the mandolin slicer, which became common in France. The mandolin used a flat surface with a fixed blade where vegetables could slide across to produce thin and uniform slices. This design greatly improved speed and consistency in vegetable preparation and is considered one of the earliest forms of a manual vegetable cutter.

Figure 2. 1*: Existing cutter.*

Manufactures also began producing mechanical kitchen appliances with handles that allowed users to cut vegetables by applying manual force. These tools increased productivity in both domestic and commercial kitchens and were widely adopted before electric appliances became common.

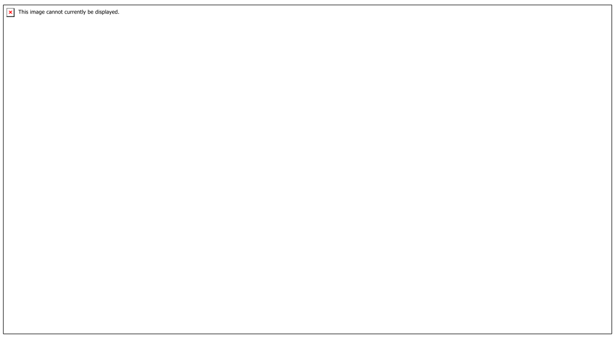

Figure 2. 2*: Existing manual cutters.*

These manual cutters were not expensive, easy to use, and required no electricity, making them suitable many households. They became an important step in evolution of kitchen technology before the wide spread adoption of electric food processors and electric vegetable cutters (Liu et al., 2019).

2.3 Existing Electric and Mechanical Vegetable Cutters

Traditional and mechanical vegetable cutters commonly used in kitchens range from simple manual tools to more advanced devices; traditionally kitchen knives remain the most widely used for slicing and chopping vegetables due to their versatility (Rifka Alkhilyatul Ma'rifat, I Made Suraharta, 2024), often used alongside wooden or plastic chopping boards to ensure safety and efficiency (Aguilera, 2018), while handheld peelers are essential for removing skins before cutting (Kohli et al., 2021), and graters are used for shredding vegetables like carrots and cabbage (Kingsley A. et al., 2020); in many traditional settings, a mortar and pestle is also used to crush or grind vegetables; mechanical but manually operated tools include mandolin slicers for uniform cuts (Raj, 2009), hand-operated vegetable choppers that use pressing or pulling mechanisms (Manual, 2024), rotary drum cutters with rotating blades for slicing and grating (County & Brown, 1858), mechanical lever cutters that apply force for efficient cutting and spring-loaded choppers that function through downward pressure (Cadet & 2024); more advanced mechanical devices include manual food processors that are hand-cranked, as well as electric vegetable cutters and food processors which automate cutting, slicing, and dicing operations, while blender-based cutters use high-speed rotating blades to finely chop or puree vegetables (Ganyani & Mushiri, 2019).

2.4 components of Electric Cutting Systems (Motors, Blades, Power Sources).

2.4.1 AC motor

2.4.2. Historical Development of AC Motors

The development of AC motors can be traced back to the late nineteenth century with the work of several pioneers in electrical engineering **(Guarnieri, 2018)**. Nikola Tesla played a major role in the invention of the induction motor, which is the most widely used type of AC motor today. Tesla's invention was demonstrated in 1888 and later became a key component of alternating current power systems (Swezey & Swezey, 1948).

At the same time, Galileo Ferraris independently discovered the principle of the rotating magnetic field. This discovery provided the scientific basis for the operation of AC motors. The practical implementation of these discoveries was further supported by the power distribution systems developed by George Westinghouse.

According to Electrical Machines, Drives and Power Systems by Theodore Wildi, the widespread adoption of AC motors occurred in the early twentieth century when industries required efficient and reliable electric drives for machinery.

Existing vegetable cutting systems, both manual and electric, offer several advantages. Manual cutters such as knives, peelers, and hand-operated slicers are inexpensive, readily available, easy to use, and do not require electricity. They are suitable for small-scale domestic applications and provide flexibility in cutting different types of vegetables. On the other hand, electric vegetable cutters and food processors significantly reduce the time and effort required for food preparation. They can process large quantities of vegetables quickly, produce more uniform cuts, improve productivity, and are particularly useful in commercial kitchens, restaurants, and food processing industries.

Despite these benefits, existing systems also have notable disadvantages. Manual cutting methods are labor-intensive, time-consuming, and highly dependent on the operator's skill. Prolonged use can cause fatigue, and there is a high risk of cuts and injuries due to direct contact with sharp blades. Electric vegetable cutters, while faster, are often expensive to purchase and maintain. They require a continuous power supply, consume electrical energy, and may be too complex for users with limited technical knowledge. Additionally, some models occupy considerable kitchen space and generate noise during operation.

The limitations of current vegetable cutting systems further justify the need for improved designs. Manual cutters cannot efficiently handle large volumes of vegetables and often produce inconsistent cutting sizes, which affects cooking quality and presentation. Many electric cutters are designed as multipurpose food processors rather than dedicated vegetable-cutting machines, making them unnecessarily complex and costly for simple cutting tasks. Some existing systems also lack adequate safety features, are difficult to clean, and it is not suitable for small-scale users due to their high cost and maintenance requirements. These limitations highlight the need for an affordable, safe, efficient, and easy-to-maintain electric vegetable cutter specifically designed for domestic and small commercial applications.

2.4.3 Basic Operating Principle of AC Motors

AC motors operate based on the principle of electromagnetic induction. When alternating current flows through the stator windings, a rotating magnetic field is produced (Boldea & Fellow, 2017). This magnetic field interacts with the rotor conductors, inducing current and producing torque that causes the rotor to rotate.

According to Electric Machinery by A.E. Fitzgerald, the speed of the rotating magnetic field is known as synchronous speed, which depends on the frequency of the supply and the number of poles in the motor**.**

The synchronous speed is given by:

$$\boldsymbol{Ns = \frac{120f}{P}}$$

Where:

$\mathbf{N_S}$ = synchronous speed (rpm)

$\boldsymbol{f}$ = supply frequency (Hz)

$\boldsymbol{P}$ = number of poles

This relationship shows that AC motor speed can be controlled by adjusting the supply frequency or changing the number of poles.

2.4.4 Types of AC Motors

AC motors are generally classified into two main categories: synchronous motors and induction motors.

Induction Motors

Induction motors are the most widely used type of AC motors because they are simple, rugged, and economical. In these motors, the rotor current is induced by the stator magnetic field without direct electrical connection (Ceban et al., 2012). According to Electric Machinery and Transformers by Bhag S. Guru, induction motors are commonly used in household appliances and industrial machines.

There are two main types of induction motors:

Squirrel cage induction motor

Slip ring induction motor

The squirrel cage motor is more common due to its simple construction and durability.

Synchronous Motors

Synchronous motors operate at a constant speed equal to the synchronous speed of the magnetic field. Unlike induction motors, synchronous motors require external excitation for the rotor (Puranen, 2006)**.** According to Electric Machinery Fundamentals, synchronous motors are mainly used in applications requiring precise speed control such as clocks, compressors, and power factor correction systems.

Food processing equipment

In food processing devices such as electric vegetable cutters, the AC motor provides rotational motion to cutting blades, enabling rapid and uniform cutting of vegetables. According to Food Processing Technology, motor-driven cutting machines improve processing efficiency and reduce manual labor in food preparation (Kadim & Mahgoub, 2007).

Advantages of AC Motors

AC motors have several advantages that make them suitable for engineering applications which include:

High efficiency

Simple construction

Low maintenance requirements

Long operational life

Compatibility with AC power supply systems

According to Electric Machinery Fundamentals, these advantages have made AC motors the most widely used electric motors in modern industry (Boldea & Fellow, 2017)**.**

2.4.5 Relevance of AC Motors in Engineering Design Projects

In engineering design projects, the selection of an appropriate motor is important for ensuring efficient operation of mechanical systems. For devices such as electric vegetable cutters, the motor must provide sufficient torque to rotate the cutting blades while maintaining stable speed (Barta et al., 2019).

AC motors are commonly selected for such designs because they are readily available, affordable, and capable of continuous operation (Dorrell et al., 2014)**.** Their integration with cutting mechanisms allows automated food processing systems to operate efficiently and safely

2.4.6 Cutting blade

The blade is the component that performs the cutting action. It converts the motors rotational energy into mechanical cutting force.

2.4.7 Power source (energy supply component)

The power source supplies electrical energy required to run the motor and the entire cutting system.

Types of power sources

AC power (mains electricity): comes from the wall socket and its commonly used in household and industrial cutters.

DC power (batteries): used in portable devices, rechargeable batteries increase mobility.

Alternative sources: generators or Solar systems (less common in small cutters)

Function in the system.

Supplies electrical energy to the motor.

Determines power rating and efficiency

Influences portability.

2.5 Gaps in Existing Designs and Opportunities for Improvement

Existing electric and mechanical vegetable cutting systems have several limitations that affect efficiency, safety, and usability. Most traditional vegetable cutters rely heavily on manual operation, which requires considerable physical effort and increases the risk of hand injuries caused by direct contact with sharp blades. Many commercially available electric cutters are expensive, bulky, and designed for large-scale food processing, making them unsuitable for household users, small restaurants, and small-scale food vendors. In addition, several existing designs use low-power motors that experience overheating during prolonged operation, resulting in reduced efficiency, increased maintenance requirements, and shorter service life. Poor blade alignment, rapid blade wear, and inconsistent cutting performance are also common problems, leading to non-uniform vegetable sizes that negatively affect food presentation and cooking quality. Furthermore, many existing machines consume relatively high amounts of electrical energy and lack portability due to their dependence on mains power and heavy construction.

Another weakness of previous designs is the limited consideration of user safety and hygiene. In many cases, cutting blades are partially exposed, increasing the likelihood of accidents during operation and cleaning. Some machines are also manufactured using materials that are difficult to clean or prone to corrosion, which can compromise food safety. Additionally, many designs offer only a single cutting mode, reducing their flexibility when processing vegetables of different shapes and sizes.

The proposed electric vegetable cutter addresses these shortcomings through a design that emphasizes safety, efficiency, hygiene, affordability, and ease of use. The machine incorporates a fully enclosed blade system and protective housing to minimize the risk of operator injury. Food-contact components are fabricated from stainless steel, ensuring resistance to corrosion and compliance with food hygiene requirements. A properly selected electric motor provides sufficient torque and stable blade speed, enabling consistent cutting performance while reducing the likelihood of overheating. The design also incorporates removable cutting blades for easy cleaning and maintenance, thereby improving operational convenience and hygiene.

Furthermore, the proposed cutter is designed to produce uniform vegetable slices, enhancing food quality and reducing preparation time. Its compact structure improves portability and makes it suitable for domestic kitchens, restaurants, schools, and small food-processing enterprises. Compared to existing systems, the machine offers a cost-effective solution that reduces labor requirements, improves productivity, minimizes food preparation time, and enhances user safety. Consequently, the proposed electric vegetable cutter contributes to the development of a more efficient, reliable, and user-friendly vegetable processing system capable of meeting the needs of both household and small-scale commercial users.

CHAPTER THREE: MATERIALS AND METHODS

3.0 Introduction

This section mainly involves research design, materials and components selection, conceptual and detailed design, Design considerations, Description of major components, working principle of the machine, construction procedure and testing and performance evaluation.

3.1 Materials and components

Table 3. 1*: Showing materials that were used.*

Material	Source
Single phase AC motor	0.75 HP (559 W), 1400 rpm.
Power switch	Bought from an electronic shop
Bolts and nuts	Garage spare parts shop
Electric cable	Electronic shop
Stainless steel	Local market
Wood	From a carpentry workshop
Voltage	AC current source
Bucket	Bought from the market
Cutting blade	Bought from the shop

3.2 Methods

3.2.1 Design of the vegetable cutter

The dimensions of the frame were measured as 11.5cm × 11cm and the holes were well marked followed by the measurements of the bucket where the radius was measured as follows:

Bottom radius = **19cm**

Top radius = **25cm**

The height of the bucket = **28cm**

The frame was designed to provide insulation and support the weight of the motor, the load carrier (bucket) and withstand the dynamic forces from the rotating components. The top of the wooden frame where the motor was measured to exactly match the motor holes which were **4cm ×2.4cm**

3.2.2 Construction of the vegetable cutter

3.2.2.1 Fabrication Procedure

The following step-by-step procedure was followed to fabricate the machine:

Hard wood was measured using a 30cm ruler with dimensions **11.5×11cm.**

The sides of wood were smoothened by a smoothening plane, and the holes were made using a driller.

The base rectangle was assembled (**11.5cm × 11cm).**

Four holes were made on the top of the frame where bolts and nuts are passed through to hold the bucket.

Figure 3. 1*: Construction of the frame*

3.2.2.2 Blade Preparation

A steel knife was bought from Nagongera market, the length and thickness measurements were done using a ruler and a vernier caliper respectively in the Physics laboratory.

The knife base or the handler was removed, and the steel metal was cut out using a grinder. The knife was measured such that it does not touch the sides of the bucket. The Centre of the blade was measured, and a hole was drilled at the center and the sides of the blade were sharpened on both sides by the grinder.

3.2.2.3 Holes drilling and Motor Mounting

Holes were drilled on top of the wood near the Centre as shown in figure 3.2

Figure 3. 2: *Holes drilling*

The AC motor was fixed at the top of the frame using M10 bolts aligning the motor shaft vertically upwards. The motor shaft was made sure that it was perfectly perpendicular.

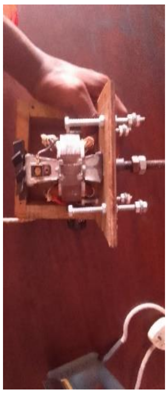

Figure 3. 3: *Motor mounting*

3.2.2.4 Bucket Modification

A food-grade plastic bucket was selected.

Four holes were made where the bolts and nuts were passed

A small circular hole at the bottom of the bucket to accommodate the blade was cut.

A rectangular outlet was made on the side of the bucket near the bottom, and the outlet cute chute was placed·

All cut edges were smoothened to avoid injury.

Figure 3. 4*: Bucket modification*

3.2.2.5 Bucket Mounting

The modified bucket was mounted above the blade so that the blade sits inside the bucket through the bottom hole.

The bucket was secured to the frame using brackets and bolts.

The clearance of (2–3) mm between the blade and the bucket walls was considered.

3.2.2.6 Electrical Wiring

Connect the 3-core power cable to the motor terminals (Live, Neutral, and Earth). The switch was installed in series with the live wire. The earth wire was connected to a dedicated bolt on the metal frame. All connections were insulated with electrical tape and enclosed in a wooden box as shown in **Figure 3.5**.

Circuit diagram

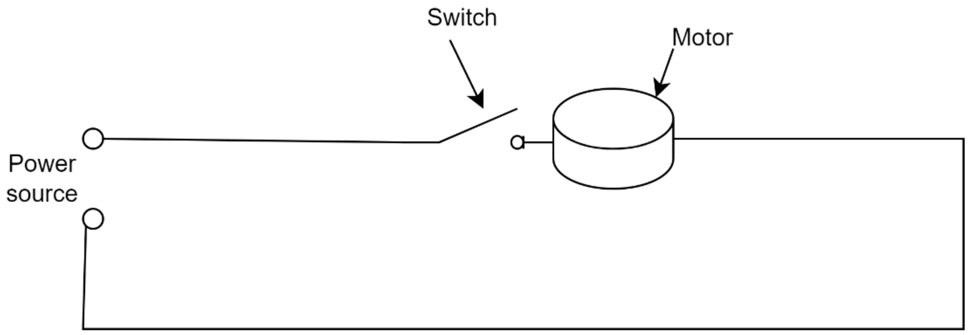

Figure 3. 5*: Circuit diagram*

Figure 3. 6*: Assembled frame*

3.3 Integrating an AC motor to drive the cutting blade

3.3.1 Blade mounting.

The blade was mounted tightly on the shaft using M17 bolts.

3.3.2 Design considerations

Several design factors were considered during the development of the electric vegetable cutter to ensure safe, efficient, and reliable operation. Safety was given high priority by ensuring that the cutting blades are adequately covered to prevent accidental contact and reduce the risk of injuries during operation. Hygiene was also considered by selecting stainless steel for all food-contact components because it is corrosion-resistant, easy to clean, and suitable for food-processing applications. Stability of the machine was enhanced using a strong and rigid frame capable of minimizing vibration during operation, thereby improving performance and user comfort. To achieve efficient cutting, a motor with adequate power was selected to provide sufficient torque for driving the cutting mechanism under varying load conditions. Additionally, ease of maintenance was considered by designing the cutter with removable cutting blades, allowing for convenient cleaning, sharpening, replacement, and routine servicing. These considerations contribute to the overall functionality, durability, safety, and effectiveness of the electric vegetable cutter.

3.3.3 Working principle of the machine.

The machine is connected to a 220-240 V AC supply.

When the switch is turned ON, current flows through the AC motor.

The motor rotates the shaft.

The shaft rotates the cutting plates.

Vegetables are fed through the hopper (inlet).

The rotating cutting plates slice the vegetables.

Cut vegetables exit through the outlet chute

Block diagram

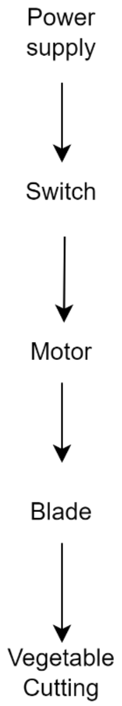

Figure 3. 7: *Block diagram*

3.4 Testing and performance evaluation

The machine's performance was evaluated based on three key metrics: Sukuma, tomatoes, and eggplants.

3.4.1 Cutting Efficiency Test

Prepare samples of Sukuma, carrots, and onions (washed and peeled where necessary).

Weigh each sample using a digital scale (accuracy ±1 g).

Start the machine and feed the vegetables through the inlet chute at a steady rate.

Collect the cut vegetables from the outlet chute.

Separate the acceptably cut mass (where acceptable mass is the mass which has been cut and collected from the

$$\boldsymbol{efficiency} = \frac{\boldsymbol{acceptable\ mass}}{\boldsymbol{total\ mass}} \times \mathbf{100}\%$$

Where acceptable mass is the mass which has been cut and collected from the outlet

Repeat each test three times and take the average.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Design calculations

4.1.1 Motor Power

The selected motor had the following specifications:

$$\boldsymbol{Motor\ power = 0.75\ HP}$$

$$\boldsymbol{Motor\ speed = 1400\ rpm}$$

Converting horsepower to watts

$$\boldsymbol{P = 0.75 \times 746}$$

$$\boldsymbol{P = 559.5\ W}$$

Therefore,

$$\boldsymbol{P = 559W}$$

The motor power was considered sufficient to rotate the cutting blade and overcome the resistance offered by vegetables during cutting.

4.1.2 Angular velocity of the motor

The angular velocity was calculated using:

$$\boldsymbol{\omega = \frac{2\pi N}{60}}$$

Where $\omega =$ angular velocity (rads/s)

$N =$ Rotational speed (RPM)

Substituting:

$$\boldsymbol{\omega = \frac{2 \times 3.142 \times 1400}{60}}$$

$$\boldsymbol{\omega = 146.6\ rads/s}$$

4.1.3 Torque produced by the motor

Motor torque was calculated from,

$$\boldsymbol{P = T\omega}$$

Rearranging,

$$\boldsymbol{T = \frac{P}{\omega}}$$

Substituting,

$$\boldsymbol{T = \frac{559}{146.6}}$$

$$\boldsymbol{T = 3.81Nm}$$

This torque was adequate for rotating blade and cutting vegetables continuously.

4.1.4 Bucket volume

The bucket was approximated as a frustum of a cone.

Given:

Top radius = 25cm

Bottom radius = 19cm

Height of the bucket = 28cm

Volume of frustum

$$\boldsymbol{V = \frac{1}{3}\pi h(R^2 + r^2 + Rr)}$$

$$\boldsymbol{V = \frac{1}{3} \times 3.142 \times 28(25^2 + 19^2 + 25 \times 19)}$$

$$\boldsymbol{V = \frac{1}{3} \times 3.142 \times 28 \times 1461}$$

$$\boldsymbol{V = 4280cm^3}$$

OR

$$\boldsymbol{V = 42.8L}$$

The bucket could accommodate approximately 42.8l of vegetables.

4.2 Constructed Machine

The electric vegetable cutter was successfully constructed according to the design specifications. The machine dimensions were measured using a ruler. The final product was robust and stable during operation. The integration of the bucket as a load carrier proved effective, providing a simple and hygienic processing chamber. The direct drive system eliminated belt slippage and reduced maintenance.

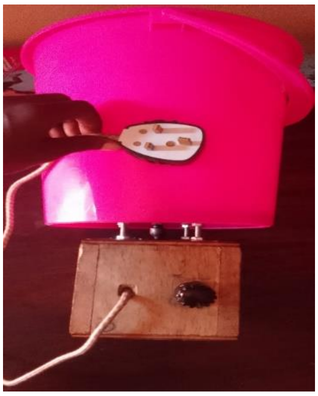

Figure 3. 8: *Constructed vegetable cutter*

4.3 Performance Test Results

The results of the performance tests are presented in **Table 4.2**.

Performance Evaluation of the Electric Vegetable Cutter

Table 4. 1*: Showing cutting efficiency*

Vegetable type mass(kg)	Trials	Input mass(kg)	cut mass(kg)	Cutting efficiency (%)
Tomatoes	1	0.025	0.0125	50
Tomatoes	2	0.025	0.0156	62.4
Egg plants	1	0.050	0.042	84
eggplants	2	0.050	0.046	92
Sukuma	1	0.050	0.038	76
Sukuma	2	0.050	0.041	82

4.3 Discussion of Findings

Cutting Efficiency: The machine demonstrated high cutting efficiencies, ranging from 76% for Sukuma to 84% for egg plants and a low cutting efficiency of tomatoes. This high efficiency is attributed to the sharp blade and the direct drive, which delivered full motor torque to the blade without losses.

Throughput Capacity: The motorized cutter showed a dramatic improvement in processing speed. This confirms that the machine effectively addresses the problem of time inefficiency.

Product Uniformity: The cut slices produced by the machine were not uniform
Safety and Usability: The machine was easy to operate. The use of the bucket as a containment chamber prevented accidental contact with the rotating blade, enhancing operator safety. The direct drive also reduced the risk of belt-related injuries.
Some results align with the literature, confirming that a well-designed machine with an AC motor and direct drive can effectively process vegetables. The performance surpasses that of the manual method in all key metrics, validating the project's main objective.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

This research successfully designed and constructed a functional electric vegetable cutter using a single-phase AC motor, a high-speed steel blade mounted via direct drive, and a modified bucket as the load carrier. The machine demonstrated excellent performance, with a high cutting efficiency, significantly outperforming manual cutting methods. The project achieved its primary aim of creating a cost-effective and efficient solution using locally available materials.

5.2 Conclusions

Based on the findings, the following conclusions were drawn:

- It is feasible to design and fabricate a high-performance electric vegetable cutter using locally available materials in Uganda.
- The direct drive system simplifies the design, reduces maintenance, and improves reliability compared to belt-driven alternatives.
- The machine performed satisfactorily for eggplants and Sukuma but exhibited reduced efficiency when processing tomatoes.

5.3 Recommendations

- It is recommended that small-scale restaurants and food vendors adopt this technology to enhance their operational efficiency and service speed.
- Use food-grade stainless steel for all parts that come into direct contact with vegetables to ensure the highest standards of hygiene and durability.
- The physics workshop could produce a few units of this machine for use by the university's catering department or for demonstration purposes in applied physics courses.

5.4 Suggestions for Further Research

- Material and Safety Optimization: Further research should focus on constructing a machine with a complete stainless-steel housing and a more robust interlock safety system that meets all EN 1678 standards.
- Power Source Variation: Research into using a solar-powered DC motor could be conducted to increase the machine's utility in off-grid areas of Uganda.
- Capacity Scaling: Studies could be undertaken to scale up the design for industrial use, employing a more powerful motor (for example, 2-3 HP) and a continuous feed system.

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