UNIVERSITY OF EDUCATION WINNEBA

COLLEDGE OF TECHNOLOGY, KUMASI

DESIGN, FABRICATE AND TEST OKRA SLICING MACHINE

BY

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APRIL, 2021

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION-KUMASI

FACULTY OF TECHNICAL/VACATIONAL EDUCATION

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PROJECT WORK SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING EDUCATION, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENT OF **MASTER OF TECHNOLOGY** IN MECHANICAL ENGINEERING

APRIL, 2021

DECLARATION

CANDIDATE'S DECLARATION

I declare that, this project work is the result of my original research and that, no part of it has been presented for another degree in this University or elsewhere.

Candidate's Name: **AKURUGU ERASMUS AYIKA**

Candidate's Signature:……………………….
Date:……………………………

SUPERVISOR'S DECLARATION

We hereby declare that, the preparation and presentation of this project work was supervised in accordance with the guidelines and ethnics on supervision of thesis laid down by the University of Education, Winneba

Candidate's supervisor: DR. K. OFFEH GYIMAH

Supervisor's Signature: ……………………………..

Date: ………………………………………………..

DEDICATION

I dedicate this project to the Almighty God who has been my strength and source of knowledge throughout the entire process. I also dedicate this project to all those who in diverse contributed to its success and to my dearest families for the support and encouragement.

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ABSTRACT

Okra is one of the most essential nutrition food item needed for human consumption from which high quality minerals and essential vitamins are derived. However, certain categories of consumers such as the children and elderly might not be able to patronize the delicacies made from okra due to the following reason; contamination and improper slicing of the okra. In order to address these problems, It has becomes necessary to have an okra slicing machine, to ensure that the problems can be eliminated, A slicing machine was developed base on four concepts generated and using the design and functional requirements. The circular cutter which will be operated manually was selected. The fabrication was done using locally available materials such as wood, stainless steel and galvanized steel The machine can slice 900 grames of okra within three minutes at an efficiency of 90%. The machine can be used both domestically and also be used for roots and tubers such as plantain. Potatoes etc.

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Okro or okra known in many English-speaking countries as ladies finger okra, is a flowering plant in the mallow family. It is valued for its green seed pods and its scientific name is*Abelomoschus Esculentus.* The geographical origin of okra or okro is disputed with supporters of West Africa, Ethiopia and South Asian origins. The plant is cultivated in tropical, subtropical and warm temperature regions around the world. Okra or okro is known by many local names in different parts of the world it is called lady's finger in England, gambo in the United States of America,guino-gomboinSpanish,guiberro in Portugal and bhind in India. It is quite popular in India because of its easy cultivation, reliable yield and adaptability to varying moisture conditions. Even within India different names have been given in different regional languages (Chauban, 1972). It is among the most heat and drought tolerant vegetable species in the world and tolerates soils with heavy clay and intermittent moisture content.

Ghana has rich and favorable climate zones making her suitable for its cultivation and production. In Ghana, the climatic requirement for okro cultivation is most favorable such that it can be cultivated anywhere as a warm seasoned crop. It does well in warm moisture, Low lying areas with evenly distributed annual rainfall of 1000 mm and a temperature range between 25-30 degree Celsius. Okro plant can withstand extreme temperatures amid the dry season. It is the fourth most popular vegetable after tomatoes, pepper, and garden eggs.

In Ghana,BrongAhafo, Ashanti, Northern,Volta, Greater Accra and Central regions are the bulk producers in terms of tonnage. About 10-15 Tonnes per Hectare of yield can be obtained under good management (NARP. 1993).

Okra provides an important source of vitamins and minerals, and has significant level of carbohydrate and potassium. The seeds of okra are reported to contain between 15 - 26 percent of protein and over 14 percent edible oil content (NARP.1993)

Okra is utilized both in fresh and dried forms for soups/stew making, and it could be used to fortify non-protein foods. Okra in powdered form, also exhibits properties as an emulsifier and isuseful in making emulsified prepared foods (Douglas.1982).

The variation in the sizes in which these products are obtained have made it expedient for certain reduction techniques to be utilized. Reducing it sizes either for further processing or to improve the eating quality or suitability for direct food consumption becomes very necessary. Processes such as cutting, slicing, mincing and pulping have been utilized to ensure the size reduction of these products. One of the processes commonly used is the slicing process. The slicing process from time immemorial, has involved the use of knives. But as technology advances, efforts have been made to eradicate the inefficiencies posed by the use of knives which are evident in the time wastage. The increase consumption of vegetables either domestically or commercially, has greatly influenced the variation in the slicing technology. With the basic principle of the action, shearing by blades and other types if cutters remaining the same. The vegetable slicing machine has utilized in the reducing varying sizes of vegetables A typical slicing machine consist of a product pusher, Push plate, Pusher support, Housing, Blade protector, blade, lock unit, Blade handle, Base plate and suction cup.

1.2 Problem Statement

Traditional Slicing involves using knife to cut the okra to the desired size, and to grate for food preparation. This has been considered difficult to operate as it is energy and time consuming, and prone to injury when care is not taken(Srivastava al. 2006). The process can lead to contamination due to the way the process is handle (Owolarefe et al. 2007)

1.3 Aim

The main aim of this project work is to design, fabricate and test an okra slicing machine.

1.4 Objectives

The specific objective is to:

- Review existing designs
- Design a slicing machine
- Fabricate a slicing machine
- Test a slicing machine

1.5 Scope of the Project

The emphasis of this project is to design, construct and test okra manual slicing machine which would be useful for domestic and commercial purposes.

CHAPTER TWO

LITERATURE REVIEW

The development of manually operated slicing machine is necessary to produce a machine that is portable and at the same time light in performance as compared to its size. Industries nowadays are trying hard to improve machine efficiencies to maximize outputs. As more amounts of energy and cost are reduced, there is direct or indirect increase in profit. In the case of manual machine, the higher the efficiency, the easier the machine would be operated as it requires less energy, (Burr and Cheantham, 1995)

2.1 Origin and Botany of Okra

Okra, (Abelmoschusesculentus L) has its origin in West Africa (Joshi et al., 1974; Kochhar, 1986). It is currently grown on a large scale in Africa, especially in the Sudan, Egypt and Nigeria (Joshi et al., 1974). It is also very important in other tropical areas including Asia, Central and South American. Okra is a warm-season annual herbaceous vegetable crop grown primarily for immature fruits used in soups and stews The Nile Basin seems to have been the route by which this plant spread through north Africa, the Eastern Mediterranean, Asia Minor and to India, Okra reached the new world by the way of Brazil and Dutch Guinea, African slaves brought okra to North America by way of New Orleans according to Hamon et al., (1990) and Bish et al., (1995). There are a number of varieties, both wild and cultivated. Some of these are esculentus, caillei, moschatus, manihot, ficulneusandtetraphyllus. Two species in the genus Abelmoschus are cultivated; manihot L. andmoschatus L. (Stevels, 1988; Siemonsma, 1991)

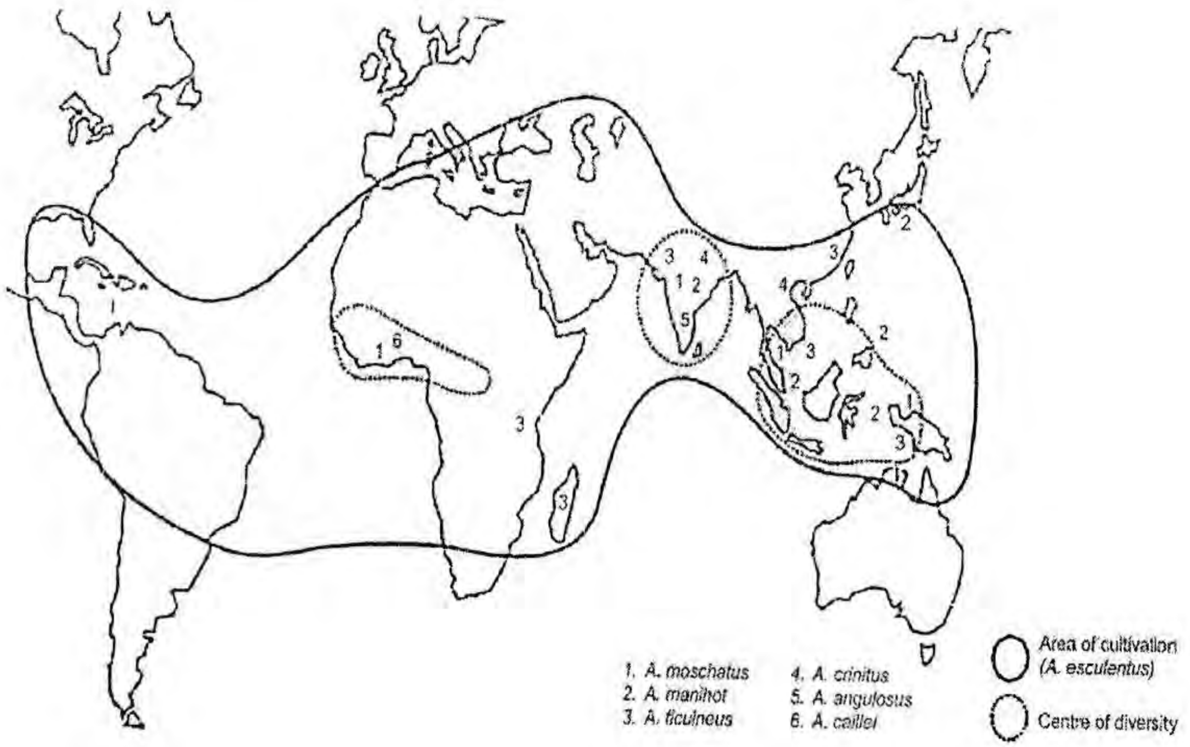


Figure 2.1 Geographical origin and Distribution

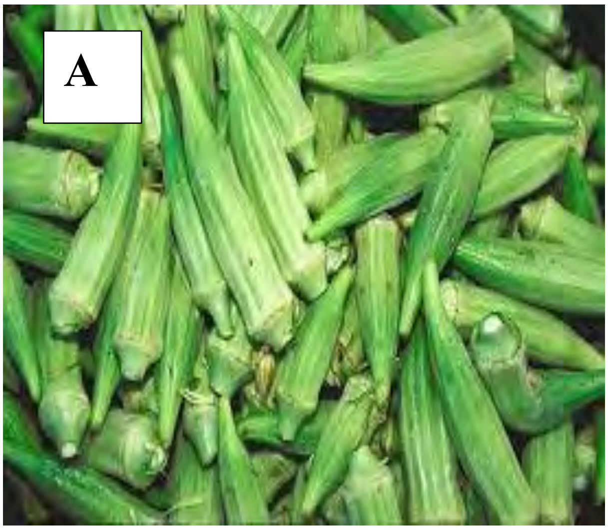
Okra is an amphidiploid having a complete diploid set of chromosomes derived from each parent form (Siemonsma,1982) with varieties displaying a tremendous variation in plant size, shape, fruit type and color. Okra seed is also similar in size to soyabeans and can be handled with most of the same equipment (Martin 1982). Okra plant is a semi woody, fibrous herbaceous annual with an indeterminate growth habit (Nonnccke,1989). The plant forms a deeply penetrating tap-root with dense shallow feeder roots reaching out in all direction in the upper part of the soil (45cm). The seeds are dicotyledonous and they vary in shape; roundness, kidney or spherical with epigeal germination (Hamon et al., 1991;

Ariyo,1993). The flowers of okra are self –compatible (Martin, 1983; Hamon et al., 1990). About 35-60 days after emergence, the plant begins to flower; the flower remains open for a day. It is mainly self-fertilized; however, insects such as bumble bees can cross-pollinate it. Immature fruit of 8-9 cm long are ready for harvest within 4-5 days. As fruits become mature, plant growth declines and few flowers developed.

Fruits are harvested from 4 to 7 days after the flower has opened, and the fruits are not fibrous (fruits 2 to 4 inches. long). Mature fruits should be removed and discarded as they reduce the plant growth and decrease yield (Purewal and Rhandhawa, 1947; Ramu, 1976). The rate of allogamy differs according to varieties and ecological conditions (Hamon et al., 1991). Okra has broad leaves and the flowers have five yellow petals with a large purple area covering the base. The fruits which are harvested immaturely, are pale green, green, or purplish fruits (Hamon et al., 1990). When matured, they are dark brown dehiscent or indehiscent capsules. The fruit shape ranges from round to ridged and short to long (siemonsma,1982). The plant and fruits may have small spines on them that create allergies in some people (Ariyo,1991; Duzyaman, 1997).

Figure 2.2 A and B: Typical Okra plants

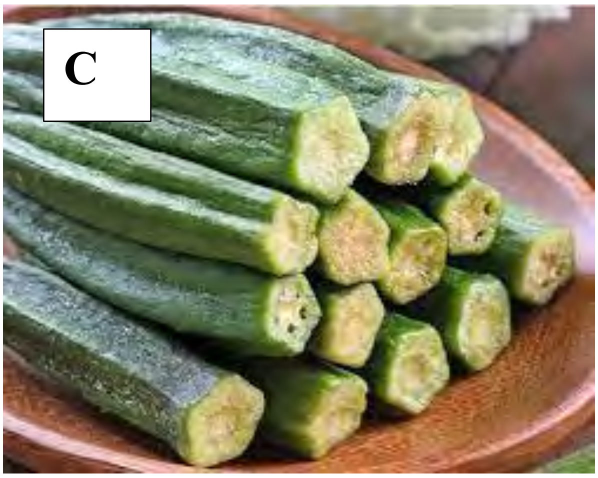
2.1.1 Varieties of Okra in Ghana



B

Cleamsonspincless

Lady's finger



D

Quim bimbo Labadi dwarf

Figure 2.3 A, B, C and D:Variety of okra in Ghana

2.2 Okra Nutritional Information

Okra is a source of valuable nutrients (Grubben et al., 1977; Candlish et al., 1987). Nearly half of which is soluble fiber in the form of gums and pectins. Soluble fiber helps to lower serum cholesterol, reducing the risk of heart disease (Brown et al., 1999). The other half is insoluble fiber which helps to keep the intestinal tract healthy, decreasing the risk of some cancer, especially colorectal cancer (Schneeman, 1998). Nearly 10 percent of the recommended levels of vitamin B6 and folic acid are also present in a half cup of cooked okra (Hamon and Charrier., 1997).

2.3 Physical Properties of Okra

Okra has some characteristic physical properties like diameter and length (Shape and size), volume, density, and surface area which vary from specie to specie. The length, maximum diameter, mass, density and percentage moisture content were determined as shown in Table

2.1 (Ogbobe,Ugwuishiwu, Origshagbemi& Ani,2007)

Table 2. 1 Physical properties of okra

Parameter	Big fruit	Medium	Small fruit
Length (mm)	84	73	28
Maximum Diameter (mm)	37	25	16
Mass (g)	23	19	3
Density (cm)	0.086	0.056	0.068
Moisture content(%w)	86.75	85.90	86.65

2.4 Environmental Requirements of Okra

Okra is a warm season crop grown between the minimum and maximum mean temperature of 18 degree Celsius (63fahrenheit) and 35degree (95fahrenheit) respectively (Martin. 1982). In recent years there has been interest in cultivating as it protects greenhouse effect the in Northern Europe (Buchholz et al., 2006). Optimum temperature requirements range from 21degree Celsius to 30 degree Celsius (Martin. 1982).

It develops well in a wide range of soil types with good drainage system. It is tolerant of wet and poorly drained and acidic soils (Incalcaterra and curatolo,1997). Okra does not do well in Water logged area but tolerates soil PH range of 6.0 to 7.5 (Incalcaterra and curatolo. 1997).

The addition of lime or dolomite may be necessary during soil preparation to keep the soil PH to about 6.0 to 6.5 (Incalcaterra and Caratolo, 1997). Optimum soil temperature for seed germination is 24'c -32 degree Celsius (75-90fahrenheit), (Martin, 1982). Short day length stimulates flowering of most cultivars (Martin. 1982). Flowering begins at very early stage of growth of less than 11 hours during the day. Okra is best eaten just after it is picked but it can be stored for several days. Okra will keep for 7-10 days when kept at a temperature between 45-50 degree Celsius with a relative humidity of 90%-95% (Martin. 1982)

Okra is very sensitive to ethylene gas, therefore not recommended to be stored with vegetables and fruits that give off ethylene gas such as apples and pears (Lutz and Hardenburg. 1966).

2.5 Slicing and Size Reduction

Slicing is a form of reduction and the general term ‘’size reduction’’ includes slicing, cutting, crushing, chopping, grinding, milling. The reduction in size is brought by mechanical means without change in chemical properties of the material and uniformity in size and shape of individual units of the end production (Leo and Balogun. 2009).

Such processes as cutting of vegetable for canning, shredding sweet potatoes for drying, slicing, chopping corn fodder, grinding grain for livestock feed and milling flour are size reduction operations, Reducing the size of food raw materials is an important operation to achieve a definite size range (Henderson and perry. 1980)

Size reduction may help in the extraction of desirable constituents from raw materials such as crushing fruits for juice or for fermentation. Some other operations in food processing and preservation are facilitated by smaller size particles. For instance, when food material such as yam is to be dried, it is cut into slices to expose more surface areas to drying medium. Similarly, in drying of okra or tomatoes, they are sliced into smaller pieces to facilitate heat transfer and removal of moisture (Leo and Halogun, 2009).

2.6 Historical Background of Vegetable Slicer

Cutting and slicing of agricultural material or product such as okra, onion,cucumber,tomatoes and carrot have been a great and a difficult task to agriculturists and processors. Over the years. Efforts have been made to mechanize some operations involved in cutting or slicing of agricultural materials and product as mentioned above. The act of vegetable processing is known to be as old as man in its development. Vegetable slicing or cutting is embarked at different stage in food processing either locally or industrially. Domestically, it is done by hand using tools such as knifes in the modern age and stones as well as objects with sharp edges in the primitive age. Mostly, the slicing of vegetables is still carried out using conventional method of hand and knife in different shape and size. The traditional slicing used by rural farmers, food processor, and house wife, contributes to high wastages, human energy losses and poor quality of cuts. As technology advances in recent times, electric appliances developed in 20th century, are used for variety of food preparation/processing functions including kneading,chopping,slicing,blending and pulverizing. An American Engineer and inventor, refined Verdun's machine to produce the Cuisinart. The widespread success of the Cuisinart following its exhibition in Chicago in 1973 led to a number of manufacturers to design competing models. Food processors are of two types, those in which most of the work is done in a single bowl by a flat blade and those fitted with many attachments. Standard accessories include a work bowl. Lid, chopping blade, mixing blade and disk for slicing and shredding (Britannica.Com)

Clark in 1987 reported that several slicing machines have been designed and tested in various developing countries especially the Caribbean and south—East Asia countries. Various types of machines are manufactured from small hand—operated batch –types to large automatic continuous operation models.

2.7 Review of Existing Slicers

Several slicing and dicing machines have been designed and tested in various developing countries especially the Caribbean and South East Asian countries as reported by Clarke, 1987. Various types of machines are manufactured from small hand—operated batch-types to large automatic continuous operation models.

Some are petrol, diesel or electric motor operation. There are cassava chippers,tomatoslicers, okra slicers and other root and vegetable choppers, Ukatu and Aboaba (1996).

2.7.1 Traditional Manual Kitchen Slicer or Cutter

The traditional manual kitchen slicing of fruit and vegetable such as tomatoes, onions, carrot etc involve the use of well sharpened knife-edge in its operation. In this method the fruit or vegetable is kept in a stationary position on a solid material mostly wood and knife edge is moved with pressure enough to initiate a cut on it. This cutting action depends on the strength and pressure applied by the processor's hand. This method is exploited daily in most kitchens and other food processing places. It is obviously cheap, easy to operate with little or no skill or no training. Its limitations are as follows: low output per unit time, Poor cut surface finish, unsafe and energy sapping to operators and finally cannot be used for commercial purposes.

Figure 2.4 Knife for slicing

2.7.2 Grater or Shredder

Grater is a kitchen appliance used to grate foods (vegetable) into fine pieces. It was invented by Francois Bouiler in the 1540. It is the commonly used method of slicing vegetables on the local market.

Figure 2.5 Grater

2.7.3 Stationary Slicing Machine

This is the most commonly used slicing machine in food processing both domestically and commercially. It consists of glass fiber casing which is mounted on a stainless, steel cutter placed at an angle of 30 degree to the direction of the vegetable movement. To ensure its stability and cutting efficiency, an adjuster,which selects the chip size to be cut is between 1.0-50mm, guidesthe cutter during its cutting action. In this method, the vegetable is held by and moved against the surface of cutting edge, producing regular and sized chips. Though the operator's hand becomesendangered as the food size diminishes, an improve version was later introduced onto the market. This works similar to the grater but comes with a bowl and a safety hat. The shortcoming of that design was that the safety hat had steel pins for gripping the vegetable to chip off and fall into bowl with the vegetable when the pins hit the cutting blade. Another short coming is that part of the vegetable gets stuck on the pins in the safety hat as it reduces in size thus wasting the vegetable (www.scharticles.com/improved.design-and-fabrication-of –a-portable-vegetable-cutting-or –slicing-machine)

Figure 2.6 Stationary slicer

2.7.4 Spiral Vegetable Slicer (Spiralizer)

Spiralizers are kitchen appliances used for cutting vegetable such as zucchinis, potatoes, cucumbers, carrots, apples, parsnips, and beetroots into linguine-like strands which can be used as an alternative. Spiralizers are especially popular among people following the paleodiet,other low-card diets and raw vegans. Spiralizers usually contain three blades; an around blade for spaghetti, a small flat blade for ribbons and a large wide blade for spiral strands. Vegetable isclamped between the blade and crank. As the handle turns with pressure, the vegetable is pressed between the turning handle and the blade which cuts into spirals. Spiralizers are often used to produce vegan or vegetarian meals or to make a lower-calorie or lower-carbohydrate version of a standard dish. In the case of potatoes, they can be used to make curly fries (Wikipedia. Org/Wiki/Spriral vegetable slicer 25/9/2018 1:15pm Wednesday).

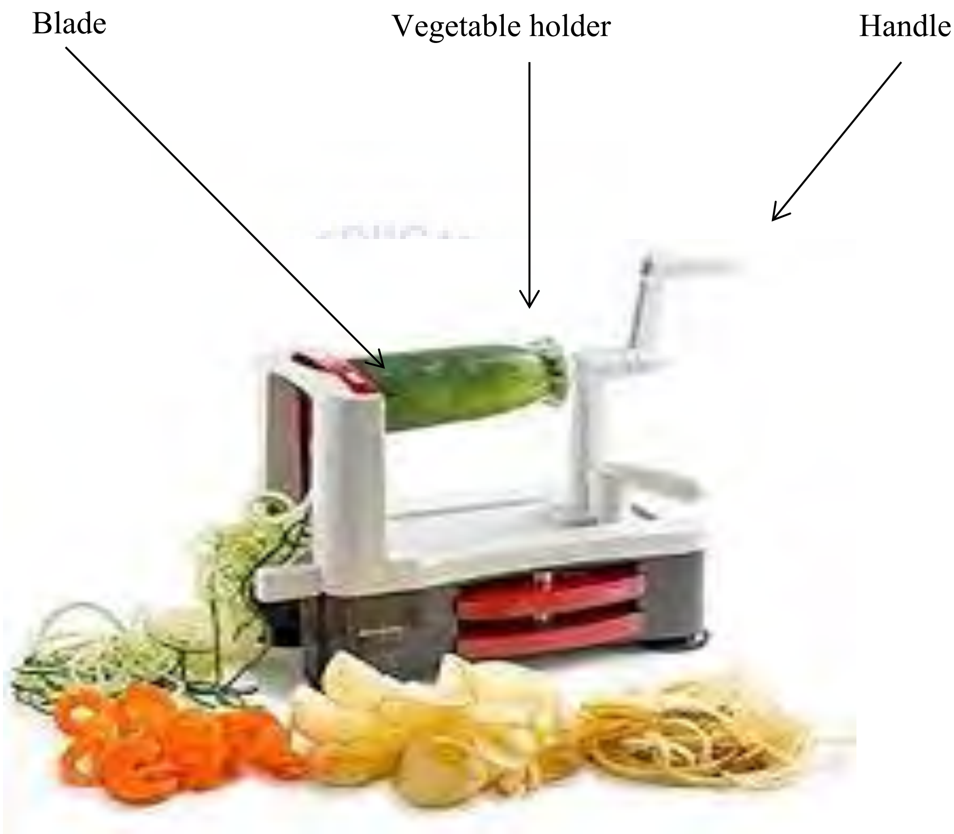


Figure 2.7 Spiral Slicer

2.7.5 Rotary Cutter Handfed Slicer

This type of sling machine was designed to eliminate difficulties associated with the stationary cutter food slicer. This machine designed; consists of a stainless cutter secured into a slot on a driven spur gear. The slot serves as a passage for sliced food vegetable materials.

The pinion mesh with the wheel and the fruit or vegetable is fed through a horizontal chute. During slicing operation, the handle is rotated manually, carrying the transmission element with the cutter. The food is fed into the machine horizontal against the cutter through the chute whiles the sliced food is forced out through the slot on the driven spur gear. The machine operates at a rate of 60 slices per minute. A major limitation of this machine is that its slice sizes cannot be adjusted like the stationary cutter (www, scharticles.com/improved design and fabrication of a portable vegetable cutting slicing or slicing machine).

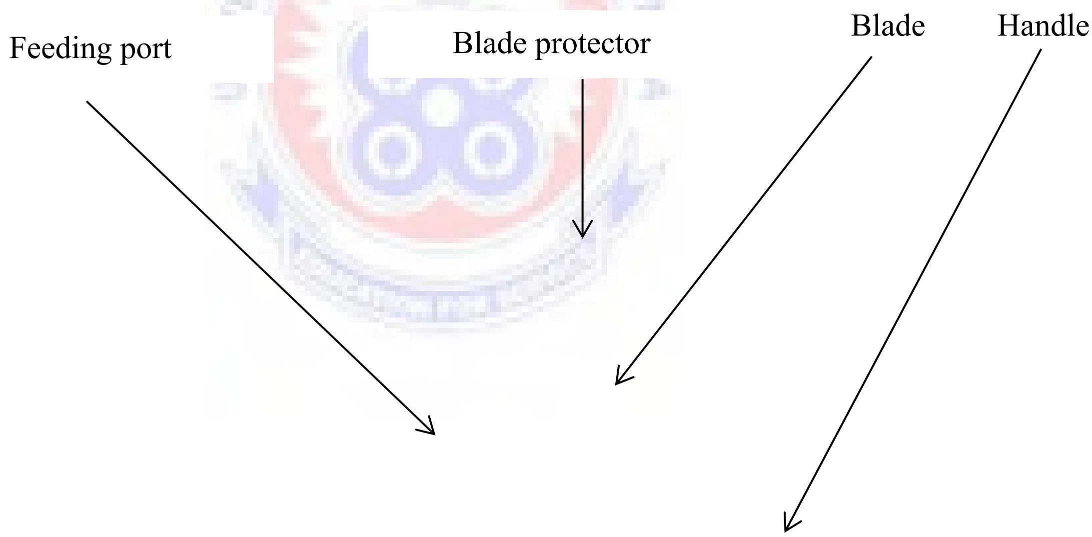


Figure 2.8 Rotary cutter hand fed slicer

2.7.6 Food Processor

The food processor is a kitchen appliance used to facilitate repetitive tasks in the preparation of food. Today, the term almost always refers to an electric-motor-driven appliance, although there are some manual devices also referred to as food processors. The processors are similar to blenders in many forms. The primary difference is that food processors use interchangeable blades and disks /attachments rather than a fixed blade. Food Processors are user friendly for all users. The product has multiples features to separate it from the blender. In half the time, the food Processor can blend, chop dice, and slice allowing for a quicker meal preparation.

A food processor typically requires little to no liquid unlike a blender, which requires a set amount of liquid in order to blend the food.

The base of the unit houses a motor which turns a vertical shaft. A bowl, usually made of transparent plastic fits around the shaft. Cutting blade is attached to the shaft and operates near the bottom of the bowl. A lid with a feed tube is then fitted onto the bowl. The feed tube allows ingredients to be added while chipping grinding or pureeing. It also serves as a chute through which items are introduced to shredding or slicing disks. A pusher is provided, sized to slice through the feed tube, protecting the user's fingers. Almost all modern food processors have safety devices which prevent the motor from operating if the bowl is not properly secured to the base or if the lid not properly secured to the bowl.

Figure 2.9 Food Processor

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter introduces the conceptual designs proposed and selection of the final concept for detail design and construction.

3.1 Concepts Generation

Four concepts were generated base on the functional and design requirements, the evaluation criteria and parameter are used to select the concept. Ranking of points is used for evaluation.

3.1.1 Design Requirements

- It should be able to slice 900 grams within two minutes.
- It should have a 90% slicing efficiency as outcome.

3.1.2 Functional Requirements

- The okra slicer must be able to slice to predefined required thickness.
- Minimal pressures will be required for turning the handle for slicing.

3.2 Evaluation Criteria

There are many types of evaluating criteria but the following fiveare selected.

These are:

- Manufacturability
- Functionality
- Reliability

- Safety

3.2.1 Objective for Evaluating the Slicer

1. Manufacturability: This objective refers to how easy the manufacturing process would be for the concept. The parameter used for this objective is number complex parts.

2. Functionality: This objective refers to the capability and suitability of how the slicer does its work to accomplish its purpose. The parameter used for this objective is complexity of the slicer.

3. Reliability: It is about how dependable the concept is, and the parameter used for this objective is to slice without alteration to the slicer.

4. Safety: It refers to the control of recognized hazards in order to achieve an acceptable level of risk. The parameter used for this objective is to slice without injury to finger.

3.3 Ranking for Concepts

Table 3.1 Ranking for concept

POINT SCALE	MEANING
1	Poor
2	Average
3	Satisfactory
4	Good
5	Excellent

3.4 Evaluating Table

Objective		Manufacturability	Safety	Functionality	Reliability	Overall Value
Weight		0.25	0.25	0.25	0.25	
Parameter		Number of complex parts	Slice with injure to finger number of parts, ease of cleaning trapped food particles	Complexity of slicer	Slice without alteration to slicer	
Bevel Cutter	Magnitude	3	5	4	3	
	Score	4	4	3	4	
	Value	1	1	0.75	1	3.75
Worm Cutter	Magnitude	2	3	3	4	
	Score	3	3	4	4	
	Value	0.75	0.75	1	1	3.5
Whirl Cutter	Magnitude	4	5	2	3	
	Score	3	3	3	3	
	Value	0.75	1.25	0.75	0.75	3.5
Circular Cutter	Magnitude	3	4	4	4	
	Score	3	4	4	4	
	Value	0.75	1	1	1.25	4

3.5. Circular Cutter

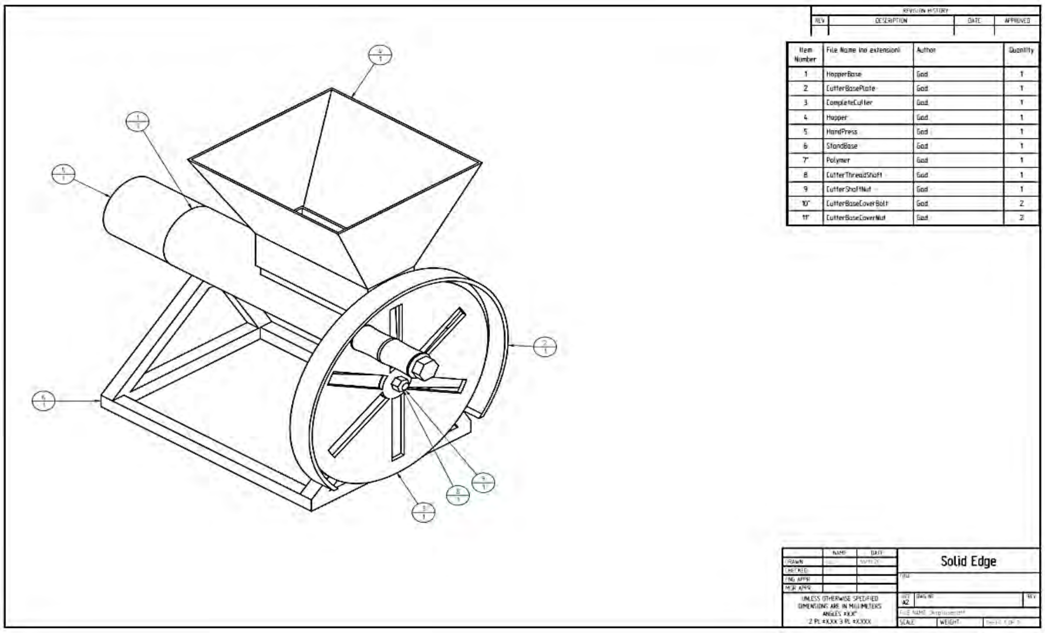


Figure 3.1 circular cutter

3.6.1 Working Principle

The machine works by feeding the okra via the hopper which falls into the cylindrical base by gravity. With the aid of the product pusher, it is pushed to have contact with the blade. As the blade handle turns, the okra is sliced to the required thickness.

ADVANTAGE

- ❖ Has high slicing efficiency
- ❖ Moderate force neededto turn blade during cutting
- ❖ Moderate pressure neededon theproduct pusher

DISADVANTAGES

- Expensive to construct.

By careful analysis using the evaluating table, the final design selection falls under concept four, giving the highest total score of four

CHAPTER FOUR

FABRICATION, TESTING AND RESULTS

4.1 Fabrication of the Model

The fabrication activity involves marking and cutting out the sheet metals and round pipes to be used for the design based on the scale given in the production drawings. Most of the cuttings were done using the grinding machine with a steel cutting disc and a few were done with the CNC machine.

NO	DESCRIPTION	PROCESS/ACTIVITY	TOOLS/EQUIPMENTS
1	Main frame	A round pipe formed from AISI 304 stainless steel pipe of 2mm thickness, length of 380mm, and height of 155.6mm was cut and welded to the required shape.	Tape measure, scriber, cutting disc cross cut machine arc welding machine.
2	Hopper	A stainless-steel plate of 2mm was cut to a length of 236mm and a width of 220mm was welded to form the hopper frame.	Scriber tape measure, cutting disc, grinding machine, arc welding machine
3	Cylindrical push	An AISI 304 stainless steel pipe of 400mm of length, 84mm diameter pipe of 2mm thickness.	Scriber, tape measure, cutting disc, grinding machine, cross cut saw.
4	Slicer Blade	AISI 304 stainless steel disc of 4mm thickness,198.6mm diameter.	Engineering's vice, scriber, tape measure, cutting disc, grinding machine, pneumatic saw, Drilling machine.
5	Stand	A galvanized square tube of 20mm and of length 380mmwelded onto a main frame.	Engineering's vice, try square, tape measure, scriber
6	Blade guard	An AISI 304 stainless steel plate of 2mm thickness with a diameter of 259mm.	Engineering's vice try square, tape measure, scriber, cutting disc, grinding machine.
7	Blade shaft	A 12mm diameter galvanized bolt of length 100mm	Engineering's vice tape measure.

4.1.2 Detailed Design and Fabrication of Model

This chapter summarizes the detailed design of the chosen design concept of fresh okra slicer, the fabrication and the cost estimation. The fresh okra slicer comprises the following components:

- push cylinder
- Hopper
- Blade [cutting disc]
- Blade protector
- Blade handle
- Base support

Below are the orthographic views of the final design from which the various components are selected for the design analysis.

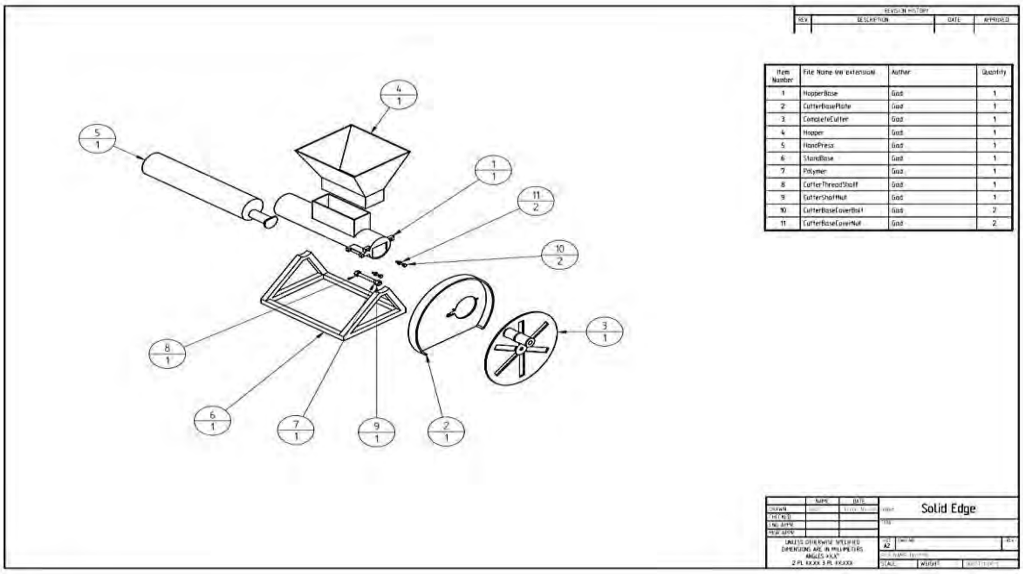


Figure 4.1

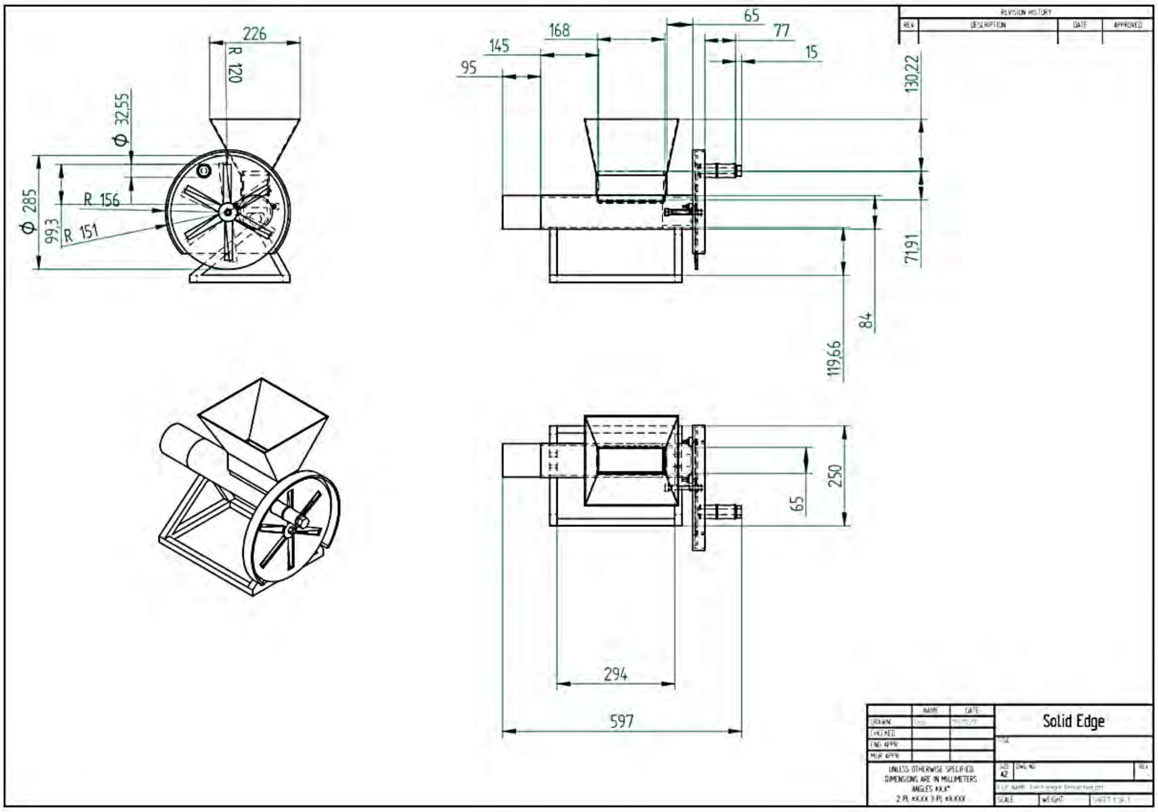


Figure 4.1.2 Orthographic projection

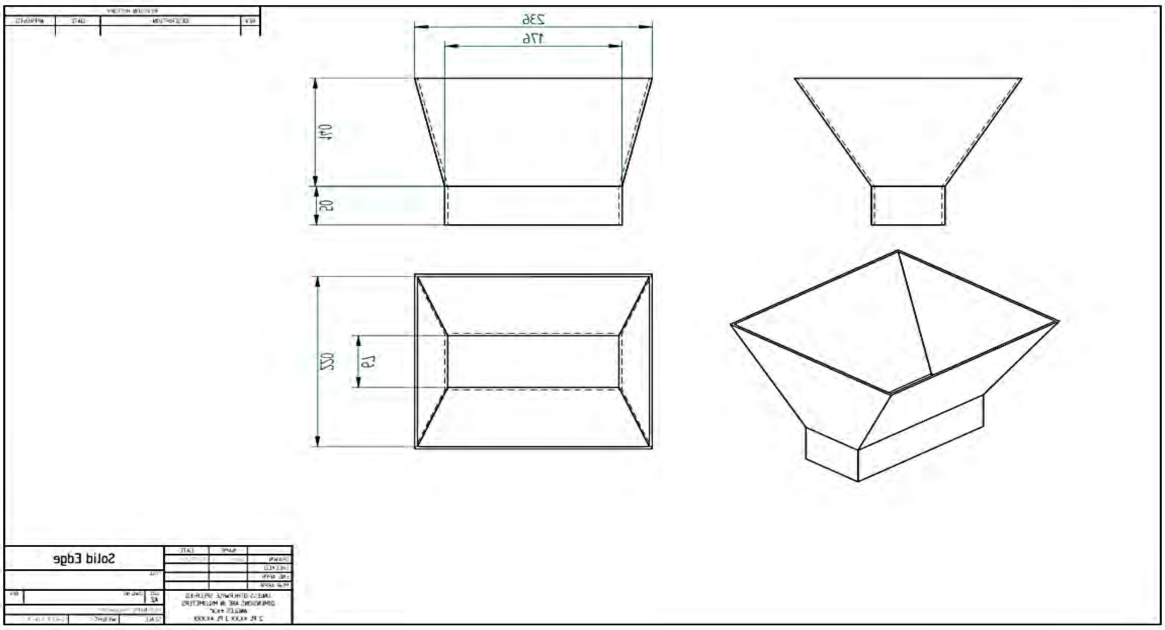


Figure 4.1.3

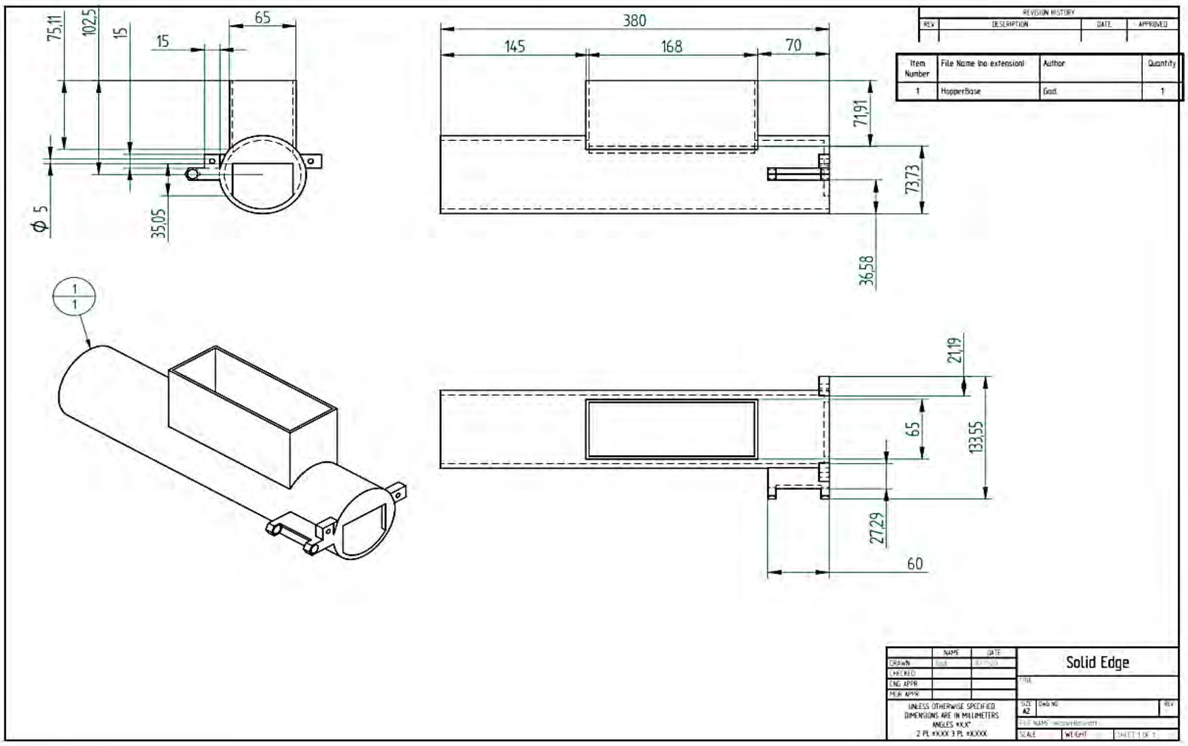


Figure 4.1.4

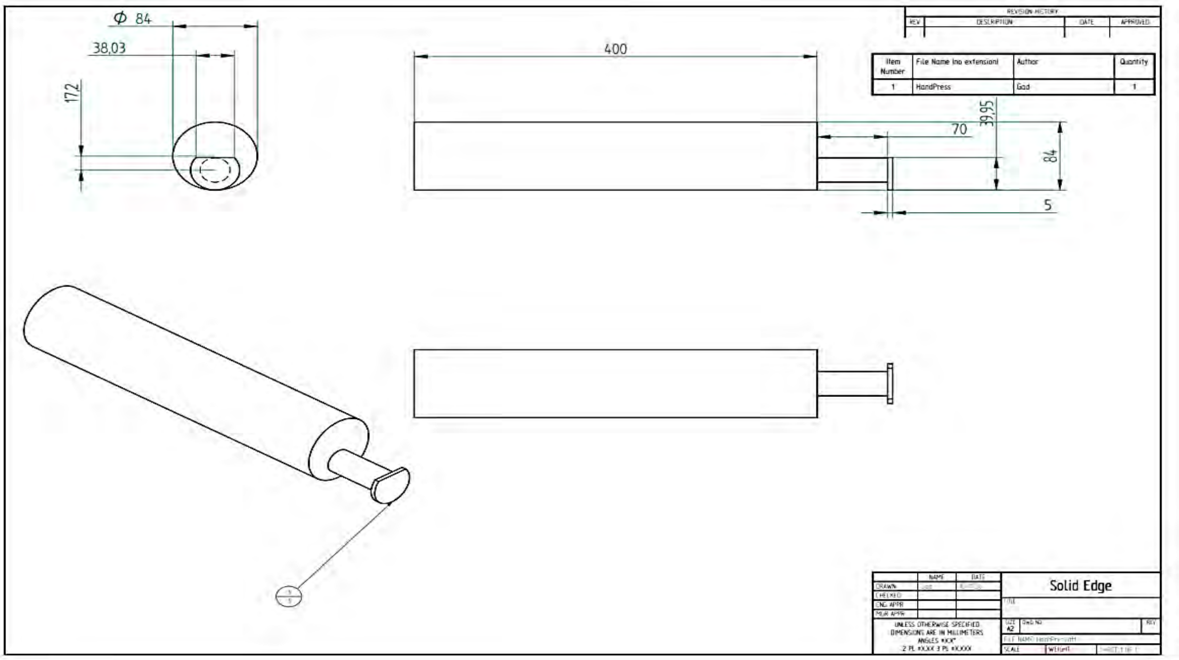


Figure 4.1.5

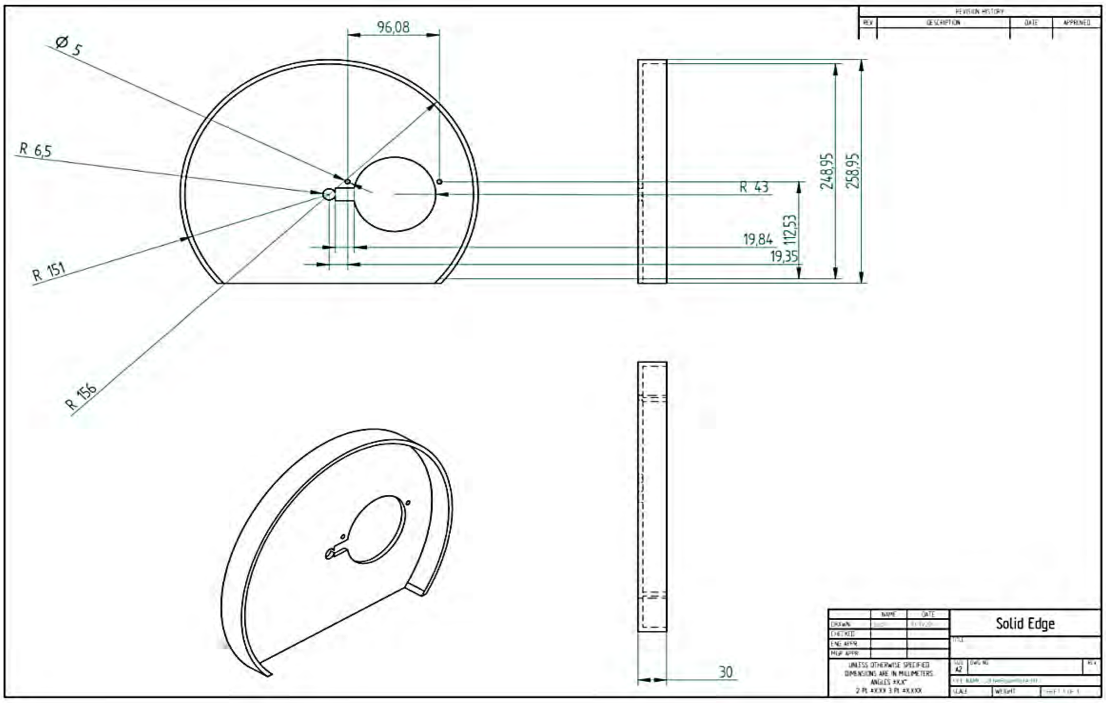


Figure 4.1.6

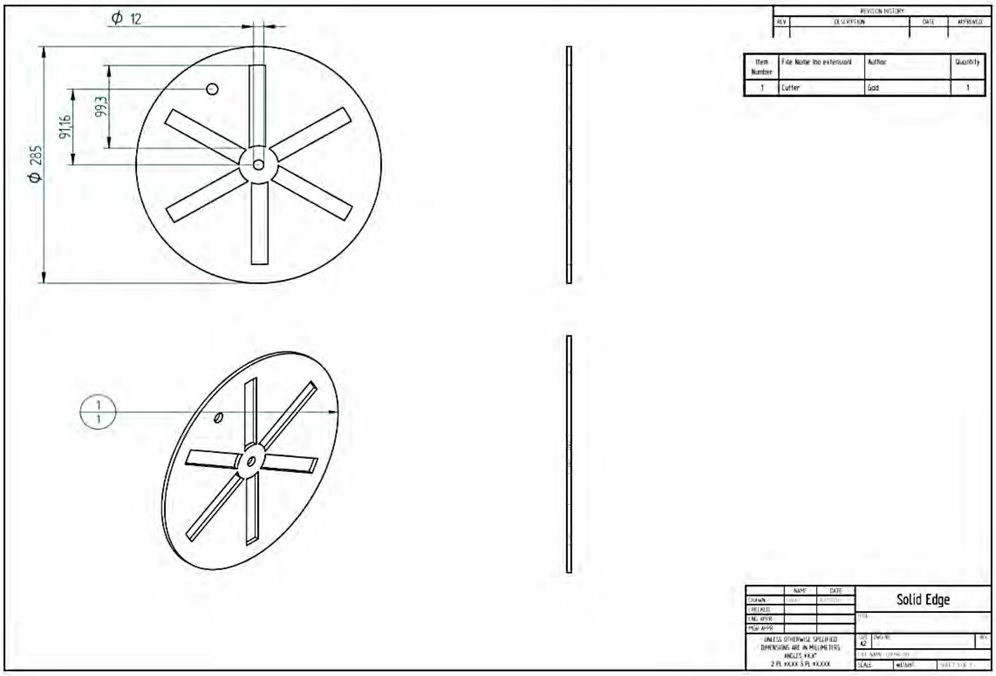


Figure 4.1.7

The detailed design includes: calculation of the weights of the various components that might cause stresses and bending on the blade and the stand that might aid in the selection of the thickness of the materials and the nature of the material cross section. These are:

- ❖ Frame
- ❖ Push cylinder
- ❖ Blade
- ❖ Hopper

Also, the shear force and bending moment calculation on the frame and the maximum volume the hopper can hold are considered to enable the selection of the required dimensions of the materials.

4.1.3 Weight Exerted on The Main Frame

The total weight exerted on the main frame includes:

1. The weight of the hopper frame
2. The weight of the push cylinder
3. The weight of the blade
4. The weight of the hopper

The table below summaries the various and the total weight of the components mounted on the main frame.

Table 4.1 Various parts and their total weights.

PART NUMBER	DESCRIPTION	WEIGHT(N)
1	Hopper	11.77
2	Slicer blade	17.66
3	Blade guard	9.81
4	Push cylinder	14.72
TOTAL		53.96

R=Radius of the disc,

N=Number of revolutions per minute

Assumption

N=20 rpm

R=100 mm

$\omega=2\pi\times20/60=2.094$

$\omega=2.1$ rad/s

$V=2.4\times100$

V=209.4 m/s

Power of cutting disc was calculated using the following expression.4

$P=T\times\omega$

$T=F\times R$

Where

P= Power required by the cutter, HP

ω=Angular velocity, rad/s

T=Torque, Nm

F= Force required to the sliding disc, N

If F=400N, R=100mm=0.1 m

Then $T=400\times0.1$

T=40Nm

W=2πn/60

Where

N=20rpm

W=2.1rad/s

P=40×2.1rad/s

P=84W

P=84/746

P=0.11 HP

Pressure on the disc from the push cylinder

Pressure=force/area

But Area (A) $= \frac{\pi d^2}{4}$

Force =400N

Diameter=0.02 m

A=$\frac{\pi * 2^2}{4}\pi \times 2^{0.5}$

A=0.03142m^2

Pressure, P=400N/0.0314 m^2

P=12732.4N/m^2

Twisting moment of the cutter shaft.

T=t×J/R

Where

T=Maximum twisting moment (Torque). Nm

J=P0lar moment of inertia

t=Shear Strength, m (Riley Sturge and Morris.2001)

But $J=\pi d^4/32$

D=the diameter of the shaft

T=620.5Mpa or 90000 psi (galvanized steel)

Diameter=12mm. R=6mm

Length=100mm

$J=\pi\times 12^2/32$

J=2035.8MM’4

T=620.5×2035.8/6

T=210535.65Nmm

T=210.54 KNm

But Power=2πnt/60

P=2×π×20×210.54/60

P=440.95KW

The angle of twist of the rotation shaft

Ø=LT/JG

Where G is the modulus of rigidity of stainless steel and it is given as 86 GPa.

=86 .9×10^3N/mm^2

Ø=2629×50/12723×86×10^3

Ø=0.12˚

Ø=6.88 rad

4.1.4 Shear Force and Bending Moment on The Frame Diagram

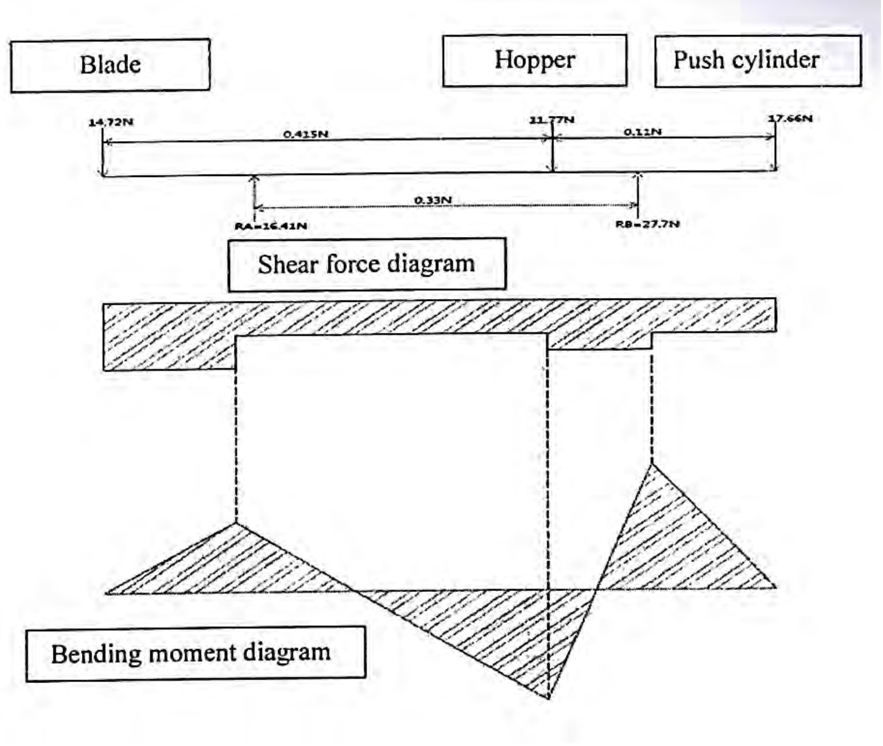


Figure 4.8 Shear force and bending moment on the frame

4.2 Design Calculations

4.2.1 Handle

Ergonomically, an average of 170.6 N efforts is assigned to operate the machine. The maximum force required for a single person to operate the hand is 400 N with the hand length of 150mm (khurmi, 2005)

The maximum bending moment of the handle (ML)

$ML = (P \times 2L)/3$

$= (170.6 \times 0.15)/3$

$ML = 17.1Nm$

Constant twisting moment (Torque) 'T'

$T = 2/3 \times P \times L$

Where $P = 170.6$ N

$L = 0.1501$ m

$T = 2/3(170.6 \times 0.1501)$

$T = 17.1Nm$

4.4.2 The Blade (Cutting Disc)

This is the primary or basic component which does the slicing. Some basic empirical properties were determined as shown below.

Speed of rotation of disc $V = \omega r$

But w=2πN/60

Where

V=linear velocity of disc. rad/s

W=Angular velocity, rad/s

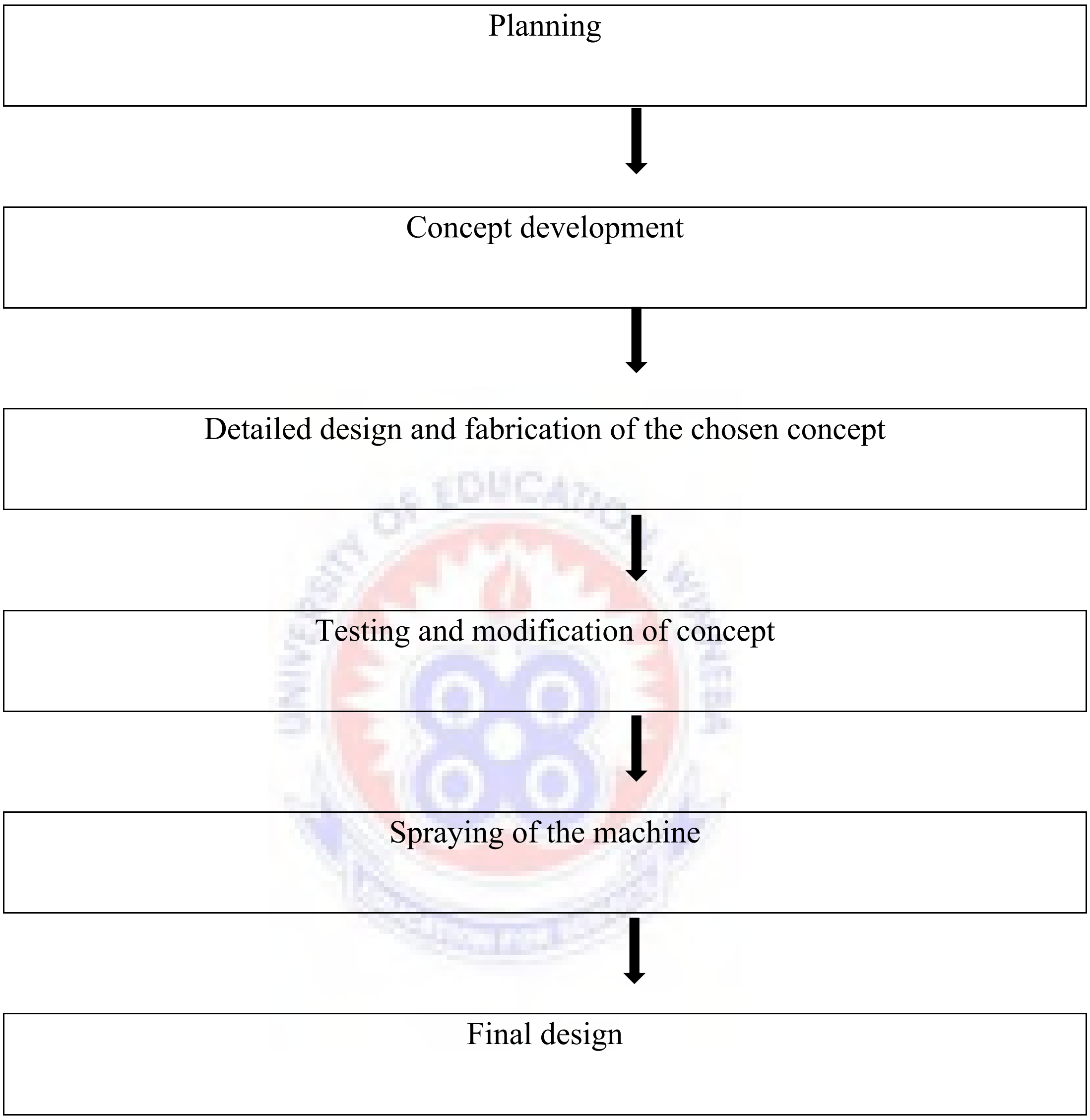
4.2.2 Cost Estimate

ITEM NO	QUANTITY	DESCRIPTION	MATERIAL	DIMENSIONS [mm]	Cost GH€
1	1	Blade handle	Wood	87	15.00
2	1	Main frame	AISI 304 stainless steel	380mm×155.6mm	450.00
3	1	Hopper	AISI 304stainlesssteel	236mm×220mm	100.00
4	1	Slicer blade	AISI stainless steel	4mm thickness 198.6.mm diameter	750.00
5	1	Blade guard	AISI stainless steel	259mm diameter	250.00
6	1	Push cylinder	AISI stainless steel	2mm thickness,400mm length and 784mm diameter	4000.00
7	1	Blade shaft	Galvanized steel	12mm	5.00
8	4	Frame stand	Galvanized steel	330mm×340mm ×70mm	20.00
9	2	Washer	Galvanized steel	M12	3.00
10	1	Lock nut	Galvanized steel	M10	300
11	1packet	Weld electrode	E-6013 STAINLESS Rod	Gauge 12	100.00

12	6	Cutting disc	Resinoid - bonded Abrasive cutting tool	450mm	70.00
MISCALLANEOUS; telephones, transportation					500.00
LABOUR/WORKMANSHIP					1.5100.00
TOTAL					2.010.00

4.2.3 Work Flow Diagram

Table 4.2 Work flow diagram



4.3 Material Selection

Two major materials of consideration are: the crop material consideration and the materials for machine construction based on material properties, availability, physical, mechanical and economic considerations. Crop material considerations: Freshly harvested Okra fruits were sourced from local markets around the 7-8th March, 2020

AgricEngInt: institution; dark green-colored fruits were selected for the study (Figure 1). The average dimensions (length and mean diameter) of the fruits were taken. Due to the variations in okra physical characteristics from specie to specie, which affects machine performances, the selected sample specie (Abelmoscus esculentus L) was sorted for rejects and particulate materials. The sample fruits categories were thoroughly washed and sliced using the developed machine. Figure 1 Fresh Okra fruit samples (Abelmoscus esculentus L.)

4.4 Assembly of the Model

The fabricated components were assembled using arc welding machine with electrode (Stainless steel gauge 12).

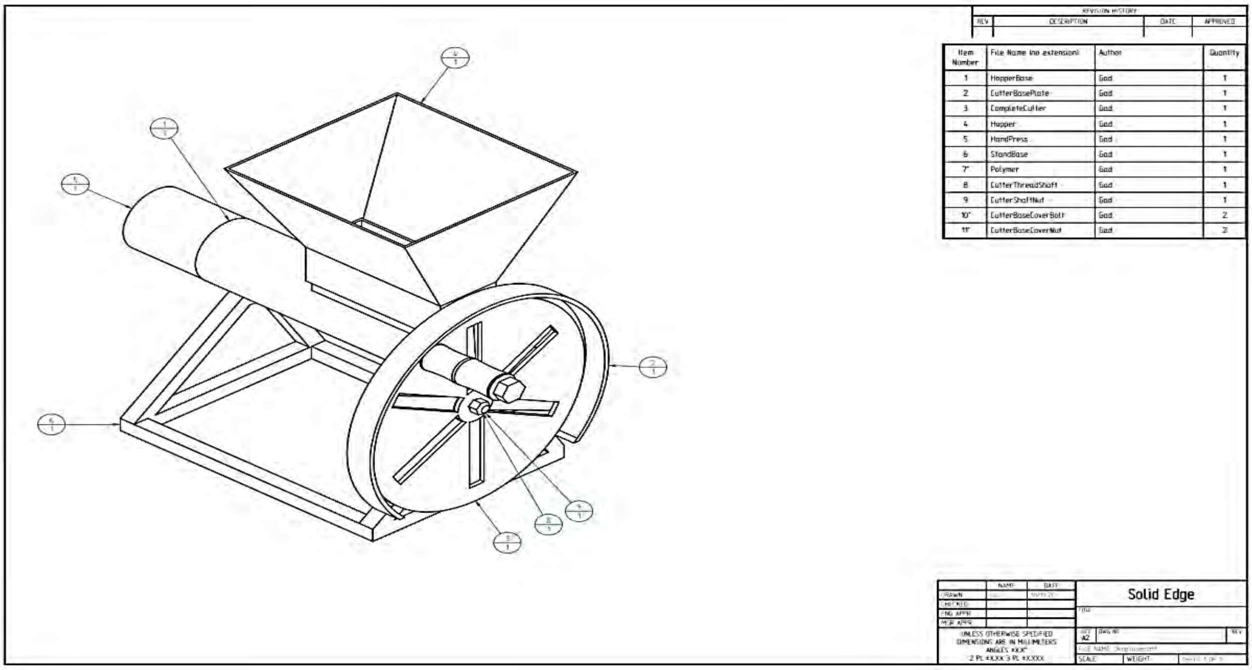


Figure 4.9 Assembly drawing

4.5 Testing of the Model

A manually operated device developed by Owolarafe et al. (2007) adopted as a unit of an integrated system for Okra processing by rural women in Ghana because it reduced the drudgery associated with manual slicing appreciably. Olajide et al. (1997) evaluated an Okra slicer and found that there was higher loss in the traditional method of slicing than in the mechanical slicer. He reported a 65% slicing efficiency and 312 kg hr-1 capacity. Ogbobe et al. (2007) designed a motorized Okra slicer with 42.8 kg hr-1 capacity and 95% efficiency when compared with hand slicing and manually operated machine methods. It produced slices of uniform thickness with deviation and variance of 0.13 and 0.14, respectively. Kamaldeen and Awagu (2013) designed a manual tomato slicing machine to cut tomatoes at 2cm thickness. The capacity of the machine was 540.09 g min-1 and its slicing efficiency was rated 70%. Various drying methods had been employed in drying different agricultural products with varying advantages and limitations. Many of such systems utilized both direct and indirect solar radiation (Rossello et al., 1990): Direct solar drying of whole pods or sliced pieces using a kitchen knife at near-regular sizes is done by spreading out on trays exposed to sun radiation. This method predisposes the product to losses both in quantity and quality because of the dependence on direct solar drying and exposure of the vegetable to disease infestation and contamination. Indirect solar drying utilizes heat from the sun to heat a collector surface to either heat air or in direct contact application on the product. Choosing the right drying system for fruits and vegetables is thus important for more uniform, hygienic and attractively colored dried product with promising results in postharvest losses prevention and prolonged shelf lives. Traditionally, drying of Okra can be achieved by combined effect of drying time and slice thickness on the solar drying. A study by Adom et al. (1997) concluded that solar drying was an effective method for producing dried Okra at shorter drying periods compared with the traditional open-air sun drying method. From this study, it was observed that the thicker the slice, the more the drying time required and the organoleptic evaluation of dried products showed that the drying limit of Okra could be determined when the Okra pods became brittle on slight pressure application. Several devices in Okra processing had equally been developed for unit operations. However, considerations have also been given to integrated system approach in combines process operations such as slicing and drying. Such efforts had yielded the experimental machine used for this research work. Preliminary evaluation of this device indicated a slicing efficiency of 89.41% while the machine capacity was 20.15 kg hr-1. The average slice thickness of samples obtained is 8.6 mm. The drying chamber at no-load condition reached a temperature of about 50˚ C and due to convective heat transfer; it takes approximately 4.5 minutes for the compartment above the tray to experience temperature increase. Efficient performance of engineering machinery is the hallmark of engineering profession and an integral part of research innovations in technological development; hence this performance can be improved on which is a major objective of this research.

4.5.1 Methodology Utilized In Testing

Determination of physical characteristics of okra samples: The weight, mean axial length, diameter, density, volume, sphericity and roundness of the fruits were measured using a venier caliper for each sample and the approximate values calculated using the following procedures and equations. a. Determination of crop sample weights: The samples were graded into three size categories of small size fruits (sample A), medium size fruits (sample B) and big size fruits (sample C) (Figure 1).

Each category was weighed using a precision electronic weighing scale (SF400, capacity 5000g x 1g), and the number of fruits noted. b. Mean axial length of okra: The mean axial length, butt diameter (a), intermediate (b) and apical (c) diameters, weight of 20 randomly selected fruits from each sample categories were measured and the mean of three sample replicate readings were taken for each sample and recoded. c. Okra mean diameter: The okra mean diameters were determined by measuring the dimension of the principal axis; butt (major), intermediate and minor (apical) diameters of randomly selected fruits samples using venire caliper. The major, minor and intermediate axes for okra are shown in figure 4.10

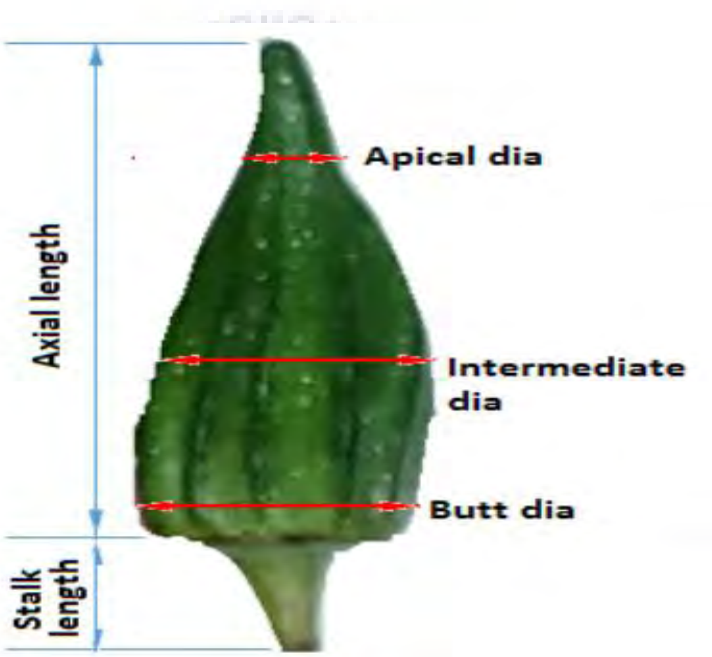


Figure 4.10 Okra Picture

The measured dimensions of okra fruits The mean diameter dp in mm was calculated using the following expression (Mohsenin, 1986; Bello and Odey, 2011) $\boldsymbol{dp} = \frac{\mathbf{a+B+C}}{\mathbf{3}}$: (1) Where a= Butt (major) diameter of okra b= Minor (apical) diameter of okra c= Intermediate diameter of okra d. Sphericity of okra fruit: Sphericity (φ) is defined as the ratio of the surface area of the sphere having the same volume as that of the fruit to the surface area of the fruit, determined through equation (Mohsenin, 1986; Dursun and Dursun, 2005; Bello et al., 2018) 1 3 [abc] Sphericity (φ) = $\frac{(abc)1/\,3}{a}$ e . Volume of okra fruit: Fruit volume (V) was calculated using the equation given by Al-Mahasneh and Rababah (2007), Bello et al. (2018):

V= $\pi \frac{b^2}{6} \frac{a^2}{(2a-b)}$ ((3) (2) Device modification factor: The following considerations were used as basis for the modifications. a. . Effectiveness of cutting mechanism: The machine capacity to slice fed okra. The machine was also observed to determine the efficiency. b Other considerations include safety of operation, maintainability, user friendliness and ease of operation. 2.3 Machine performance indicator Testing is a vital step in machine process development. The following indicators were used to measure the performance of the machine. a. Slicing efficiency: Slicing efficiency is expressed as the effectiveness of machine slicing a unit feed of Okra compared to known machine performance. The slicing efficiency is given by the following expression (Balasubramaniam et al., 1993):$\boldsymbol{\alpha} =$ $\frac{\text{Number (mass)of okra effectively sliced}}{\text{Total number (mass) of okra fed}} \times 100\%$100 Also, $\alpha \boldsymbol{x} = \frac{\text{Nt}-\text{Nt}}{\text{N}} \times 100\%$ (5)

Where: α = slicing efficiency (%), NT = Total number of okra fed into machine, ND = Number of total Okra sliced b. Machine capacity: Actual capacity/throughput of the machine was also determined by feeding Okra into the machine and finally weighing all the slices irrespective of damage. Machine capacity expressed as the quantity of Okra sliced per unit time of measurement: Machine capacity = Type equation here.Total weight of pkra sliced kg Machine capacity= ( ) Time taken hr (6) c. Slice thickness: Three randomly drawn samples of each category, containing 30 slices were used for determination of slice thickness, uniformity and shape. Slice thickness was determined at four points around the periphery of the slice using micrometer screw gauge. d. Product evaluation: After machine test, the product samples were sorted into three categories: whole sliced, chopped slice and unsliced. The mean sample of each product sizes were determined.

4.6. Results

The diameters and axial lengths of randomly sampled 20 Okra fruits picked from the three categories (A, B, and C) were measured with a mean average butt diameter of 28.10, 22.65, 19.23 mm for A, B and C, respectively; intermediate diameters of 32.81, 26.45, 21.48 mm for A, B and C, respectively, and apical diameters of 13.14, 8.95, 7.16 mm for A, B and C, respectively. The mean axial lengths of 74.62, 59.7 and 44.03 mm were also determined for A, B and C, respectively. From these results, it is evident that the okra specie has a larger diameter at the intermediate section than the butt and the apex. The geometric mean characteristics of okra were determined and presented in Table 1 with mean equivalent diameters for sample categories A, B, and C equals; 24.54, 19.20 and 15.79 mm, respectively. The measured sphericity for each sample are 0.56, 0.55 and 0.62 respectively with an average sample.

Sphericity of 0.58. This is an indication that all the samples have an oval shape with the fruits at rest along the longitudinal axis. By implication, the okra will approach the blades in longitudinal axis, hence increasing the tendency of uniform slice.

Table 4.3 Geometric mean characteristics of all sampled Okra

Okra Sample	Mean axial length			Equivalent diameter			sphericityA		
	A	B	C	A	B	C	A	B	C
	81.10	68.20	46.30	25.22	20.25	14.99	0.50	0.50	0.60
	76.20	63.30	42.30	53.53	21.75	17.01	0.60	0.60	0.60
	71.3O	56.20	42.10	24.98	16.88	15.56	0.60	0.50	0.60
	90.10	58.20	50.20	24.01	20.31	17.29	0.50	0.60	0.60
	64.30	67.20	5230	24.13	19.91	16.65	0.60	0.50	0.60
	74.20	49.10	47.20	22.53	16.43	15.72	0.50	0.60	0.60
	73.30	64.20	44.20	24.98	20.43	14.71	0.60	0.50	0.60
	66.20	58.20	45.20	26.33	17.60	17.00	0.60	0.50	0.60
	77.20	56.20	35.20	24.11	19.06	14.70	0.50	0.60	0.70
	73.30	56.20	35.20	23.62	19.38	14.29	0.60	0.60	0.70
Mean	74.62	59.70	44.03	24.54	19.20	15.79	0.56	0.55	0.62

Okra sample Mean axial length Equivalent diameter Sphericity Modifications made on device.

4.6.1 Machine performance evaluation

Slicing unit performance tests: The machine performance evaluation on the basis of the slicing efficiency. The product samples obtained from the slicing operation were sorted and categorized into three: well sliced, unsliced and chopped

Ten pieces 0f sliced, chopped and unsliced okra were randomly but carefully sorted from the chipped sample in each of the three categories and the length and width of each chip/sliced samples measured and the slicing efficiency calculated on the basis of chip slices

Table 4 4 Mean sizes of sliced, chopped and unsliced okra

Chop Replicates	Chopped sample		Well-Sliced Sample		Thickness	Unsliced sample	
	Length	Width	Length	Width		Length	Width
1	31.10	8.20	18.10	7.10	3.12	38.10	8.10
2	21.10	10.10	27.20	6.10	2.74	33.10	11.10
3	18.20	10.10	27.10	8.10	4.21	42.10	12.10
4	11.10	11.10	17.20	8.10	2.78	35.10	13.10
5	35.10	9.20	17.10	8.10	3.52	40.20	16.10
6	26.10	9.10	15.20	8.10	4.36	36.10	19.10
7	29.20	11.10	24.20	8.20	3.44	52.20	12.10
8	29.20	14.10	15.20	7.20	2.87	50.20	22.20
9	23.20	9.10	16.20	6.10	3.65	35.10	10.10

10	22.10	8.10	18.10	8.10	3.23	56.20	7.20
Mean	26.64	10.02	19.56	7.52	3.39	41.84	13.72

4.7 Maintenance Schedule

Table 4.5 Testing of Model

Mass of okra (grams)	TIME (minutes)	Efficiency (%)
900	1;40	50
900	1;30	55
900	1;55	66
900	1;58	69
900	1;45	60

The machine is clean daily after use and checked monthly to maximize its life span.

Table 4.6 Maintenance schedule

Frequency	Work detail	Action
Daily	Check for equipment cleanliness after work. Check for rust Check for slack in the lock nut.	Clean up equipment after work Tight the lock nut.
Monthly	Check for rust. Check for slack in lock nut, Check for blunt blades.	Clean up equipment after work. Tight lock nut, Sharpen the blades

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

This chapter summarizes the degree of achievements and challenges encountered during execution and the recommendations made at the end of the entire project.

5.1 Concluding Remark

The design and fabrication of the Okra slicer model was completed successfully. The testing of the model device is suitable for slicing fresh okra for household cooking. Some engineering properties of okra were also studied. The mean equivalent diameter for each sample category A .B and C are 24.54,19.20 and 15.79mm respectively. The maximum slicing efficiency of the modeldevice is 95% with overall efficiency of 90.76%, the average chip length, width and thickness are 19.56mm.7.52mm and 3.39mm respectively. The model device was able to achieved size of slicing and uniformity.

5.2 Recommendations

It is recommended that the project should be continued to achieve the intended 90 efficiency of uniform okra slicing and a two stroke engine can be employed to further reduce human effort .Further work can be done on the fabricated machine by reducing the thickness of the blade from 4mm to 3mm. Screws are to be introduced to reduce or increase the gap between the blade frame and the cutter.

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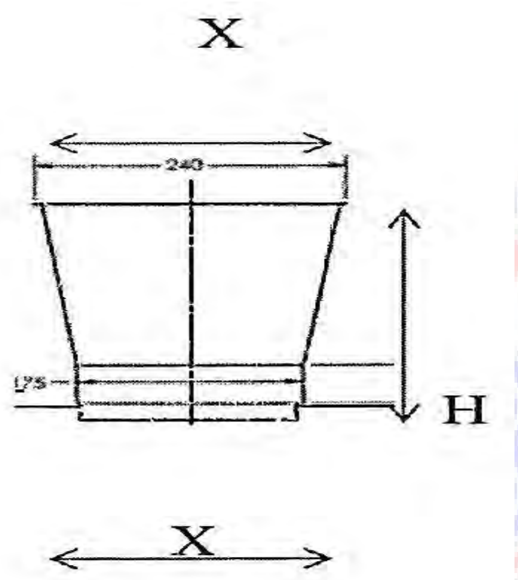
APPENDICES

APPRENDIX A

DESIGN CALCULATIONS

Maximum of volume of the hopper

Sketch space



Length. ‘X’

Width, ‘y’

Height,’H’ =180mm

Upper X =240mm and Lower x=170mm

Y=170mm and Lower y 70mm

$V= 1\times H[X^2Y-X^2Y]/3\times X-X$

$V=1.018[0.24^2\times 0.17-0.17^2\times 0.07]/3\times 0.24-0.07$

V=0.00665MM

V=6.65m^3

Total Weight on the main frame

Force=Mass × Acceleration

Hopper=1.2kg×9.81m^2/s=11.77N

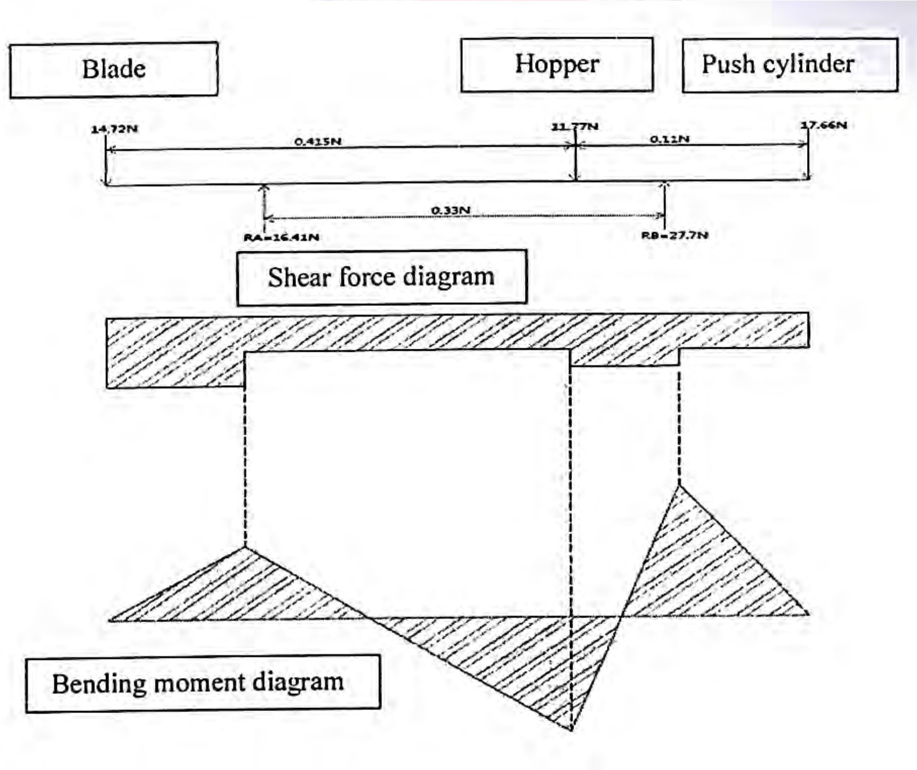
Slicer blade =1.8kg ×9.81m^2/s=17.66N

Blade protector= 1kg×9.81^2/s=9.81m^2/S

Push cylinder=1.5kg×9.81m^2/s=14.72N

Total weight=53.96N

Shear force and bending moment diagram



Reaction at A=16.45N

Reaction at B=27.74N

Shear force

SA=-14.72N

SB=-14.72+16.45=1.73N

SC=1.73-11.77=-10.04N

SD=10.04+27.74=17.66N

SE=17.66-17.66=0

Bending moment

MA=14.72×0=0Nm

MB=0+[16.45×0.00425]=0.699Nm

MC=0.6999-[11.77×0.305]=-2.89Nm

MD=-2.891+[27.74×0.3725]=7.43Nm

ME=7.43-7.43=0Nm