DESIGN, MODIFICATION AND CONSTRUCTION OF A CASSAVA MINI GRATER

BY

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NOVEMBER, 2017

DEDICATION

I dedicate this report to the Almighty God, for seeing me through my final year project, and also to my parent Mr & Mrs Emmanuel Amechi for their love, support, and encouragement.

CERTIFICATION

This is to certify that this report is a detailed account of the final undergraduate project undertaken by AMECHI SAMUEL CHIDIEBERE at Federal University Oye Ekiti, for a period of 5years and has been prepared in accordance to regulations guiding the preparation of reports for the award of Bachelor of Engineering (B. Eng.) in the Department of Mechanical Engineering, Federal University Oye Ekiti.

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ABSTRACT

Grating of cassava means the transformation of cassava tubers into pulp form. Cassava grating machines are mainly used in African countries. There is need for a hygienic processing of cassava. Prevalent, conditions in the commercial grating areas of this staple food show a susceptibility to food contamination This project addresses the need for the development of a home-scale cassava grater where the materials, the tubers of cassava being grated, vegetables, fruits etcetera can be properly monitored. Some design considerations used in this project are; the machine should be efficient during use in the household as well as movable (portability) and safety or easily operated. Another problem consideration is that cassava produces a large amount of cyanogenic glycosides so in selecting materials, for construction, adequate care must be taken not to use materials that cannot degrade or corrode easily due to the acidic content in cassava, and the product surfaces must be completely free from crevice which can harbour bacteria. The grater is small & transportable, motorized & runs on electricity (Motor Speed: 1500 RPM), Easy to install & maintain, the components touching the cassava are mPade of food safe stainless steel, there is no rusting or paint chips falling into the cassava. The efficiency of the grater is 86.7% time savings over traditional hand grater. The estimated material cost of the grater is #41,800. The largest portion comes from the motor, which costs #20,000.The only operational cost for owning the Mini Grater is the cost of electricity, which is small. The aim of this project is to modify the design of the existing cassava grater (dimensions), to reduce the cost, to use stainless steel drums used in cassava grating machines due to the acidic nature of the cassava fluid & to promote healthy consumption of cassava products.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Cassava originated from Latin America and was later introduced to Asia in the 17th century and to Africa in about 1558. In Nigeria, cassava is mostly grown on small farms, usually intercropped with Vegetables, plantation crops, yam, sweet potatoes, melon, maize etc. Cassava is propagated by 20 -30cm long cutting of the wood stem, spacing between plants is usually 1-1.5 meters. Intercropping with bean, maize, and other annual crops is practiced in young cassava plantations.

There are two common varieties of cassava, namely, the bitter and sweet varieties. The cyanide content differs as well as suitability for different growing and consumption conditions. Usually, higher cyanide is correlated to high yields. Nigeria is the world largest producer of Cassava tuber in the world, producing about 34 million tonnes of the world's 174.0 tonnes.

Over the past 25years significant market opportunities for cassava have opened up in the animal feed industry, initially in the EEC (European Economic Community) countries but more recentlyfor the rapidly expanding animal feed industries of tropical developing countries. Cassava roots compete with other carbohydrate sources, especially maize and sorghum, on the basis of price, nutritional value, quality and availability. Cassava has several advantages compared with other carbohydrate sources, especially other root crops. It has a high productivity under marginal climatic conditions, which result in a low cost raw material. Root dry matter content is higher than other root crops at 35-40%, giving optimum rates of25:1 or better. Over 85% consists of highly digestible starch. Cassava starch has excellent agglutinant properties which make it especially suitable for shrimps and fish feeds, replacing expensive artificial agglutinants.

The potential disadvantages of cassava roots are their bulk and rapid perish ability, their low protein content and presence of cyanide in all root tissues. Through simple processing the disadvantages of bulk and perish ability can be overcome: A stable product is reached when moisture content falls below 14%, natural drying is widely used to achieve this objective. Drying also permits the elimination of most of the cyanide from root tissues. The dried cassava product thus has only one disadvantage with respect to other carbohydrate feed sources; low protein content. This can be overcome through price competitiveness. For export markets, where transportation over thousands of kilometers is necessary, further processing to produce high density pellets is carried out to minimize transport costs.

The total areas under cassava cultivation in Nigeria, is about 3.60 million hectares. All states in clouding the Federal Capital Territory (FCT), cultivate appreciable quantities of cassava. However, Akwa Ibom,Edo and Delta States including Cross River are major producers. Most of the cassava produced in Nigeria are processed and consumed in various forms locally with little processed for export.

Table 1: cassava names

COMMON NAME	**BOTANICAL NAME**
Cassava	Manihot esculenta
LOCAL NAMES IN NIGERIA	
Hausa	Rogo
Igbo	Akpu
Yoruba	Ege

In the traditional bush-fallow system, some cassava plants are always left to grow with the fallow which is long enough to enable the cassava to flower and set seed. The natural out crossing habit of cassava leads to the production of numerous new hybrid combinations from self-sown seed from which farmers select and propagate desirable types. By this process, pools of new local varieties are continuously created which are adapted to the different agro-ecological zones of the country. As these selections are made on account of their excellent cooking qualities, low HCN(Hydro-cyanide) content and high yields, they are used as parents in breeding programmes mainly to improve pest and disease resistance.

The local varieties are;

(i) Oko Iyawo

(ii) Panya

(iii) Akintola

(iv) Akon

(v) Etunbe

(vi) Akpu

(vii) Dan wari

1.2 JUSTIFICATION

1. Presently in Nigeria, the products of cassava are usually locally consumed and exportation is limited because the products do not always meet the international standards for healthy foods. Thus, the need to encourage the small scale (home production) of cassava product to ensure quality of products and good hygienic values (reduce foreign body and sand content in products), thereby protecting the health of basic building element of our nation.
2. Mechanization in all its form ensures ease(less effort) and speed of production. To ensure that cassava is processed with ease (reduce stress during processing) and within short time(time economization).
3. According to my survey around Ekiti State, I discovered that most small scale farmers, house-wives and retailers usually have to trek long distances or transport with fresh cassava tubers for grating.

1.3 PROBLEM STATEMENT

Small farms remain the center of agriculture and rural development. Small scale farming is more prominent to the volume of production than in industrialized farms, particularly in cassava production in the Ekiti Region. Thus;

- The product tuber spoils after 2-3days of harvesting, hence need for processing into safer stable products.
- A lesser availability of locally designed and fabricated grating machines for cassava processing due to the high cost.
- Cassava root tubers contain cyanide acid that reacts with materials prone to contamination such as low carbon steel and may contribute degradation of cassava quality.
- The existing grating machines in the Ekiti Region are too heavy.

1.4 OBJECTIVES

In view of the above mentioned problems and the overall importance of the cassava products the following objectives are required to address the shortcomings of the grater;

- To design and fabricate modern mini cassava grater.

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- To modify and innovate the design of the existing cassava grater to the home use-small scale size.
- To change the crude wooden drums used in cassava grating machines to lasting stainless steel and galvanized pipe.
- To save time and Cost of Processing Cassava products by the small scale Farmers.
- To promote healthy consumption of cassava products.

1.5 SIGNIFICANCE OF THE STUDY

Due to the increasing demand for low cost carbohydrates, cassava is now considered as one of the source for food and feed for livestock. The machine can be utilized in rural areas of this country Nigeria where small scale farming of cassava is their primary commodity and it is operated by electricity for continuous operations. This machine will improve the livelihood of farmers or Gari producing women. I have done so by providing tools to ease their physical burden and increase their gari production efficiency, both of which ultimately contribute to a larger income. This Machine tool is an electric cassava grater that renders the process seven times faster than the current method of hand grating. The machine is easy to operate which gives less labor for the user.

1.6 SCOPE OF STUDY

The scope of the project is to design and construct a Mini cassava grater which will be useful for home-use, retailers and small scale farmers and also;

- To carry out a literature review on cassava and cassava graters in existence.
- To obtain some data or information that will be required and that are suitable in the design and construction of cassava grater.
- To select suitable materials based on result of the analysis for the construction of the machine
- To prepare a neat and detailed working drawing for the construction process.
- To discuss the results of the performance test.
- To present the necessary information on the machine efficiency.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 BACKGROUND

Cassava (*Manihotesculenta Crantz*) is one of the favored root and tuber crops of the tropics and also a major source of energy in the human diet in the tropics. It is the third most important source of calories in the tropics after cereal crops (FAO, 2008). In addition, it is an important staple, food security, and cash crop that thrive where most other crops fail (Olukunle, 2005).The crop originated in South America, where its tubers have been used throughout the ages as a basic food from where it spread to other regions of the world, its cultivation has spread throughout the humid tropics and subtropics (Nwekeet al., 2002). Adetunji and Quadri (2011) reported that cassava is mostly grown on small farmsin Nigeria and usually intercropped with vegetables, plantation crops, yam, sweet potatoes, melon, maize, beans, and other annual crops. FAO(2003) reported that highest production is in Africa with 99.1 million tones while 51.5 and 33.2 million tonnes are for Asia and Latin America respectively Cassava production in Nigeria was put at about 33.8 million tons a year (FAO, 2006).Nworgu(2006) reported that Nigeria has annual output potential for cassava production of 75.5 million tonnes. (Ajao and Adegun 2009) reported that the total area of harvested crop in 2001 was 3.1 million / ha with an average yield of about 11 t/ha.Katz and Weaver (2003) reported that cassava contains protein and also contain significant amounts of calcium, phosphorus, and Vitamin C.Oluwole et al. (2004) also reported that edible part of fresh cassava root contains 32% – 35% carbohydrate, 2% – 3% protein, 75% – 80% moisture, 0.1% fat, fibre and 0.70% – 2.50% ash.

Cassava is the most perishable of roots and tuber crops and can deteriorate within two or three days after harvesting. Additionally, the cyanide acid content in cassava roots would need to be reduced to a level that is acceptable and safe for human consumption (Akogun, 2015). For these reasons, cassava is sold as a processed product such as gari, flour, fufu, atieke, to mention a few whilst other roots and tubers are most frequently sold as fresh produce. Otiet al. (2010) defined gari as a creamy-white, granular flour with a slightly fermented flavor and a slightly sour taste made from fermented, gelatinized fresh cassava tubers. It is consumed by either soaking in cold water with sugar, coconut, roasted peanut, fish, or boiled cowpea as complements or as a paste made with hot water and eaten with vegetable sauce (IITA, 2005).

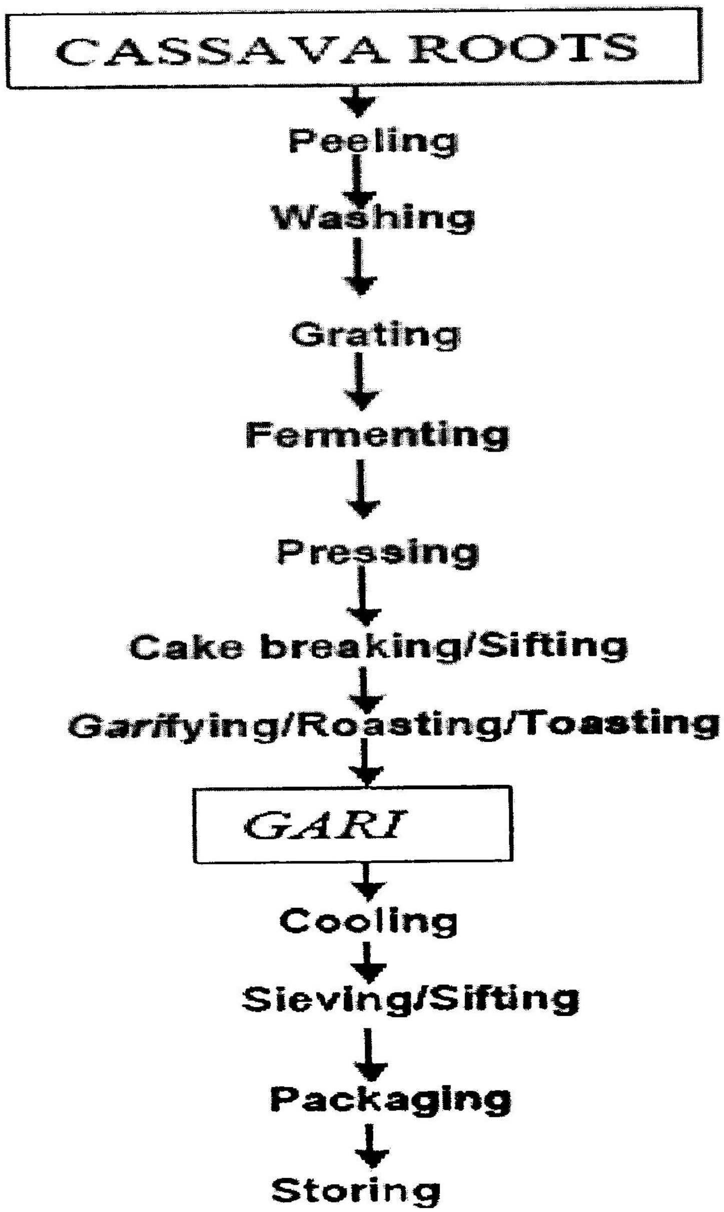

Figure 2.1 Flow chart of gari processing (Source: Otiet al, 2010)

2.2 RELATED LITERATURES

ENGR. (PROF.) E. U. ODIGBOH once said in an inaugural lecture that "The inspiration behind agricultural mechanization may be summed up as follows: If I dig with my hands the crust of the earth, my hands will blister and bleed. If between my hands and the soil I interpose a spade, then out of the labour of my body, the crust is broken and my hands remain whole". The mission of Agricultural Engineering is to mechanize agriculture. The agricultural engineer only seeks to extend the logic of the above quotation thus: "Let a machine be interposed between the man and the spade; the spade cuts, the machine labours, the field is tilled and the man is spared to turn his attention to other tasks, to higher levels of human endeavour". Surely, this is one of the most effective ways to "restore the dignity of man". (Odigbo 1976), stated that manual grating as done traditionally is tedious and time consuming and often involves scrapes and bloody injuries to the operators fingers. Thus, manual grating of cassava is unhygienic and leads to non-uniformity of the grated particles as well as substantial losses arising from the difficulty of holding small pieces of cassava tubers for grating. However there now exist various versions of mechanical gari graters powered by electric motors or small internal combustion engines. "The main attraction of the manual grating machine is its technical simplicity. It provides a powerful alternative to the sedentary drudgery and pain-inflicting process of the traditional manual cassava grating technique. The output of the prototype grater of 125-185 kg/h is many times more than the 2 to 5 kg/h possible with the old traditional method. Loss or wastage of useful tuber flesh inherent in the traditional method is eliminated; a greatly improved quality product, in terms of the uniformity of particle sizes of the resultant gari mash, is achieved and the product is infinitely more wholesome. This manual gari grating machine is considered a very appropriate development that would meet the needs of thousands of peasant gari producers in most of West mid Central Africa if manufactured and made available to them (Odigboh, 1982)."

(Mohammed B. NDALIMAN) designed a Cassava grating machine which has two modes of operation. It can be powered either electrically or manually. It takes care of power failure problems, and can be used in rural settlements where electricity supply is not in existence. Cassava is fed with the Machine through the hopper made of metal sheet to the granting drum, which rotates at a constant speed. This process grates the cassava into cassava pulp. The chute constructed of metal sheet accepts the pulp and send it out because of its inclination which operated manually, the efficiency of the machine was found to be 92.4%, which the efficiency of the electrically powered machine was found to be 91.9%. However the material used for the grater was mild steel and this could corrode and thereby causing food poisoning.

(O.R. Adetunji, M.Sc.* and A.H. Quadri, B.Sc.) designed a home-scale cassava grater which was improved on in design and fabrication. The machine efficiency, safety factors, and portability were considered in this research. The grating hopper and drum were modified with the drum having a stainless steel sheet wrapped around a galvanized mild steel core, The machine runs on a single phase one horse power electric motor at a speed of1440 rpm. The capacity of the grater fabricated was 158kg/hr and about 50 % reduction in price was achieved. However it is still heavy and expensive.

(Oriaku E. et al) designed a double action Cassava grating machine, developed and its performance evaluated. Cassava tubers sorted into10kg, 20kg, 30kg and 40kg sourced locally were used in the experiment and the data collected were analyzed. Results showed that for a total of 100kg of sample tested, the average feed and grating time were 1.46 and 2.00 minutes respectively. The average feed and grating rates were 20.16 and 12.18 kg/min respectively. The average mass-loss partially grated and completely grated were 1.43kg, 1.48kg and 22.09kg with an average grating efficiency of 86.23% and collection efficiency of 92.60%.

(Jesal O. Pugahan and Jesal O. Pugahan) designed, fabricated and evaluated the Performance of an Automated Combined Cassava Peeler, Grater and Presser for Small Scale Processing, The machine was designed, automated, and locally fabricated. Locally available materials were used in constructing the machine. The machine was tested with a minimum of three trials with 10 kilogram cassava tubers feed per loading. During testing, the maximum length of tubers to feed was 10 inches for peeling and the largest diameter of tuber peeled was 65mm. The average peeling efficiency was 75.4601% with a mean flesh loss of 8.801%; likewise, the washing capacity was 120kg/hr. The average grating and pressing efficiency was 83.779% and the grating and pressing capacity was 21.216kg/hr.

(Ben Chapman and Ndungu Muturi) designed a Mini grater that is portable, off-the-shelf cassava grater designed to be owned, operated, and maintained by individual gari producing women, however they are working to improve the durability and affordability of the grater. The machine also still has issues with vibration.

2.3 GRATING MECHANISM

The transformation of cassava tubers into pulp form is called grating. Traditional tools used in Garri processing includes: Millstone, grinding stone, pestle and mortar. In these methods, they have low productivities and low hygienic solution to these problems that led to the designing and construction of machines that can grate the cassava of high quality in a short period of time and reduce human drudgery. Some of the machines include: roller crushing mill, hammer mill, bar mill, grater etc, all having one problem or the other (Ndaliman .M 2006).The grating operation is usually carried out manually, but power-operated graters of various makes and models are being more widely used.

2.4 DEVELOPMENT OF CASSAVA GRATING

Various types of cassava grating machines have been developed. Many designs and construction were published and the developments of the grating mechanisms were showed.

Oyesola (1981) reported that, the traditional method of grating involves placing of the local grater, which is made of perforated metal sheet on the table where it is convenient for effective use and brushes sheet metal. The cassava turns into pulp and drop into container that is being used to collect the grated pulp cassava. Adejumo (1995) in his design used a wooden grater in which the cassava forced into a hopper is rubbed against the grater which is being electrically power. Enhanced quantity of cassava can be grated using this method. However the durability of the grater is low because of its wooden nature. Ndaliman (2006) described a pedal operated cassava grinder which is powered by human efforts applied to pedal. The grinder pulverizes the cassava tubers into paste which canpass through a wine sieve. The effective performance of the design was at 60%.

Below are some methods of cassava grating;

1. Traditional method

Hand grating is invariably considered the most tedious and painful operation of the whole process. The women who still grate the cassava manually, when asked about the problems of gari processing, will simply show the palms of their hands. To hand grate one tons of fresh peeled cassava roots generally requires 10-15 man days of effort, (Cock 1985).

The cassava is usually grated at least one hour after washing in order that excess water can drain off the peeled and washed cassava; otherwise the roots are too slippery and too difficult hold during grating. The manual grater is usually only a piece of galvanized metal sheet or even a piece of flattened can or tin, punched with about 3mm diameter nails leaving a raised jagged flange on the underside. This grating surface is fixed on a wooden frame and the cassava pieces are pressed against the jagged side of the metal and rubbed vigorously with strong downward movements. Particular care has to be taken and some skill is required "*not to also grate the fingers*" but still accidents sometimes happen. This traditional technology can be improved by mounting the grating surface on a wooden table at a convenient height so the rubbing action is horizontal rather than in a downward slant when the grating surface is supported against the operator's legs. It is not possible to completely grate a whole cassava piece, 3% to 5% of the cassava has to be left ungrated (Flach 1990, Bencini 1991). A skillful person is able to produce only about 20 kg/hour. In 1990 manual graters were sold for US$2 to $3 each in village markets of the north-west province of Cameroon (Flach, 1990).

2. Mechanized grating

Sometimes a group of processors will purchase their own mechanically powered rasping or grating machine or a private contractor will travel within a group of villages grating cassava for a fee. There are two types in common use;

i) Modified hammer mills and
ii) Graters using an abrasive disc.

The abrasive surface can be either cylindrical or a flat disc and is frequently a galvanized metal sheet with nail-punched holes, as in the hand grater, and attached to a wooden frame. It is said the grating surface normally wears out with six months of regular use and must be replaced otherwise the output of the machine is significantly reduced. One further disadvantage with this rudimentary grating surface is the difficulty of cleaning it after use. Debris becomes lodged in the holes and within the torn flanges and becomes a substrate for microbial growth and the possible subsequent contamination of the grated cassava which could affect the subsequent fermentation.

Many of the simple graters in use have been developed by local institutions. In the early 1970s a cassava grater was developed in the Intermediate Technology Development Group's workshop in Nigeria made from simple workshop spare parts and using hacksaw blades mounted on a vertical disc. It was driven by somebody peddling. The "Wadwha" disc grater was developed in vertical disc. It was driven by somebody peddling. The "Wadwha" disc grater was developed in Ghana and consisted of a disc shaped wooden block to which a perforated metal sheet was nailed. The disc was driven by a 5 hp diesel engine and a throughput of one ton of cassava was claimed. The Tikonko Agricultural Extension Centre in Sierra Leone developed a vertical drum grater. The outer surface of the drum was covered with a sheet of perforated metal and as it rotated the cassava was pressed against the grating surface by a wooden block. The drum was powered by a 4 hp electric motor or diesel engine. In general, capacities range between 300kg to 1,000kg per hour (Bencini, 1991). In Cameroon many of the cylindrical power graters used in villages are based on the design of CENEEMA which has some unique design features intended to improve grating efficiency and output without necessarily increasing the power requirement. There are, however, many variations in design, power transmission, capacity and type of construction. The body of these graters can be wood, galvanized metal sheet, mild steel or aluminum. The inside parts of the hopper and the chute should not have exposed steel (iron) because iron causes a bluish tinge to develop on the grated mash. Where the hopper or the grating cylinders are made of wood, they should be lined with aluminum or galvanized sheeting to make thorough cleaning easier.

3. Mini grater

Just like the name implies, mini grater is a grater designed in a small or minimum size to grate cassava. Various people and groups have been working towards modifying and innovating cassava grater to an efficient portable machine. According to (Ben Chapman and Nndugu Munturi2014), they designed and fabricated a mini cassava grater, their aim was to provide tools to ease the physical burden of Garri producing women and increase their Garri production efficiency, both of which ultimately contribute to a larger income. However in the production of the mini grater, the electric motor they used was one the major problem they encountered. Some of the problems they also encountered were; the high cost of the motor used, there were some imbalances in the head design, the vibration of the machine. The frame can still be further designed so as to withstand the fatigue that the weight might impose in the future.

According to (Ben Chapman and Nndugu Munturi2014), many improvements were made on their previous models to increase rigidity, mitigate grater vibration, and standardize materials and processes for scaling. However, on their trip it became apparent that they still had issues with the design. During the operation, the grater experienced runaway vibration caused by the head's imbalance and by its deteriorating interaction with the shaft. Vibration was a serious problem because it led to accelerated wear of the motor and decreased grater lifetime."Large scale production with our current methods would turn out unfeasibly expensive, so we re-examined our design to prepare it outside manufacture"(Ben Chapman and Nndugu Munturi2014).

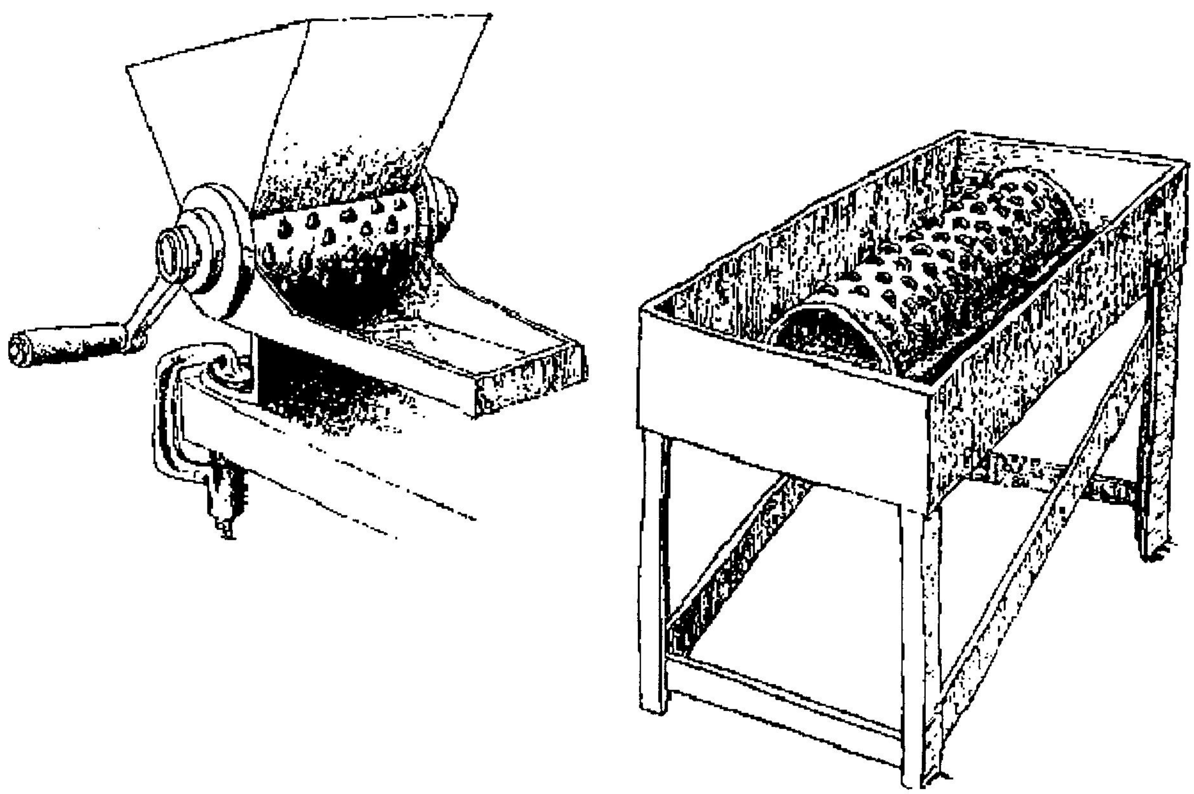

*Fig 2.4.3 **Traditional grater (Muchnick and Vinck, 1984)***

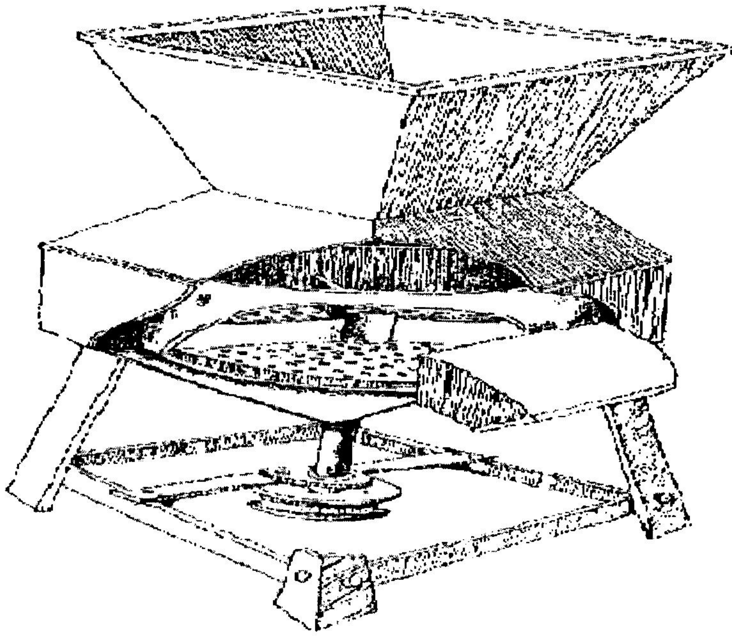

Fig 2.4.4 Wadwha disc grater(Source: Google image search)

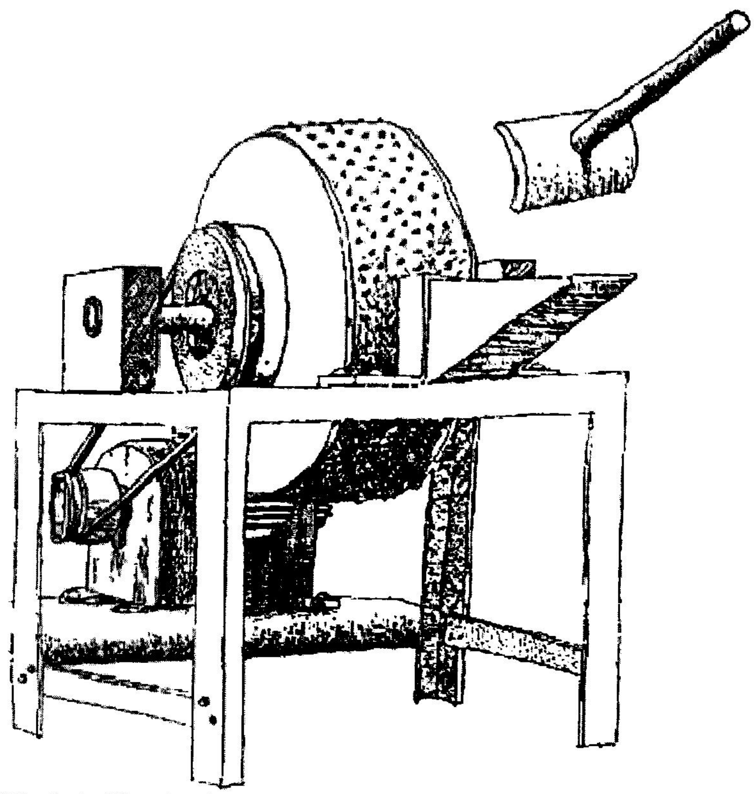

Fig 2.4.5Vertical drum grater(Source: Google image search)

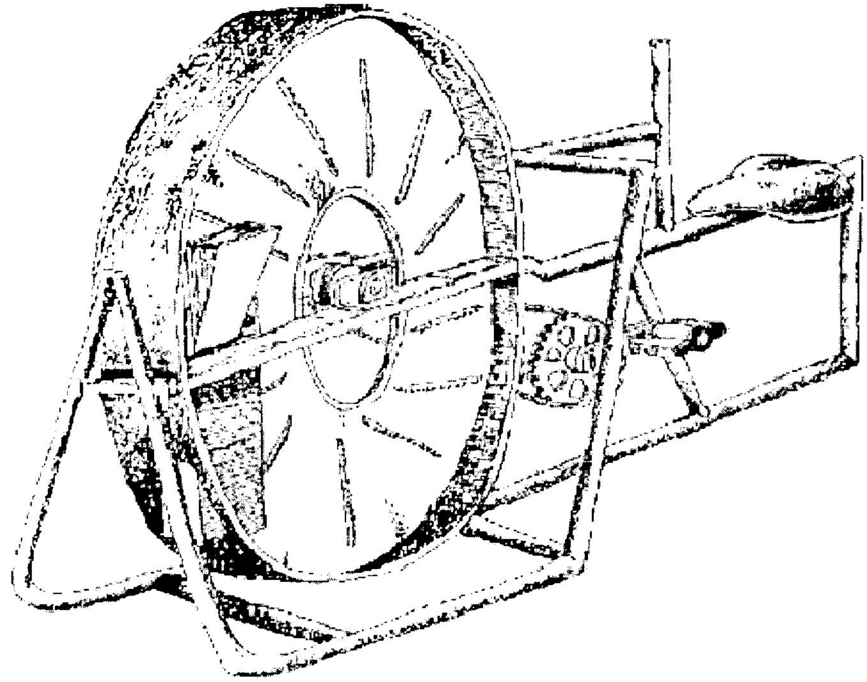

Fig 2.4.6 Pedal grater(Source: Google image search)

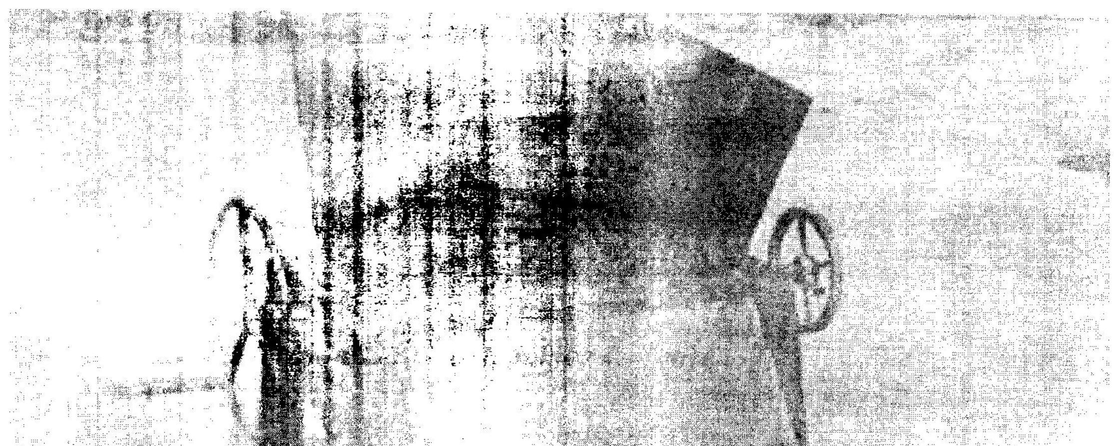

Fig 2.4.7 A Dual - Operational Cassava Grating Machine (Source: Ndaliman .M 2006)

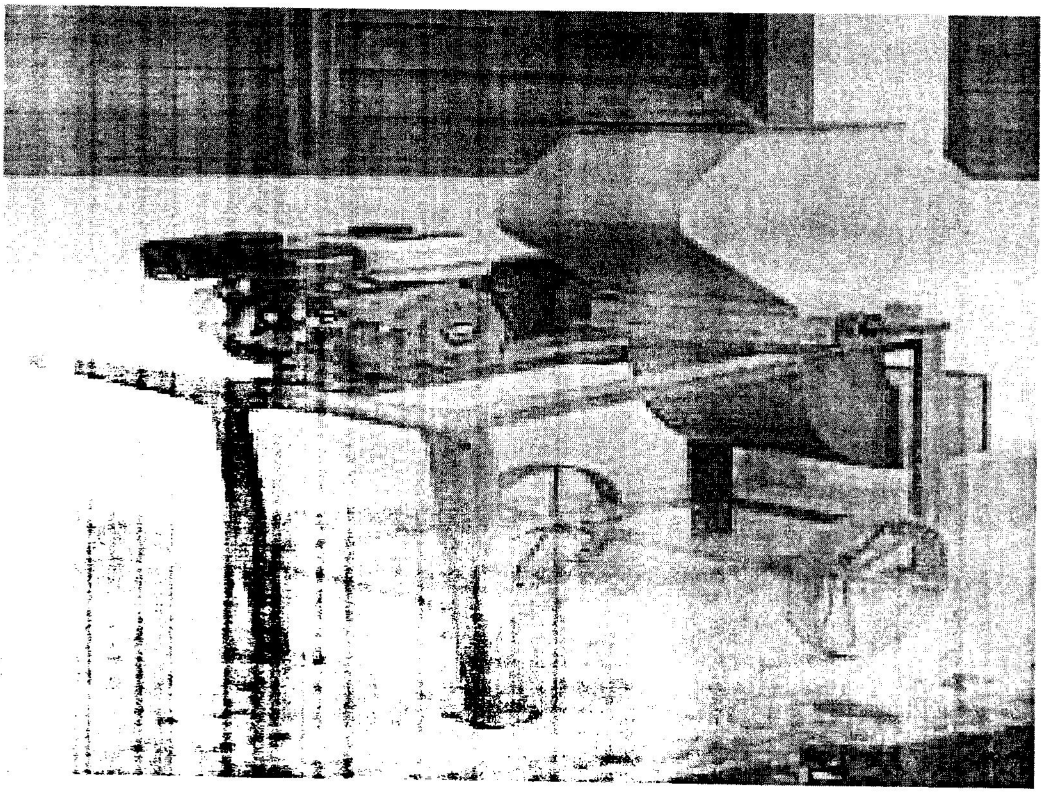

Fig 2.4.8 Cassava Grating Machine powered by a fuel engine (Source: Google image search)

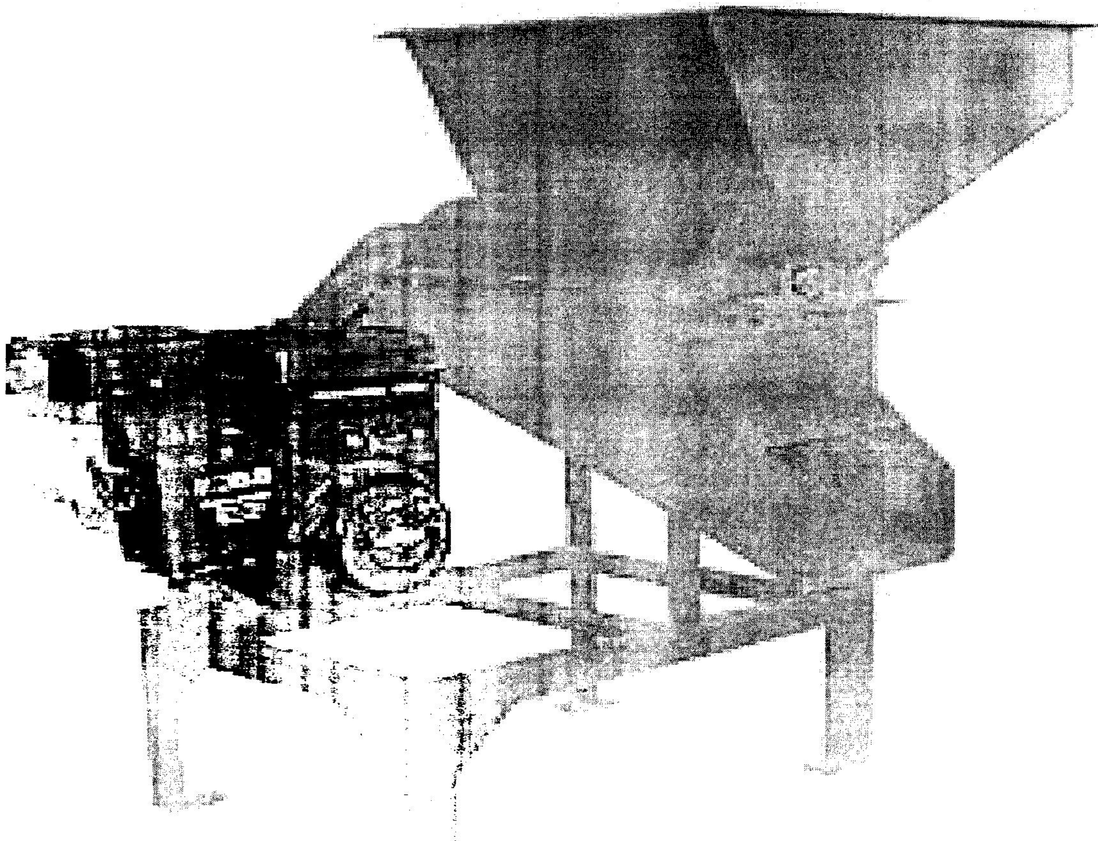

Fig 2.4.9 ***Cassava Grating Machine powered by a fuel engine (Source: Google image search)***

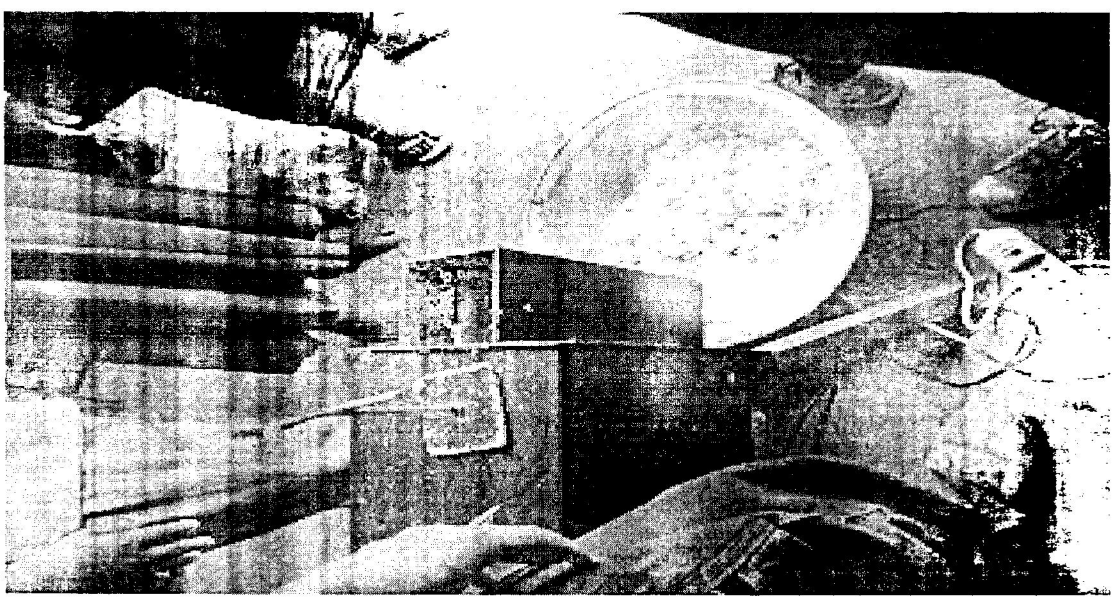

Fig 2.4.10 ***A Mini Cassava Grating Machine (Source: Google image search)***

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 DESIGN CONSIDERATIONS

In designing the mini cassava grater, to achieve effectiveness, acceptability during operation and testing of the machine, the materials used must be properly selected because of the large amount of cyanogenic glycosides in cassava which can easily cause corrosion. Also the machine should be portable, movable and user friendly.

3.1.1 MACHINE SYSTEM

The machine system should be in accordance with the following considerations;

1. The machine shall have proper operation, material selection and waste discharge mechanisms must be studied.
2. The machine components or elements shall be appropriate and follow standards based on the computed theoretical analysis and design.
3. The machine should be designed ergonomically for safer and convenient operation.

3.1.2 CONTROL SYSTEM

The machine control system should be in accordance with the following considerations;

1. The electric motor must be in standard form to eliminate the risk of fire and electrical shocks.
2. The control system must automatically shut-off the power supply if some part of machine operation is malfunctioning.
3. The control system must have a user friendly interface for easy operation and navigation.

3.2 DESIGN ANALYSIS

In line with the approach adopted by(Ben Chapman and Nndugu Munturi2014)which renders the grating process seven times faster than hand grating.

3.2 .1 DESCRIPTION OF THE MACHINE PARTS

The machine is expected to have the following components;

1. Chute
2. Plunger
3. Handle frame
4. Heads
5. Teeth
6. Legs
7. Electric motor
8. Coupling
9. Shaft

➢ *Chute;*

The chute is the receptacle through which cassava is admitted into the machine for grating. Chunks of cassava are pushed through the stainless steel chute with a plunger and are grated between a stainless steel teeth sheet wrapped around a cylindrical head.

➢ Plunger;

The stainless steel plunger allows for safe operation preventing users from using their hands to push the cassava into the chute. The handle of the plunger contacts the top of the chute at the bottom of the grating stroke to prevent the user from pushing the plunger too far down and again running it into the head.

➢ *Handle Frame;*

The handle frame consists of the motor mount plate, the handle, and the attachment tube for the leg as well as two handle flanges. The handle is a square pipe designed in a U-shape that allows gari producers to hold, lift, and reposition the grater in a variety of different ways.

➢ *Legs;*

The legs are welded for stiffness and to reduce vibration. The proposed leg is constructed from the same tube as the handle.

➢ *Head;*

The spinning cylindrical head has the teeth which actually grate the cassava. It is spun by the square shaft. Teeth are made by piercing a sheet. Torque is transmitted from the drum to the teeth using two metal strips welded to the teeth, positioned in slots in the drum.

➢ *Electric motor;*

An electric motor is a prime mover that drives the driven. The proposed motor electricity Requirements is 220v 50 Hz, the Power Consumption is 560W, the Motor Speed is 1500 RPM. The design will be compatible with Yachan YL90L-2

- Coupling;

A coupling is termed as a device used to make permanent or semi-permanent connection. The proposed coupling used is a helical coupling. Shaft coupling are used in machinery for several purpose, the most common of which are the following;

1. To provide for the connection of shafts of units that is manufactured separately such as motor and generator and to provide for disconnection for repairs or alternation.
2. To provide for misalignment of the shaft or to introduce mechanical flexibility
3. To reduce the transmission of shock loads from one shaft to another
4. To introduce protection against overloads.

- Shaft;

A shaft is a rotating machine element which is used to transmit power from one point to another. The power is transmitted by some tangential force and the resultant torque (or twisting moment) setup within the shafts permits the power to be transferred to various machine or its elements linked up to the shaft. In order to transfer the power from the shaft, the various members such as pulleys, bearings, drum etcetera are mounted on it. These members along with the force exerted upon them causes the shaft to bending. The material used for the shafts should have the following properties;

1. It should have high strength.
2. It should have good machinability.
3. It should have low notch sensibility factor.
4. It should have good heat treatment properties.
5. It should have high wear resistance properties

Shaft are generally manufactured by hot rolling and finished to size by cold drawing or turning and grinding (R.S Khurmi and J.K Gupta, 2005). In the design of the grater, two shafts were used namely; Transmission shaft and machine shaft.

- Transmission shafts: These shafts transmit power between the source and the machines absorbing power. The counter shaft, line shaft and overhead shaft and all factory shafts are transmission shafts. Since these shafts carry machine parts such as pulleys, gears, etc., therefore, they are subjected to bending in addition to twisting.Therefore, we may say the shaft in this case is exposed to bending moment and torsional forces
- Machine shafts: these shafts form an integral part of the machine itself.

The proposed shaft has 4 flats surface which can be used with a broached hole from an off-the-shelf square broach. The shaft is self-locating, with a large chamfer on the front face and a tapered edge on the front edge of the flats.

3.2.2 THEORETICAL ANALYSIS

- **Chute Volume (V):**

V= πr^2h

Where, r = radius of the chute

h = height of the chute

Assuming the radius, r = 10cm

V= $\pi(10)^2$ * (48.5)= 15,242.9cm^3

The chute will be made of 1mm stainless steel. It will be folded into cylindrical square shape and it will be joined together by riveting pins. The edges of the chute will be covered with rims made of the same stainless steel in order to prevent the chute from cutting the user, and it will also be joined together with riveting pins.

- **Shaft diameter:**

The shaft is subjected to twisting moment (or torque), therefore the diameter of the shaft may be obtained by using the torsion equation;

$$T = \frac{\pi}{16} \times \tau \times D^3 \text{.......................................} \quad \text{(eq i)}$$

Where, T = Twisting moment in (N-m),

τ = Torsional shear stresses in (MPa)

D = diameter of the shaft in (mm)

Since the shaft will have no keyways, therefore there won't be an allowance for a keyway. In lieu of this, according to the American Society of Mechanical Engineering (ASME) code for the design of transmission shafts, the maximum permissible working stresses in tension or compression may be taken as 112MPa.

The twisting moment (T) may be obtained by using the following relations;

We know that power transmitted in Watts (W) by the shaft,

$$P = \frac{2\pi N \times T}{60} \quad \text{Or} \quad T = \frac{60 \times P}{2\pi N} \text{.........................} \text{(eq ii)}$$

Where T = Twisting moment in (N-m), and

N = Speed of the shaft in (r.p.m)

So therefore, assuming;

Power, P = 560W

Shaft speed, N = 1500 r.p.m

τ = 112MPa = 112 N/mm^2

From equation ii,

$$T = \frac{60 \times P}{2\pi N} = \frac{60 \times 560}{2 \times \pi \times 1500} = 3.57 \text{ N-m or } 3.57 \times 10^3 \text{ N-mm}$$

Also, from equation i, $T = \frac{\pi}{16} \times \tau \times D^3$

$$3.57 \times 10^3 = \frac{\pi}{16} \times 112 \times D^3$$

$$D^3 = \frac{3.57 \times 10^3}{22} = 162.27$$

$$\therefore D = 5.5\,mm$$

Therefore, diameter of the shaft = 5.5 mm say 6mm

The shaft will be fabricated from mild steel with four flat surfaces; the diameter will be 5mm. The shaft is going to be used with a broach.

- **The frame design:**

The frame will be U-shaped designed using a square pipe and angle iron for the down part of the frame (the leg).

Below are the drawings for he proposed machine and the CAD software used is Solid works;

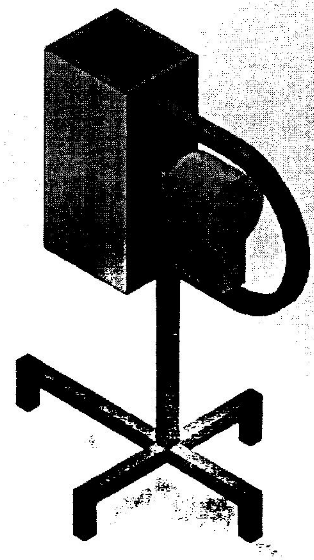

Figure 3a; CAD drawing of the cassava grater

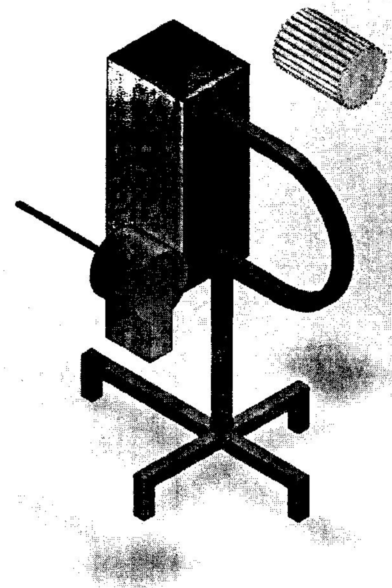

Figure 3b; CAD drawing of the cassava grater (exploded view)

3.3 MATERIALS

Material selection is the most significant factor in constructing any machine since its elements must have appropriate selection in order to perform well and to achieve the required performance output. Further, the material should be free from any chemical or physical reactions to the commodity that will be process to minimize contamination. In this case I ensured that before selecting any material to be used for the construction of the cassava grater, it met the required standard. Some of the materials used in the construction of the cassava grater are listed below;

Table 3: list of materials

No.	Name	Material used
1	chute	Stainless steel
2	plunger	Stainless steel
3	Chute flanges	Stainless steel
4	Rim	Stainless steel
5	shaft	Mild steel
6	Teeth	Stainless steel
7	Head	Stainless steel
8	Frame handle	Iron
9	Legs	Iron
10	coupling	Carbon steel
11	Electric motor	Cast iron with windings
12	Broach	steel
13	bolt	Stainless steel

3.3.1 MACHINES USED FOR THE FABRICATION OF THE GRATER

1. *Drilling machine:* This can be hand drilling or pillar drilling. This machine was used for most drilling jobs. The work is stationery while the spindle carrying the drill chuck and bit moves, the work must be held with a vice during drilling.
2. *Lathe machine:* This was used for an extensive array of precision works, such as turning, facing, chamfering of the shaft.

3. *Hand grinding\ cutting disc machine:* This is hand held and it is used for cutting and grinding.
4. *Welding Machine:* It is used in conjunction with electrode and tong for joining two or more metals together.
5. *Bending machine:* it is used for bending sheet metals up to 5mm thick at different desired angles. It was used for bending the stainless steel.
6. *Table shear:* It is big and heavy. It was used for cutting plate less than the 3mm and 4mmsheet, and it gives a straight cut edge unlike the hand cutting disc.

3.3.2 OTHER TOOLS USED FOR THE FABRICATION OF THE GRATER

1. Try square: it is used for setting and checking the perpendicular alignments of work piece.
2. Plumb/Spirit Level: It is used for checking the alignment of work pieces to ensure balance which reduces vibrations.
3. Dividers: It is used for marking out circles or circular distances to be cut using hand cutting disc.
4. Vernier Caliper, Steel rules and Tape: They are used for measuring dimensions for marking out on the work piece. Tape were used for longer dimensions
5. Scriber and Marking chalk: they are used for making the markings on metal visible. It is immune to water and dirt.
6. Center punch: It is used for marking the point to be drilled or the point for placement of a divider.
7. Drill bits: It comes in various sizes in mm and they are used for drilling.
8. Hammer: It is used for beating metals into shape.
9. Mallet: It is used for beating sheet metals into desired shapes. It prevented denting of the perforated stainless sheet.
10. Hacksaw: It is used for cutting straight edges on work piece manually.
11. Spanners (flat, ring, adjustable), Ratchet & socket: Used for tightening and losing bolts or nuts.
12. Riveting Gun/Pliers: They were used in pinning/joining the perforated stainless and the grating chute together using riveting pins.
13. Files (square, round): They were used to tarnish sharp edges to ensure smoothness and prevent injuries.

14. Allen keys: They were used in tightening or losing Allen bolts/grub screws on the shaft coupling.
15. Paints, Brush, and Sandpaper: These were used in painting the frame and leg of the grater. The sandpaper was used to remove the dirt, carbon, and previous paint.

3.3.3 SAFETY EQUIPMENT

Safety equipment or wears are the gadgets used or present in the factory which helps prevent accident, injuries, loss of life and property.

1} Hand gloves: These are generally made of different materials. The kind of hand gloves worn depends on the nature of the job to be done.

NOTE: Warnings not to use gloves when using the pillar drilling machine as it has been known to dislocate arms from the shoulder joint.

2} Eye protector: These are glasses which come in different shapes. A black lenses glass for welding to prevent ultra violet light damage to the eye cells. A clear-lenses glass is used for cutting and grinding.

3} Nose guard: This was used during painting to prevent dust or chemical inhalation.

4} Safety Boots and Wear: These are personal protective equipment. The right size of boot and overall for the fabrication was worn at all times.

3.3.4 SAFETY PRECAUTIONS

Safety precautions are the instructions taken in order not to be injured.

1. I made sure that when using welding machines, the earthen (negative terminal) must not be in contact with someone/ other metals causing electric shock.
2. I ensured that the overall was not too big, to prevent accidents.
3. I made sure that gloves were not used during drilling because while clearing metal scraps, the glove might get caught up in the working bit and lead to shoulder dislocation.
4. I ensured that when using the lathe, the work piece was tightened firmly in order to prevent flying work pieces.

5. I made sure that when walking on the lathe machine safer speeds was used to prevent accident.

3.3.5 MACHINING OPERATION

- *Marking and Cutting:* This operation encompasses the using of Scriber in marking and hand cutting disc in cutting out the marked parts.
- *Drilling:* The hand drill was used to make riveting pin holes on the chute and on the grating teeth.
- *Joining:* Full welding was used to join the frames/leg, rivet was used to join the chute and the grating teeth and some other parts while bolts and nuts are used for others.
- *Balancing and Alignment:* The chute has to be well balanced to minimize vibrations of the grater during working. Alignment is important between the shaft of the motor and the grating shaft. If good balance is not achieved, it will cause misalignment and wear of metal parts.
- *Turning, Facing and Boring:* The shaft is the only part machined to desired form on the lathe machine.
- *Welding Process:* This is the method by which the sheet metals are joined together.

CHAPTER 4

4.0 RESULTS AND DISCUSSIONS

The machine was designed and fabricated as shown below. It was tested in three different trials to attain reliable results. The main features are; an electric motor, the chute, the grating unit (shaft, teeth, and head), the coupling and the frame/leg. The stages in the construction and assembling of the machine are shown in the diagrams below;

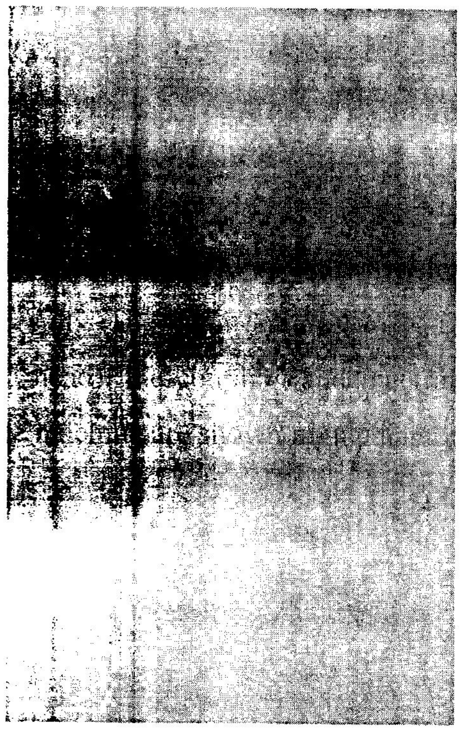

Plate 1: Marking out and cutting of the stainless steel

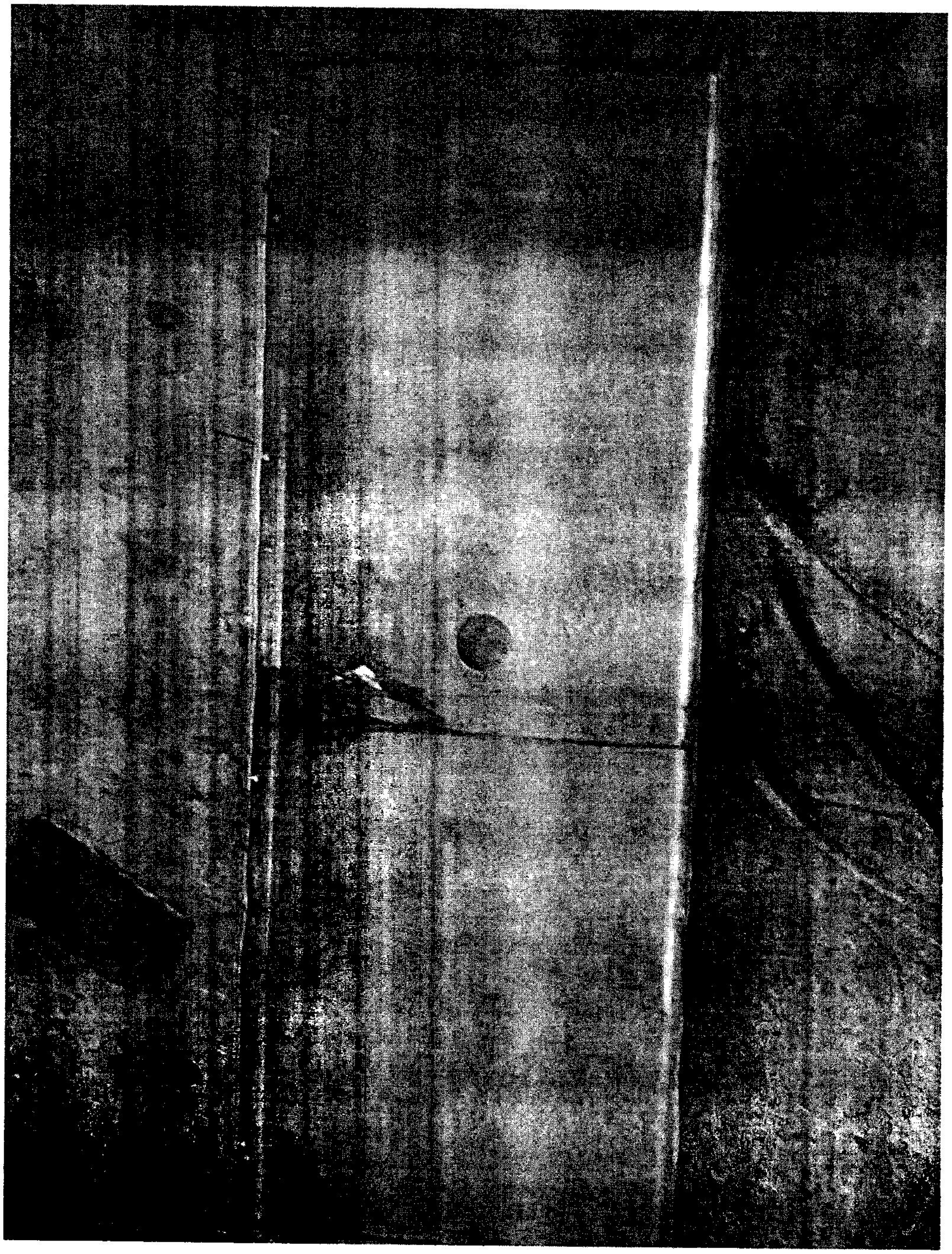

Plate 2: shaping/folding of the chute made of stainless steel

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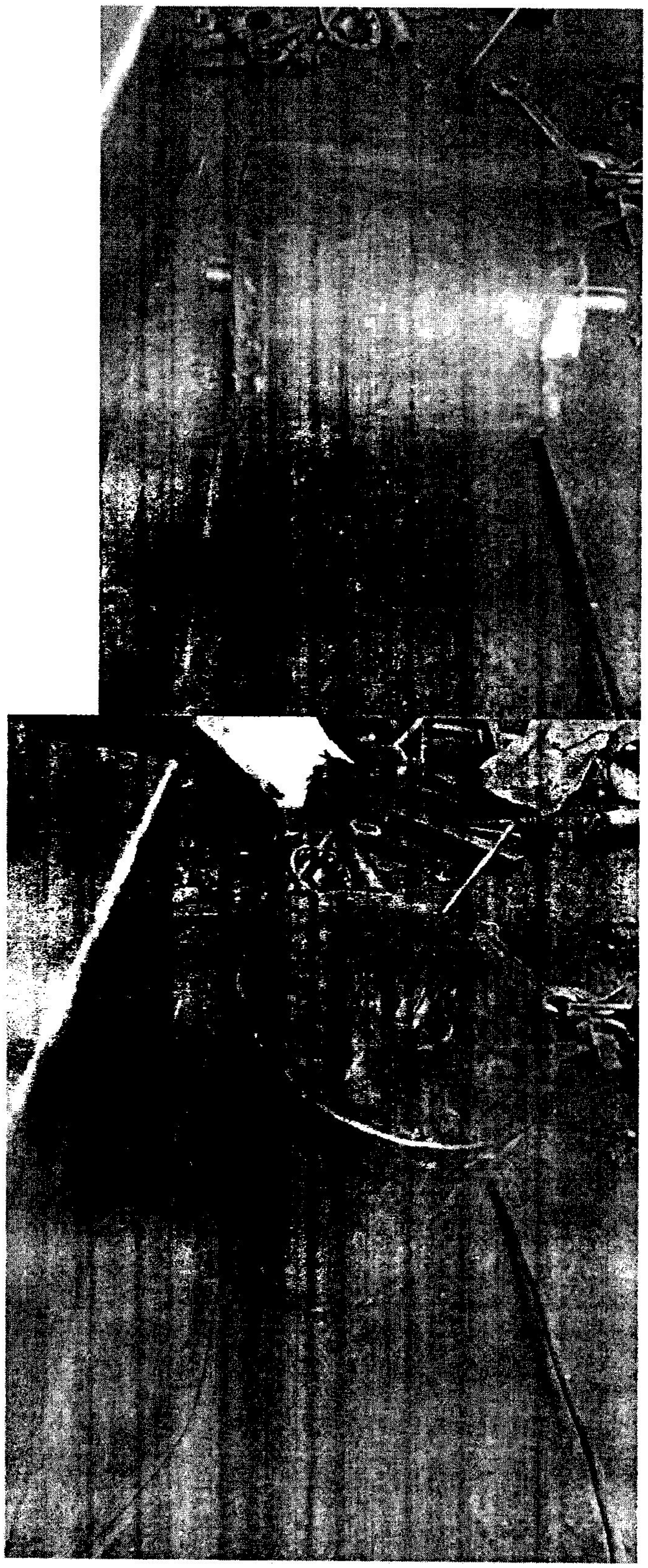

Plate 3: fabrication of the grating unit

Plate 4: joining the handle together with chute

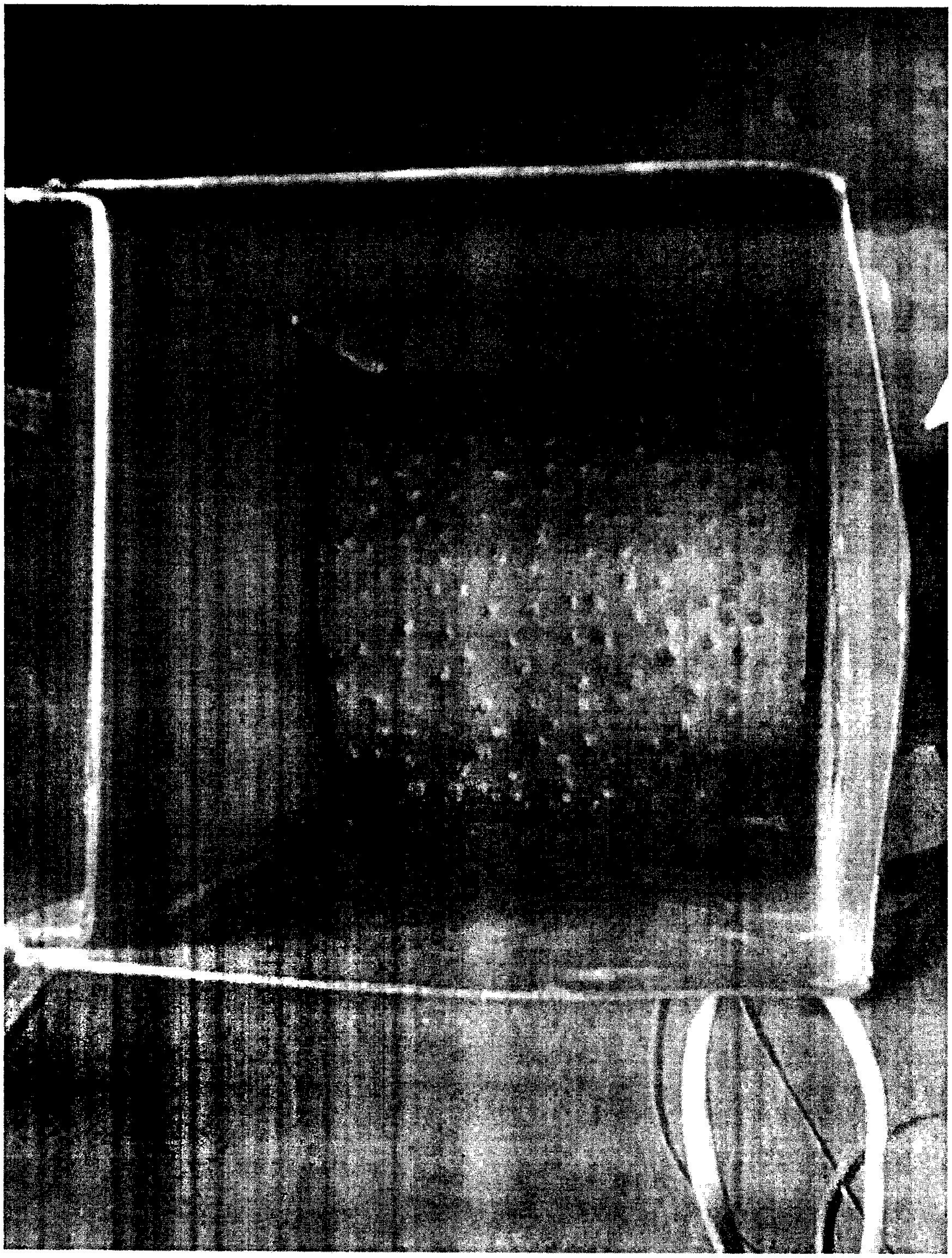

Plate 5: fixing the grating unit inside the chute

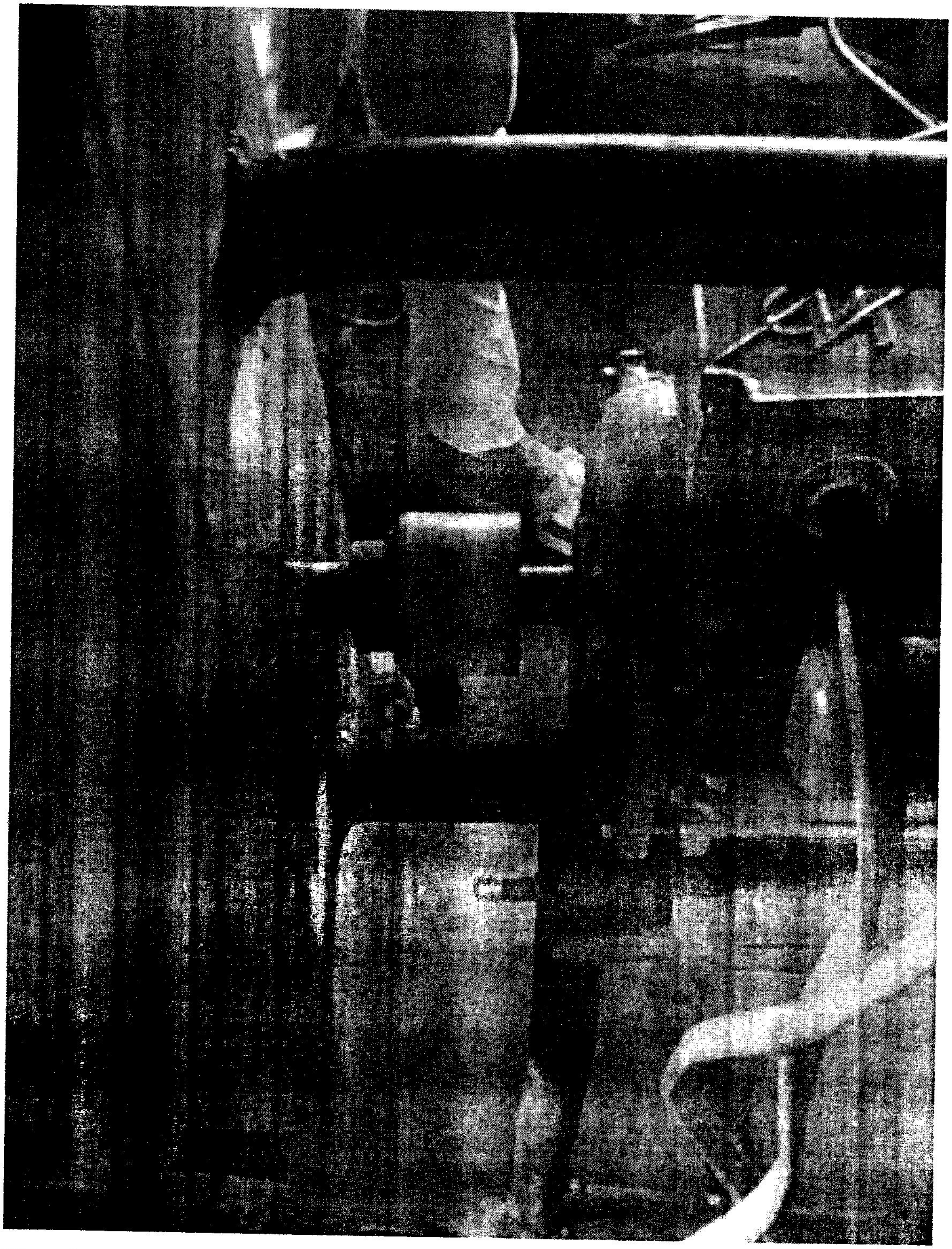

Plate 6: connection of the electric motor to the shaft using a helical coupling

Plate 7: bushing attached to the chute

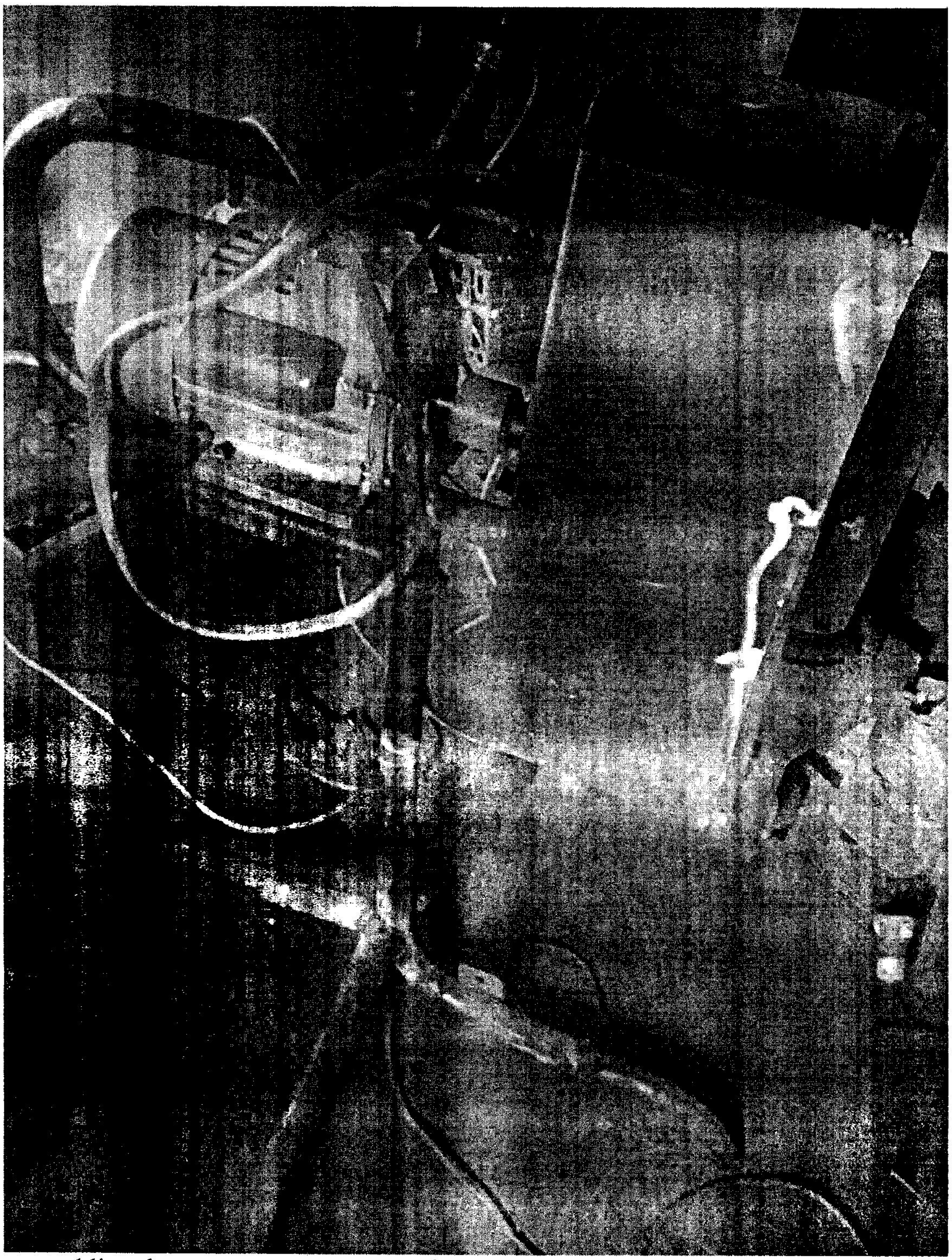
plate 8: assembling the cassava grater parts before painting

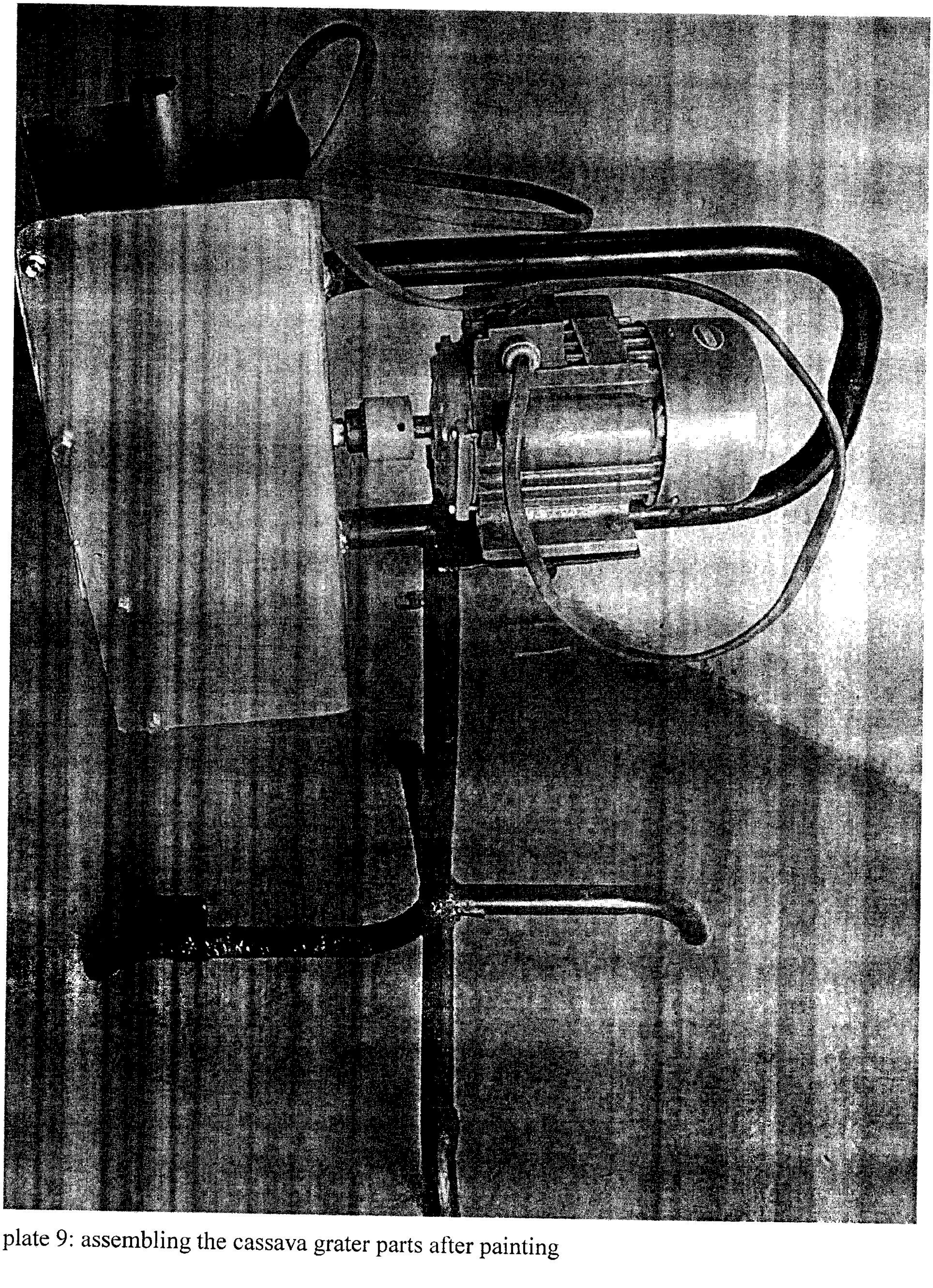

plate 9: assembling the cassava grater parts after painting

4.1 Performance Evaluation

During testing, in order to get the efficiency of the cassava grater, the cassava were measured before introducing them into the grater and the time taken for the cassava to be grated was recorded.

Mass of empty basin (M1) = 9.30g

Mass of empty basin + cassava (M2) = 412.87g

Mass of cassava (M3) = M2 – M1 = 412.87g – 9.30g = 403.57g

Mass of grated cassava = 350g = output

Tabulated result of the grater is given below;

Table 4.1: results of the grating

Trials	Weight of peeled cassava(g)	Time taken to grate(sec)
1st	403.57	5.0
2nd	403.57	4.9
3rd	403.57	5.1
Average	403.57	5.0

$$\mu = Grater\ efficiency$$

$$\mu = \frac{output(g)}{input(g)}$$

$$\mu = \frac{350(g)}{403.57(g)}$$

$$\mu = 0.867 = 86.7\%$$

Plate 10 : Grated cassava

plate 11: weighed cassava

4.2 Discussions

The cassava grating machine was designed to grate cassava tubers and it was electrically powered by an electric motor. When the peeled cassavas were initiated into the chute, the plunger was used to guide and push down the cassava to the grating unit. Then, the grating units begin to process. Many improvements were made on the previous or existing graters to increase rigidity mitigate grater vibration and to achieve better machine efficiency. Vibration is a serious problem because it leads to accelerated wear of the motor and decreased grater lifetime, however I made sure that the grater joints was reduced to eradicate the issue of the vibration.

(Odigbo 1976), stated that manual grating as done traditionally is tedious and time consuming and often involves scrapes and bloody injuries to the operators fingers. Thus, manual grating of cassava is unhygienic and leads to non-uniformity of the grated particles as well as substantial losses arising from the difficulty of holding small pieces of cassava tubers for grating. However with this my modified grater, it will eradicate the traditional or manual grating. The efficiency of the modified grater of 86.7% is many times more than the old traditional method.

Moreover in the design of my cassava grater, the grating unit was made of stainless steel suitable for food processing in order to prevent food poisoning and also the wood used in some mechanized grater was replaced with stainless steel.

It is obvious that my fabricated grater of 86.7% is effective and efficient for the purpose for which it is designed.

4.3 Cost Analysis of Cassava Grater

The table below shows the cost analysis of the fabricated grater.

Table 4.2: cost analysis of the fabricated grater

S/n	Name	Material used	Size	Quantity	Amount (₦)
1	Chute, plunger	Stainless steel	3m by 4m	1	9000
2	Electric motor	Cast iron		1	20,000
3	Shaft	Stainless steel	20cm	1	2000
4	Teeth	Stainless steel	1m by 3m	1	1000
5	Coupling	Rubber casting		1	3000
6	Legs, handle	Mild steel		1	4000
7	Bolts	Stainless steel		10	300
8	Broach	Mild steel		1	500
9	Electrodes				2000

Total amount = ₦41,800

CHAPTER 5

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The cassava grater was fabricated and tested. It was found to have 86.7% efficiency, the machine can be used for home scale or domestic applications and it is affordable since the cost of production is low (about ₦41,800) which will reduce during large scale production. The materials that were in contact with the cassava tubers are made of high stainless steel that is suitable for food processing. Based on the construction materials selection and quality of fabrication work, the machine will be durable.

5.1 RECOMMENDATIONS

In conducting a project, ample time is necessary to conduct and perform the project and thesis successfully. For further improvement of this project, I recommend that the material used for design must be locally available particularly on machine elements for ease and affordability and as well as an avoidance of the delay of fabrication. In the next line of study and for further modification of fabricated machine, a switch can be installed on the electric motor itself for ease of use, also an adjuster can be installed on the chute to control the fineness of the grated cassava. Further improvement and extensive literature review could still be done on this study to enhance more effective and acceptable performance.

REFERENCES

- Food and Agricultural Organization, FAO (1994). African Experience in the Improvement of Post-harvest Techniques, Food and Agricultural organization of the United Nations, Agricultural Engineering Service (AGSE) Support Systems Division Workshop, Held in Accra, Ghana 4th to 8th July, Rome. www.fao.org/docrep/W1544E/W1544E07.HTM
- Odigbo 1976, inaugural lectures "The inspiration behind agricultural mechanization
- Ndaliman M. B. (2006). Design and Construction of a Pedal Operated Cassava Grinder, Unpublished Manuscript.
- Adetunji, O.R. and A.H. Quadri. 2011. "Design and Fabrication of an Improved Cassava Grater". *Pacific Journal of Science and Technology*. 12(2):120-129.
- Oriaku E.C, Agulanna C.N, Ossai, E.N, Odenigbo,J.O, and Adizue U.L (2014). "Double action Grater"– Official work document: Projects Development Institute (PRODA) Enugu.
- Jesal O. Pugahan and Jesal O. Pugahan (2015)"Design, Fabrication and Performance Evaluation of an Automated Combined Cassava Peeler, Grater and Presser for Small Scale Processing"
- Ben Chapman and Ndungu Muturi (2014) "Design of mini cassava grater"
- Oyesola G. O. (1981). Technology Processing Cassava and Utilization, Advisory Leaflet No. 3Cassava and Garri Storage, NCAM, Kwara State, Nigeria.
- Onabolu, A.O., O.S.A. Oluwole, H. Rosling, and M. Bokanga. 2002. "Processing Factors Affecting the Level of Residual Cyanohydrins in Gari". *J Sci Food Agric.* 82:966–969.
- Onabolu, A., A. Abbass, and M. Bokanga. 2003. "New Food Products from Cassava". http://www.cassavabiz.org /IITA Publications
- Bencini, M.C. (1991). Post-harvest and processing technologies of African staple foods: a technical compendium. Agriculture Services bulletin No. 89., FAO, Rome.
- Cock, J.H. (1985). Cassava: New potential for a neglected crop. lADS development-orientated literature series. Pub. West view Press, Colorado.
- Delta Youth Farmers Multipurpose Co - operative Society Ltd - Proceeding of the workshop on Cassava processing and its Socio - Economic Benefits, Warri, 2002

- Flach, M. (1990). Gari processing in the North-west province of Cameroon. Working documentNo.5, FAO Project CMR/86/017.
- NSIC, Cassava Varieties, Metro Manila: Department of Agriculture.
- F. A. a. S. L. Adekunle A.A., "Commercial Utilization of Cassava in Nigeria," Nigeria, 2000.
- FAO. 1994. "African Experience in the Improvement of Post-harvest Techniques, Food and Agricultural organization of the United Nations". Agricultural Engineering Service (AGSE) Support Systems Division Workshop, Held in Accra, Ghana 4th to 8th July. FAO: Rome, Italy. www.fao.org/docrep/W1544E/W1544E07.HTM
- FAO. 2000. "Cassava: An Essential Part of Diet". Championing the Cause of Cassava http://www.fao.org/NEWS/2000/000405-e.htm.
- FAO. 2002. "FAOSTAT, Statistical Data Base of the Food and Agricultural Organization (FAO) Of The United Nations". FAO: Rome, Italy.
- FAO. 2001. "FAO/GIEWS – Food Outlook No 3". June 2001 p.9 .Product Profile on Cassava.
- Kolawole, O.P., L.A.S. Agbetoye, and A.S. Ogunlowo. 2007. "Cassava Mash Dewatering Parameters". International Journal of Food.
- Protection, Agriculture and Consumer, Storage and Processing of Roots and Tubers in the Tropics, FAO, 2006.
- L. U. Opara, "Cassava Storage," in CIGR Handbook for Agricultural Engineering Volume IV: Agro process Engineering, Michigan, CIGR, 1999, pp. 157-170.
- FAO, (2000) Storage and Processing of Roots and Tubers in the Tropics, Agriculture and Consumer Production.
- Quadri A. (2010). "Design and fabrication of an improved cassava grater" in a report submitted for the degree o B.Eng. UNAAB, Abeokuta.
- R. S. Khurmi and J.P Gupta (2005). A test book of Machine Design[A text book for the students of B.E./B.Tech., U.P.S.C (Engg. services); Section B of A.M.I.E (I)]. Eurasia publishing house (PVT.) LTD. Ram Nagar, New Dehli-110 055.

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