MODIFICATION OF CASSAVA GRATER

BY

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DECLARATION

I hereby declare that this project work is a record of research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any University or institution. Information derived from personal communication, published and unpublished work were duly referenced in the text.

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02/03/2012

Date

CERRTIIFICATION

This is to certify that this project entitled "Modification of cassava grater" by Musa, A.B Ibrahim meets the regulations governing the award of degree of bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project work is inspired and dedicated to the memory of my late mother, for all the love and affection shown to me.

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ABSTRACT

There is need for hygienic and more durable way of processing cassava. Prevalent, conditions in commercial grating areas of the staple food show a susceptibility to food contamination and high cost of constantly replacing worn out stainless steel perforation at short intervals, with more durable permanent angle iron on drum and a replaceable galvanized steel perforated mesh for efficient and more durable grating experience by impact, the tubers of cassava being grated, vegetables and fruits can be properly monitored. Some design considerations used in this project are, the machine should be efficient during use as well as moveable (Portability) and safely or easily operated. Another problem consideration is that cassava produces a large amount of cyanogenic glycosides so in selecting materials, for construction, adequate care was taken not to use materials that can degrade/corrode easily due to the acidic content in cassava, also the possibility of the machine being powered (electrically operated) was explored, and the machine surfaces were completely free crevice which can harbor bacteria. The capacity of the grater is 300kg/hr. the unit cost is N41,500 as against the N50,000 to 80,000 for current grating units in the market, the hopper and drum cover were modified with the drum cover and hopper being detacheable and easy to couple to make transporting of machine easy, the machine runs on single phase one horse power electric motor at a speed of 1440rpm

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CHAPTER ONE

1.0 INTRODUCTION

The cassava root is long and tapered, with a firm homogeneous flesh encased in a detachable rind, about 1mm thick, rough and brown on the outside. Commercial varieties can be 5 to 10 cm in diameter at the top, and around 15 cm to 30 cm long. A woody cordon runs along the root's axis. The flesh can be chalk-white or yellowish. Cassava roots are very rich in starch, and contain significant amounts of calcium (50 mg/100g), phosphorus (40 mg/100g) and vitamin C (25 mg/100g). However, they are poor in protein and other nutrients In contrast, cassava leaves are a good source of protein, and are rich in the amino acid lysine. (Beccini 1991)

Cassava had been known to Africans for more than two hundred years, it was said to have been brought into the continent by Portuguese traders who came to explore African markets. Today cassava stands tall amongst sources of carbohydrates as the chief source of carbohydrates in most African countries in the continent. The young treelike plant made its way through African forest to various locality across the continent. The plant which has its origin in Latin America was later introduced to Asia in the 17th century, In Nigeria, cassava is mostly grown on small farms, usually inter cropped with Vegetables, plantation crops, yam, sweet potatoes, melon, maize etc (Bamiro2007).

Cassava is propagated by 20 -30cm long cutting of the wood stem, spacing between plants is usually 0.5-1.5 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 *(Onabolu et al 2002)*.

Nigeria is the world largest producer of Cassava tuber, producing about 34 million tonnes of the needed 174.0 tonnes worldwide, the demand for cassava is always increasing as more use is associated with the crop. 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 recently for 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 *(Onabolu et al 2002)*.

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 of 25:1 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 perishability, their low protein content and presence of cyanide in all root tissues. Through simple processing the disadvantages of bulk and perishability 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 kilometres is necessary, further processing to produce high density pellets is carried out to minimize transport costs (Flach 1990)

1.1 Production areas

The total areas under cassava cultivation in Nigeria, is about 3.60 million hectares. All states including 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*(Kolawole et al)*.

Botanical Name *Manihot esculenta*

Local Names in Nigeria

Hausa: Rogo

Igbo: Akpu

Yoruba: Ege

To produce local varieties, some cassava plants are always left to grow in the traditional bush fallow system, 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) A kintola

(iv) Akon

(v) Etunbe

(vi) Akpu

(vii) Dan wari

1.2 Problem statement

From my survey, I discovered that most of the cassava graters loose efficiency due to clogging of the perforated hole in stainless steel grating drum. Hence reducing output capacity and poorly grated product. 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.

1.3 Objectives

I. To carryout modification of existing cassava grater.

2. To modify the design of-pre existing cassava grater(dimensions) to the home use-small scale sizes.

3. To fabricate a model of the modified grater

1.4 Justification

Presently in Nigeria, the products of cassava are locally consumed and exportation is limited. In order to increase export and to meet up with global best practices of processing food products. 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). It is more economical as processing parts are replaced less frequently.

1.5 Scope of study

The scope of the project is to design and construct a viable motorized Cassava grater which Would be useful for home-use, retailers and small scale farmers.

CHAPTER TWO

LITERATURE REVIEW

2.0 Background of study

Cassava was introduced to Africa by the Portuguese more than 300 years ago by Portuguese explorers and traders from Brazil, and today is a primary source of carbonhydrate source in sub-Sahara Africa. The plant grows as a bush or little tree. From where it was diffused by Africans, to many parts of sub-Saharan Africa over a period of two to three hundred years. In the course of its spreading across the continent, cassava has replaced traditional staples such as millet and yam, and has been successfully incorporated into many farming systems. It was initially adopted as a famine reserve crop as it provided a more reliable source of food during drought, locust attacks and the hungry season, the period before seasonal food crops are ready for harvesting. Cassava is a staple crop in many tropical countries and is harvested for its tubers, which are grated and pounded into flour. Cassava (*Manihot esculenta*), also called yuca or manioc, a woody shrub of the Euphorbiaceae (spurge family) native to South America, is extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy tuberous root, a major source of carbohydrates, cassava is the third-largest source of carbohydrates for meals in the world. It is classified as sweet or bitter, depending on the level of toxic cyanogenic glucosides. (However, bitter taste is not always a reliable measure) Improper preparation of cassava can leave enough residual cyanide to cause acute cyanide intoxication and goiters, and has been linked to ataxia or partial paralysis. Nevertheless, farmers often prefer the bitter varieties because they deter pests, animals, and thieves. In some locations the more toxic varieties serve as a fall-back resource (a "food security crop") in times of famine. Indigenous people have learned to avoid poisoning themselves by spitting into batches of the ground tubers; the saliva introduces bacteria and fungi, which activate an enzyme that breaks down the cyanide. Villagers accomplish the same thing by depositing freshly dug cassava tubers into a community pond; microorganisms in the water degrade the cyanide. The diversity of the plant is remarkable. There must be thousands of different varieties. In Brazil, every little village has its own varieties. There are bitter ones, sweet ones, even ones used as baby food. *(Schaal et al., 1999)*.

Burgeoning interest in the crop in recent times results from the realization of the potential of cassava as a food security and emergence crop which could generate employment for the rural poor and foreign exchange for the country. Since 1990, the Government, through the Ministry Agriculture, has demonstrated its determination and commitment to promote cassava for the alleviation of poverty particularly in rural households and communities. The main reasons for expansion of cassava are population growth, famines or seasonal hunger and market availability. In Nigeria, cassava is moving from a starvation-prevention crop to a cash crop for local urban consumption. The next stage is to develop the crop for use as livestock feed and industrial uses and to identify new markets. The top cassava producers are, in order, Nigeria, Brazil, Thailand and Indonesia (the next six countries are all in Africa) *(Schaal et al., 1999)*.

2.1 Role of cassava and its products

Cassava performs five main roles:

- Famine reserve crop,
- Rural food staple,
- Cash crop for urban consumption,

- Industrial raw material, and
- Foreign exchange earner,
- Also that Nigeria is the most advanced of the African countries poised to diversify the use of cassava as a primary industrial raw material in addition to its role as livestock feed. Two factors were identified for Nigeria situation: the rapid adoption of improved cassava varieties and the development of small-scale processing technologies. Despite this development, the demand for cassava is mainly for food; and opportunities for commercial development remain largely undeveloped. Cassava production exhibits high levels of variability and cyclical gluts, due mainly to the inability of markets to absorb supplies. As a result, price of storage roots decline sharply and production levels are reduced in succeeding years before picking up again. Such factors were identified by IITA as cause of price instability over the years, which significantly increase the income risk to producers. Insufficient processing options and equipment for the processing and storage leading to inadequate marketing channels, and a lack of linkages between producers and the end-users are major factors preventing greater profitability for producers and processors. There is a potential to generate from one crop multiple economic benefits through improved post harvest handling and processing. Major constraints are technical, resources, socio-economic and organizational

2.2Constraints To Further Development Of Cassava

The major problems faced by the production and development of cassava are:

- Lack of planting material (or effective distribution system), especially of improved varieties;
- High transport costs *(Asuming-Brempong, 1992, Dadson et. al, 1994)*. - Inadequate transport systems and inappropriate handling at ports (Pessey, 1996)

• Limited utilization in non-traditional products (feed, composite flours, starch and starch derivatives);

• Low uptake of new/improved products from research;

• Low profitability of Gàri processing (Asuming-Brempong, 1992);

• Poor packaging of products.

• A big problem for cassava is cassava mosaic virus, which is so devastating that Nigeria has a US$ 16.5 million grant program for just this virus. There have been very successful programs which have produced transgenic cassava plants resistant to this virus.

• Another problem is that cassava produces a large amount of cyanogenic glycosides, which our digestive enzymes break down to toxic cyanide. The plants produce this to defend against herbivores. This is why the cassava tubers must be so heavily processed, otherwise, ingestion leads to konzo (paralysis of the legs). Genetically engineered cassava has been created with greatly lowered cyanogenic glycosides.

2.3 Post harvest handling and processing

Handling and processing conditions often result in a very poor quality of the products. In addition to the high labour intensity and drudgery, the conditions during processing are generally unsanitary and unwholesome. During processing by women in rural areas, losses of some mineral and vitamin value do occur (FOA, 1994). This can be avoided with better-designed equipment *(Kolawole et al. 2007)*.Agricultural improvements via technology and marketing can make a big difference in less developed countries.

Fig2.0: showing women spreading cassava chips

Cassava undergoes postharvest physiological deterioration, or PPD, once the tubers are separated from the main plant. The tubers, when damaged, normally respond with a healing mechanism. However, the same mechanism, which involves coumaric acids initiates about 15 minutes after damage, and fails to switch off in harvested tubers. It continues until the entire tuber is oxidized and blackened within two to three days after harvest, rendering it unpalatable and useless. PPD is one of the main obstacles currently preventing farmers from exporting cassavas abroad and generating income *(onabolu et al)*

The major cause of losses during cassava chip storage is infestation by insects. A wide range of species that feed directly on the dried chips have been reported as the cause of weight loss in the stored produce. Some loss assessment studies and estimations on dried cassava chips have been carried out in different countries. (Hiranandan and Advani 1955) measured 12 - 14% post-harvest weight losses in India for chips stored for about five months, (Killick 1966)estimated for Ghana that 19% of the harvest cassava roots are lost annually, and (Nicol 1991) estimated a 15 - 20% loss of dried chips stored for eight months. (Pattinson 1968) estimated for Tanzania a 12% weight loss of cassava chips stored for five months, and (Hodges et al. 1985) assessed during a field survey postharvest losses of up to 19% after 3 months and up to 63% after four to five months due to the infestation of (Prostephanus truncatusHorn). In Togo, (Stabrawa 1991) assessed postharvest weight losses of 5% after one month of storage and 15% after three months of storage due to insect infestation, and (Compton 1991) assessed weight losses of about 9% for each store in the survey area in Togo.*(Wright et al.1993)* assessed postharvest losses of chips of about 14% after four months of storage, about 20% after seven month of storage and up to 30% when *Prostephanus truncatus*attacked the dried chips. In addition, (*Wright et al.1993*) estimated about 4% of the total national cassava production in Togo is lost during the chip storage. This was about equivalent to 0.05% of the GNP in 1989.

Plant breeding has resulted in cassava that is tolerant to post production diseases. (*Sánchez et al.1999)* identified four different sources of tolerance to post production disease. One comes from Walker's Manihot *M. walkerae* of southern Texas in the United States and Tamaulipas in Mexico). A second source was induced by mutagenic levels of gamma rays, which putatively silenced one of the genes involved in post production disease genesis. A third source was a group of high-carotene clones. The antioxidant properties of carotenoids are postulated to protect the roots from post production disease (basically an oxidative process). Finally, tolerance was also observed in a waxy-starch (amylase-free) mutant. This tolerance to post production disease was thought to be co segregated with the starch mutation, and is not a pleiotropic effect of the latter.

2.4 Uses of cassava

2.4.1 Five major cassava food products

In Africa, there are five common groups of cassava products: fresh root, dried roots, pasty products, granulated products and cassava leaves.

• Roasted in an open fire, to be eaten as food

• Boiled in water or oil. The cyanogens in the roots are destroyed by slowly cooking the roots. Starting with cold water, gradual heating promotes the hydrolysis of the cyanogen (Grace, 1977) also to be eaten as food.

2.4.1.1 Fresh root

Fresh Cassava is boiled in water or oil. The cyanogens in the roots are destroyed by slowly cooking the roots. Starting with cold water, gradual heating promotes the hydrolysis of the cyanogens; it is a staple food mostly in the northern part of Nigeria, popularly known as Rogo

2.4.1.2 Dried root

Dried cassava roots are stored or marketed as chips, balls and flour. Chips and balls are milled into flour at home by pounding with a pestle and mortar in preparation for a meal. There are two broad types of dried cassava roots:

- Fermented and
- Unfermented.

Preparing unfermented dried cassava roots by sun- or smoke-drying is the simplest method of cassava preparation. Since this method is inefficient in the elimination of cyanogens, it is used mostly for preparing sweet cassava varieties, which have low cyanogen content. In the case of fermented dried cassava roots, the fermentation is accomplished in one of two ways: stacking in heaps or soaking in water for a number of days. The fermentation process, whether in water or in heaps, influences the taste of the final product. The longer the fermentation period, the stronger is the sour taste. Taste is an important attribute, especially for consumers who eat fermented cassava products and who desire the strong sour taste. The recent introduction of a grater has eliminated stacking and fermentation and therefore saves time. The roots are simply peeled, washed and grated. The pulp is placed in a perforated container, covered and a weight put on it for about three hours and the cyanogens are squeezed out along with effluent. The half-dried pulp is then dried in the sun (Alyanak, 1997).

• Roasted in an open fire

2.4.1.3 Pasty products

Two forms of pasty cassava products are common in Africa:

• Uncooked and

• Steamed pastes.

The most popular is called uncooked paste because it is stored or marketed without cooking. To prepare the uncooked paste, the roots are soaked in water for three to five days, during which time the roots soften and ferment. The soaked roots are manually crushed and sieved by shaking it in a basket in a sack under water, thereby separating the pulp into the sack while collecting the fibre in the basket. Cooked cassava pasty products have been recently introduced in Nigerian urban markets. Every evening in major cities in the cassava growing areas of Nigeria, it is common to find women selling cooked cassava paste wrapped in plastic bags. As women go home from work or from the market, they stop and buy some for the evening meal. Although more research is needed on preparation methods, cooked cassava paste is a promising food for busy urban consumers. Preparing steamed paste is expensive because many steps are involved and each one requires additional inputs. For example, grinding and sieving are labour-intensive.

2.4.1.4 Granulated products

In Nigeria, there are three common types of granulated cassava products:

- Gari
- Attieke and
- Tapioca.

Cassava pulp is packed and weighted down with a heavy object for three to four days to express effluent from the pulp while it is fermenting. The de-watered and fermented lump of pulp is pulverized and sieved and the resulting semi-dry fine pulp is toasted in a pan. To prepare tapioca, cassava is grated and then put in water, pressed and the water is drained off. The operation is repeated several times to prepare a high quality product. The damp starch is spread on a pan and toasted in the same way as Garri, product than fresh roots.

2.4.1.5 Cassava leaves

Cassava leaves are storable in dry form and since they have lower water content, they are less expensive to dry than the roots. If leaf harvesting is properly scheduled, it does not have an adverse effect on cassava root yield *(Dahniya, et al 1983)*. Cassava leaves have a nutritive value similar to other dark green leaves and are an extremely valuable source of vitamins A (carotene) and C, iron, calcium and protein (Latham, 1979). The consumption of cassava leaves helps many Africans compensate for the lack of protein and some vitamins and minerals in the roots. Cassava leaves are prepared by leaching them in hot water, pounding them into pulp with a pestle and mortar before boiling in water along with groundnuts, fish and oil. This process eliminates cyanogens from the leaves, making them safe for human consumption.

2.4.2 Industrial uses

Because of the high-energy contents and low prices of cassava, livestock industries have since been using cassava chips in compounding animal feed production both locally and internationally. The compound livestock feeds are developed for pigs, cattle and sheep, goats and poultry

- UTA Ibadan had succeeded in extracting oil from cassava seeds. The oil is yet to be developed to edible level, but it had been confirmed that it could be used for making soap and for some pharmaceutical products. VITANOL is also obtainable from it.
- Used as monosodium glutamate, an important flavouring agent in cooking. Cassava flour is increasingly being used in partial substitution for wheat flour.
- Cassava can also be also used for alcohol, syrups etc. Alcohol is in demand in both the food and beverage industry and in the pharmaceutical industry. However, only 5% was processed into syrup for soft drinks and less than 1% was used for refined flour or adhesives, so much of the value added production potential is neglected. Cassava tubers are highly perishable and begin to deteriorate two to three days after harvesting. Unfortunately apart from delayed harvesting there are no effective methods available for prolonged storage of the tubers. Therefore, post-harvest handling of the root crop is extremely important. Approximately, 30 percent of cassava produced is consumed by the producers, whilst the rest is sold on markets and a large proportion of this is processed into various indigenous products such as Gari, agbelima and kokonte.

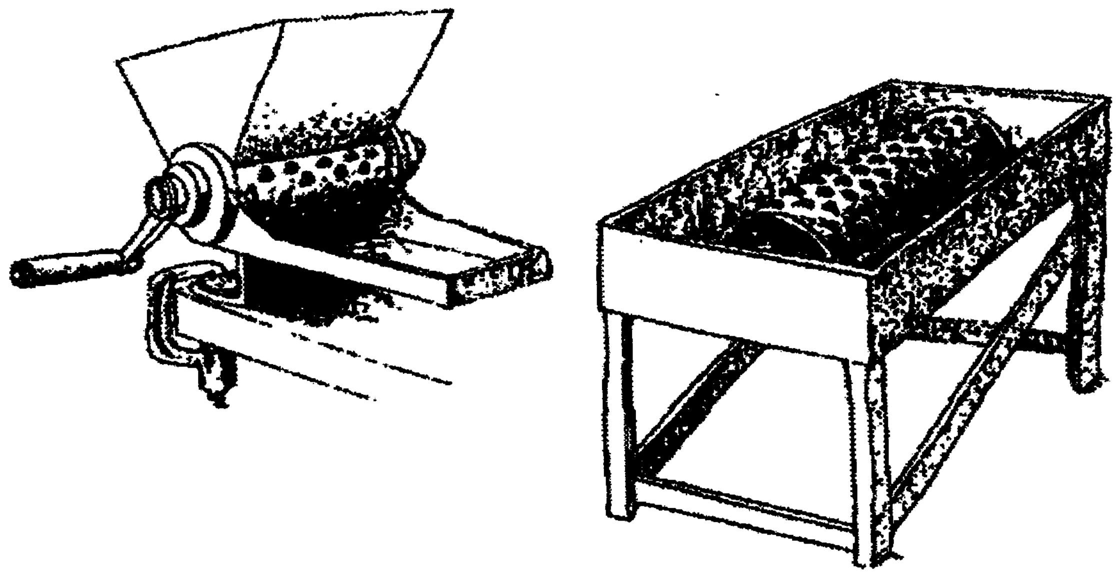
2.5.0 Evolution of cassava graters

Cassava graters had evolved from traditional method of processing to modern modern mechanized graters which are easy to use, fast and drudgeryless

2.5.1 Traditional Graters

- The traditional method of grating cassava was by pounding it in a mortar with a pestle. Later, artisans developed a manual grater in the form of a sheet of perforated metal, punched with about 3 mm diameter nails leaving a raised jagged flange on the underside and mounted onto a flat piece of wood.
- Another Innovation is by grating it with a tin can with holes punched in the bottom since the cassava root is spongy and this leads to lots of hand injuries. 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 tonne of fresh peeled cassava roots generally requires 10-15 man days of effort. (Cock, 1985).
- The traditional technology 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 operators 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 skilful person is able to produce only about 20 kg/hour.

Fig: 2.1 showing traditional grater



Traditional Graters

2.5.2 Mechanical graters

Due to high cost of imported and inefficiency of locally made graters 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 mill

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 within six months ofregular 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 breeding space for microbial growth and subsequent contamination of the grated cassava which could affect subsequent fermentation (F.A.O. 2002)

- 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 groups workshop in NIgerria made from simple workshop spare parts and using hacksaw blades mounted on a vertical disc, it is driven by human

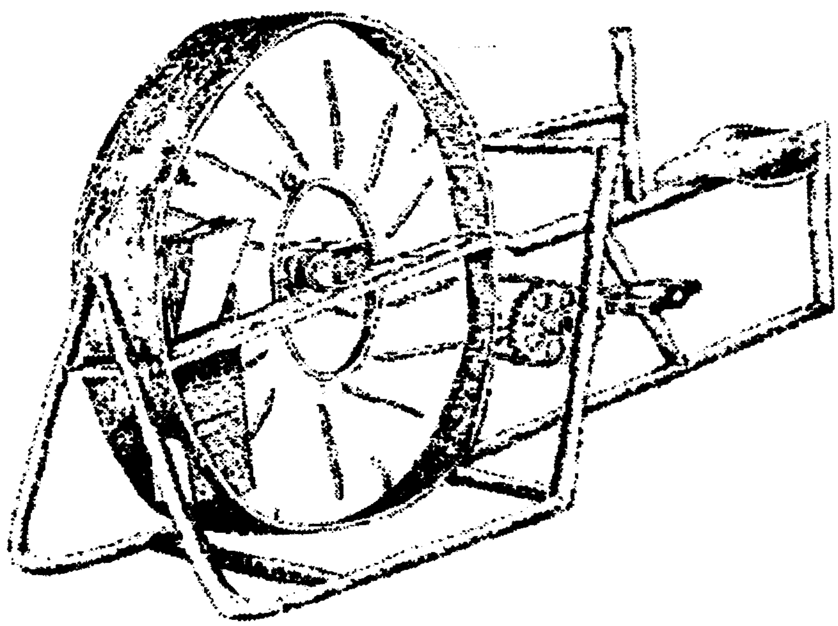


Fig: 2.2 showing pedal grater

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 tonne of cassava was claimed.(F.A.O. 2002)

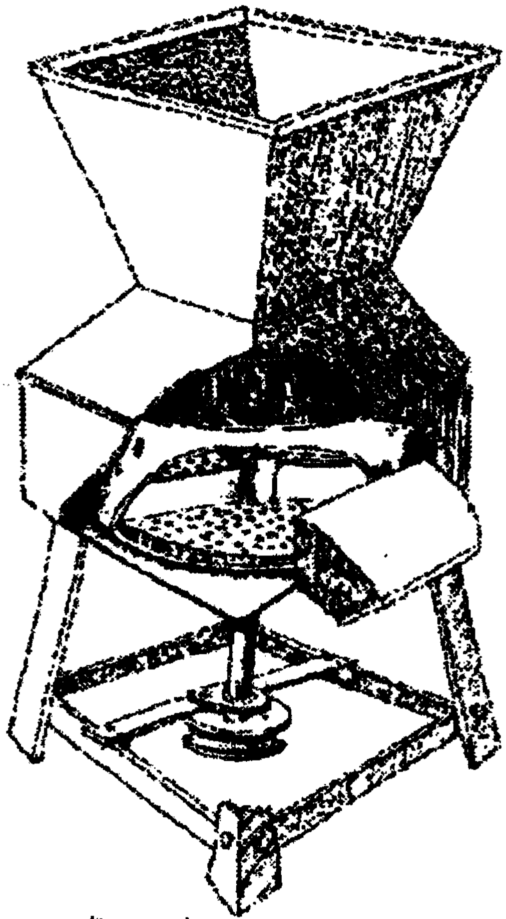


Fig: 2.3 Abrasive disc grater

• 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 4HP electric motor or diesel engine. In general capacities range between 300kg to I,OOOkg per hour (Bencini, 1991).

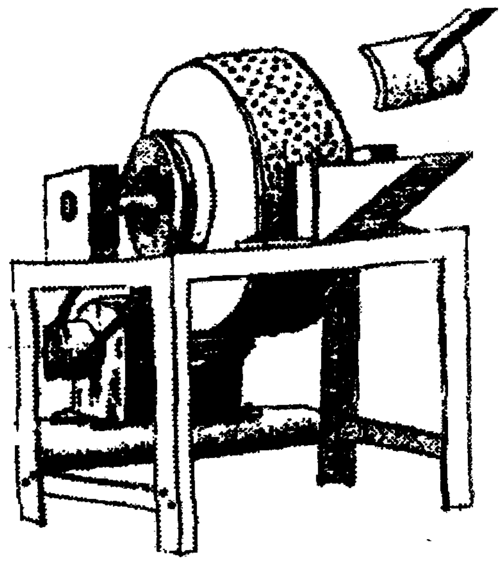


Fig: 2.4 vertical disc grater

In Nigeria many of the cylindrical graters being developed to be used in villages were based on the existing design 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.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 DESIGN CONSIDERATION

- The machine should be able to process 3000kg of cassava on an average of 10 working hours per day
- Cassava produces large amount of cyanogenic glycosides so in selecting materials for construction, adequate care must be taken to ensure that materials used does not degrade or corrode easily
- Possibility of the machine to be powered electrically would be explores
- All joining or welding along cassava passage must be free from crevices that can harbour bacteria

3.2 Material selection

Table 3.0 Machine parts and materials used

S/No.	Part	Materials used	Reason
1.	Hopper	Mild steel	Material is cheap and paint coating would prevent corrosion
2.	Shaft	Galvanised steel	To prevent corrosion along processing chamber
3.	Drum	Galvanised pipe	To prevent corrosion along processing chamber
4.	Discharge	Galvanized sheet	To prevent corrosion and possibility of contamination of grated cassava
5.	Bearing	Cast iron	To increase rotational efficiency and prevent breakage
6.	Spikes	Galvanized angle iron	It has the right edge and rigidity and balance on drum

3.3 Design capacity

The term capacity, or machine capacity, is used to define the maximum rate of output that a plant is able to produce under a given set of assumed operating condition. It is closely related to production rate, whether based on sales forecast or specific customers orders, production plans must be related to the actual productive capacity of the machine

3.3.1 Capacity calculation

For this calculation, π =3.142 and g = 9.81 m/s^2

Expected output capacity of the cassava grater = $3000kg$ per day or 5kg/min

Number of working hours per day = $10hrs$

Density of cassava = $501kg/m^3$

3.3.2 Expression of the Capacity in Volumetric Rate

Mass of cassava to be grated in one minute = $5kg$

Density of cassava = $501kg/m^3$

Density $= \frac{mass(m)}{volume(v)}$ (Douglas, 2006)

Volume $= \frac{mass}{density} = \frac{5}{501} = 9.98 \times 10^{-3}m^3$

If $9.98 \times 10^{-3} m^3$ of cassava is to be grated in one minute, therefore the expression of the machines capacity in volume per hour is

$$C_{vph} = \frac{9.98\times10^{-3}\times60}{1} = 0.5988 m^3/hr$$

Similarly the expression of the machines capacity in mass per hour is

$$C_{mph} = 501 \times 0.5988 = 299.9988 kg/h$$

% dry matter=37.5%

0.375 of 3000kg of cassava to give 1125kg of garri daily

From the C_{vph} value gotten, calculate drum diameter

Assume drum length of 0.44m

$$\text{Volume (V)} = \frac{\pi d^2}{4} \times L$$

Where,

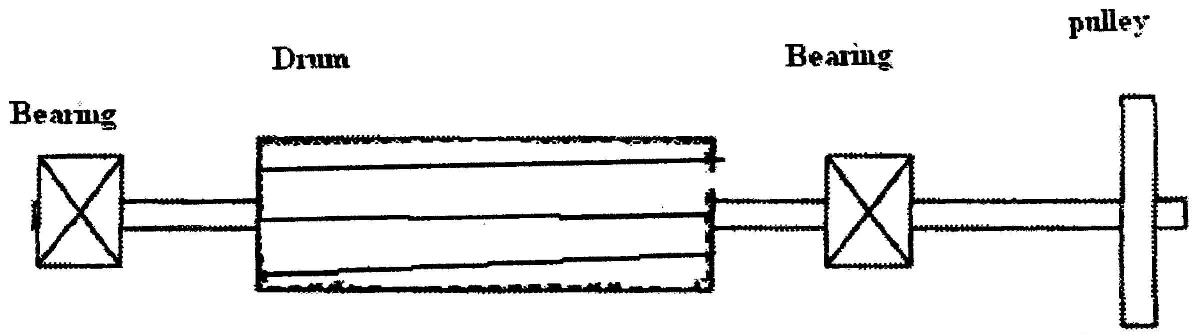
d- the diameter of the drum

$$d = \sqrt{\frac{4\times V}{\pi L}} = \sqrt{\frac{4\times0.5988}{\pi\times0.44}}$$

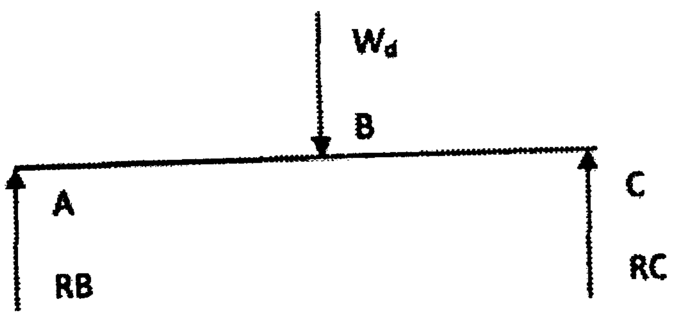
d=0.0775m

3.4 Shaft design

This consists primarily of the determination of correct shaft diameter to ensure satisfactory strength and rigidity when the shaft is transmitting power under various operating load and loading conditions. Shafts are usually circular in cross section, and may be either hollow or solid. Design of shaft with ductile material based on strength is controlled by maximum shear theory.



The machine elements that exert force on the shaft are shown clearly above and can be resolved into forces as shown below



3.4.1 Force exerted on shaft (Vertical)

The machine elements that exert force on the shaft are the pulley and drum

- Weight of pulley W_p = mass of pulley(M_p) X acceleration due to gravity (g)

M_p =1.2kg

g=9.81m/s^2

W_p=1.2X9.81=11.772N

- Weight of drum W_d={(weight of pipe) + (weight of mild steel circular plate) + (weight of angle bars)

W_d= (V_{dp} x ρ_sx g+ V_{cp} x ρ_s xg + V_{bar}x $\rho_s$xg)

W_d =(V_{dp} + V_{cp} +V_{bar}) ρ_s x g

g=acceleration due to gravity

V_{dp} = volume of drum pipe plate

V_{cp} =volume of pipe cover

V_{bar}= volume of bar on drum

ρ_s = density of steel

To calculate the weight of drum, first we find

$V_{dp} = (\pi R^2-\pi r^2)$ L

Outer radius (R) =0.0775m

Inner radius (r)=0.0745m

Length (L)=0.44m

$V_{dp} = (3.142 \times 0.0775^2 - 3.142 \times 0.0745^2) \times 0.44$

V_{dp}= (0.0188716375-0.0174388855) x0.44

V_{dp}=0.001432752x0.44

V_{dp}=0.0006304109m^3

$V_{dp} = 6.3041 \times 10^{-4} m^3$

$V_{cp} = \pi D^2/4 \times L = \pi \times 0.155^2/4 \times 0.002 = 0.07548655/0.008 = 9.43581875 m^3$

V_{bar} =2(L+B)H

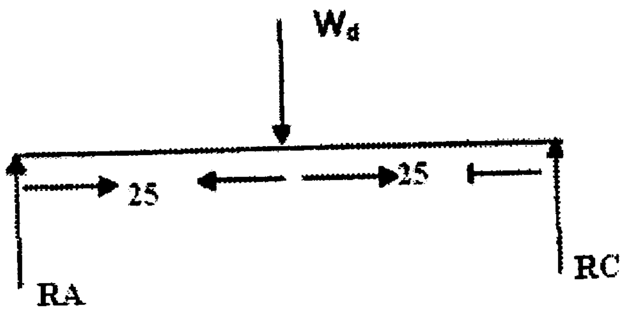
$V_{bar} = 2(0.07+0.01)0.002 = 2 \times 0.08 \times 0.002 = 3.2 \times 10^{-4} m^3$

W_d =(V_{dp} + V_{cp} +V_{bar}) ρ_s x g

$W_d = (6.3041x10^{-4}+9.43581875+3.2x10^{-4})7860x10=741730.05598N$

Distributed load due to drum= 741730.05598/0.5=1483460.112N/m

3.4.2 Analysis of forces acting on shaft



RA= Reaction at bearing A

RC= Reaction at bearing C

Taking moment at point A

W_dx25 – RCx25=0

741730.05598x25=50xRC

741730.05598x25/50=RC

370865.028N=RC

Taking moment about point C

RAx50- W_d x 25=0

RAx50=741730.05598x25/50

RA=370865.028N

Bending moment (B_m)=W_d/4=741730.05598/4=185432.514

Horizontal weight on the shaft by the pulley

Angular acceleration, ω in rad/s=2πN/60

Power rating=1hp=746W

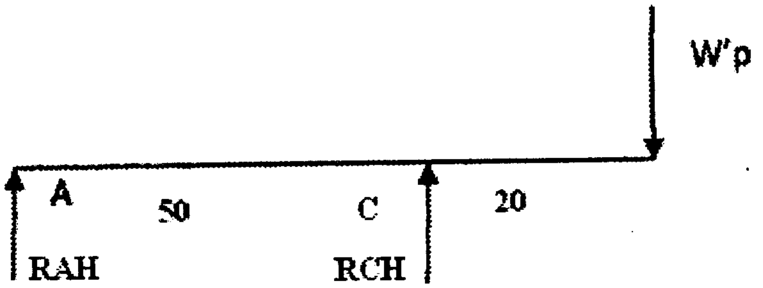
Power=Torque (M_t)x Angular acceleration (ω)

Torque=746x60/2πx1400=44760/8797.6=5.0877512Nm

Horizontal weight of pulley($W'p$)= Torque/diameter of pulley

Horizontal weight of pulley=5.0877512/0.735=6.9221105N

The horizontal reactions are gotten by taking moment about the two bearing



RAH+RCH= $W'p$

Taking moment about point A

RCHx50=6.9221105x70

RCH=4845.477/50=9.6909547N

RAH+9.6909547=6.9221105

RAH=6.9221105-9.6909547=-2.7688442

Which means the main support is at RAH

Horizontal bending moment(HB_m)= $W'p$ xL=6.9221105x70=484.547735

Maximum bending moment (M_b)=$(484.547735^2+3099183.763575^2)^{1/2}$

M_b =9604940235273.41

3.4.3 Shaft diameter

The shaft diameter can be determined by

$D_s^3=16/\pi S_s\{(K_bM_b)2+(k_tM_t)\}^{1/2}$

T_e =Permissible shear stress of the shaft material=42Mpa

D_s=diameter of shaft

S_s =Permissible shear stress of shaft material

K_b and k_t= load application constant

M_b=maximum bending moment

M_t=maximum torsional moment

Assume

$K_b = K_t=1.5$

$S_s = 42Mpa$

$D_s^3=16/\pi x42x10^6(1.5x9604940235273.41)^2+(1.5x5.0877512)^2\}$

$D_s^3=1745.9$

D_s =12.04mm

3.5 POWER TRANSMISSION

The transmission system consists of pulley system reducing motor speed by a ratio of 1:1

Note:

D_e=Diameter of driver pulley

D_d= Diameter of driven pulley

Speed ratio=D_e/D_d

From horsepower motor speed an horsepower speed of 1400rpm was selected

3.5.1 Speed transmission

The ratio between the velocities of electric motor pulley and drum driven pulley is calculated as shown below

Let N_e= speed of the driver in rpm=1400rpm

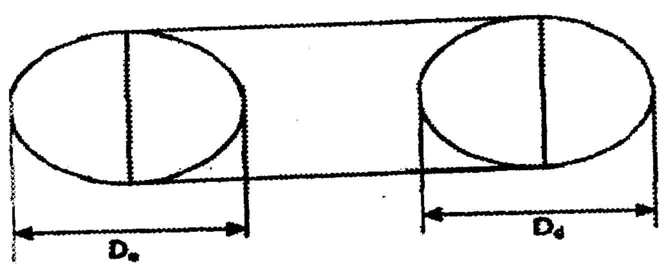
N_d= Speed of the driven in rpm=1400rpm

Length of the belt that passes over the driver in oneminute=$\pi D_e N_e$=3.142x0.735x1400=3233.118cm

Similarly,

length of the belt that passes over the follower in one minute=$\pi D_d N_d$=3.142x0.735x1400=3233.118cm

Since the length of the belt passes over the driver in one minuite is equal to the length that passes over the follower in one minuite, therefore



$\pi D_e N_e = \pi D_d N_d$

3.5.2 Determination of centre distance (C)

The rubber manufacturing association (RMA) recommended that the center distance is dictated by the following considerations

- For speed ratio less than 3, C=D_e+D_d/2+D_e
- For speed ratio of 3 or more C=D

Therefore

$C=(0.735+0.735)/2+0.735$

$C=1.47cm$

Length of belt

In order to compute the length of belt required, we use the formula below

L=length of belt required

$L=\pi\{(0.735+0.735)/2+2(1.47)+(0.735-0.735)^2/4(1.47)$

$L=11.54685cm$

3.5.3 Angle of contact on the driver belt sheave

This is the lap angle of the belt over the electric motor pulley

$\theta=(180-2\alpha)\ (\pi/180)rad$

$\alpha=\sin^{-1}[D_e-D_d/2C]$

$=\sin^{-1}[0/2C]=0=\theta=\pi=180°$

3.6 METHODOLOGY

3.6.1 Machineries and machining process used

- Drilling machine: The hand drilling machine was used for most drilling jobs. The work piece is stationary while the spindle carrying the drill chuck and bit moves the work was used for most drilling jobs. The work is stationery while the spindle carrying the drill chuck andbit moves, the work must be held with a vice during drilling.
- Milling machine: this machine was used for the cutting of the keyway on the grater shaft

- Lathe: This was used for an extensive array of precision works also such as boring, turning,facing of the assembly parts.
- Hand grinding/ cutting disc machine: This is hand held and it comes in two sizes. The disccomes in the sizes 9", 7"or 4" diameters. The 7" disc was used for cutting and grinding.
- Welding Machine: It is used in conjunction with electrode and tong for joining two or moremetals together. It was used with mild steel electrode when welding the mild steel. Welding caneither be tacking (which can be easily broken) during setting, stitching, (which can be used tohold thin metals (lmm metal sheets together firmly) or running (which is used for thick metalplates, 3mm). The mild steel electrode of gauge twelve(2.5mm diameter) was used. Weldingglasses (dark) was used when working.
- Table shear: It is big and heavy. It was used for cutting plate less than the 3mm and 4mm sheet, and it gives a straight cut edge unlike the hand cutting disc.

3.6.2 Tools Used for the Fabrication

- Plumb/Spirit Level: It is used for checking the alignment of work pieces to ensure balancewhich reduces vibrations.
- Dividers: It is used for marking out circles or circular distances to be cut using hand cuttingdisc.
- Vernier Caliper Steel rules and Tape: It is used for measuring dimensions for marking out onthe work piece. Tape were used for longer dimensions
- Scriber and Marking chalk: It is used for making the markings on metal visible. It is immuneto water and dirt.
- Center punch: It is used for marking the point to be drilled or thepoint for placement of a

divider.

- Drill bits: It comes in various sizes in mm. They are used for drilling. The drill bits used were 6mm, 10.5mm, 16mm.
- Hammer: it is used to beat metal into shape
- Mallet: it is bigger than the hammer used for beating chisel to cut sheet metal into desired shapes.
- Spanners (flat, ring, adjustable), Ratchet & socket: Used for tightening and losing bolts or nuts. The sizes used were M6, MI 0, M16.
- Hack saw: it has a metal frame and blade for cutting straight edges on work piece manually
- Riveting Gun/Pliers: They were used in pinning/joining the perforated stainless and the grating drum together using riveting pins.

  Files (square, round): They were used to tarnish sharp edges to ensure smoothness and prevent injuries
- Allen keys: They were used in tightening or losing Allen bolts/grub screws on the flange bearings.
- Painting Compressor, Engine, Cup, Brush, and Sandpaper: These were used in painting. Thesandpaper is used to remove the dirt, carbon, and previous paint.

3.7 SAFETY

3.7.1 Safety equipments

Gadgets used or present in the factory which helps prevent accident, injuries, loss of life and property are known as safety equipments.

- Hand gloves: These are generally made of different materials. The oneworm depends on nature of job to be done. Perfect fit sizes are always worn.

NOTE: Warnings not to use gloves when using the pillar drilling machine as it has been known to dislocate arm

- Drilling machine: this can be hand drilling or pillar drilling machine. This machinery was used for most drilling jobs. The work is stationary while the spindle carrying the drill chuck and bit moves the work must be held with a vice during drilling
- 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 forcutting and grinding.
- Safety Boots and Wear: The right size of boot and overall for the fabrication was worn at all times.

3.7.2 SAFETY PRECAUTIONS

1) When using welding machines, the earthen (negative terminal) must not be in contact with Someoe / other metals causing electric shock.

2) The overall is not too big, to prevent accidents. It must not get caught up in any machinery because it can lead to injuries.

3) Whilst reading the tap, rule or vernier calliper, error due to parallax must be prevented

4) Gloves are not used during drilling because while clearing metal scraps, the glove might get caught up in the working bit and lead to shoulder dislocation.

5) When using the lathe, tighten the work piece on the chuck well to, prevent flying work pieces.

6) Also safe speed was used for different types of materials to prevent accident.

3.8 MACHINING OPERATIONS

- Marking and Cutting: This operation encompasses the using of Scriber in marking andhand cutting disc in cutting out the marked parts.
- Drilling: The hand drill was used to make bolt holes and shaft hole.
- Joining: Full welding was used to join the frames and some other parts while bolts and nuts are used for others. When bolts and nuts are used, the bolts are usually welded permanently in place for nut to be used in order to ensure the ease of maintenance.
- Balancing and Alignment: The drum has to be well balanced to minimize vibrations of the grater during working. Alignment is important between the wood for adjustment and the drum to ensure that the desirable particulate size of the product (cassava) is obtained. If good balance is not achieved, it will cause misalignment and wear of metal parts.
- Turning, Facing and Boring: The hinges, shaft, pulley, flanges (side plate) are machined to desired form on the lathe.
- Welding Process: This is the method by which the sheet metals are

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Cassava Grater drawings

Engineers use computer aided designs (CAD) to create two and three dimensional drawings of machines. While it may be faster for an engineer to create an initial drawing by hand, it is much more efficient to change and adjust drawing by computer

In the design stage, drafting on the computer graphics techniques are combined to produce models of different graters. These models were manipulated on video display screens until they incorporate the best balance of features including ease of production and cost. Using a computer to perform the five step art to part process

- The first two steps in this process are the use of sketching software to capture initial design ideas and to produce accurate engineering drawings
- The third step is rendering an accurate image of what the part will look alike
- Next engineers use analysis software to ensure the part is strong enough
- Step five is the production of the prototype from model
- In the final step the CAM software controls the machine that produce the part

During the design of the machine, the drafting software used was AUTOCAD 2007 version. This was used to draw the orthogonal views, isometric views and exploded drawings of the model cassava grater before the commencement of the fabrication process. The drawings are shown in the appendix

4.2COST ANALYSIS

4.2.1 Material cost Analysis

Table 4.0 showing material cost

s/no	Material	Specification(mm)	Unit price(₦)	Quantity price (₦)
1.	Angle iron	1.5	1,200	4800
2.	Mild steel sheet (½ length)		4,500	4500
3.	Galvanised steel sheet (½ length)		9,000	9,000
4	Bearing	35 diameter	1500	3000
5.	Shaft	34x700	1000	1000
6.	Pipe	150 x 400	2500	2500
7.	1 pack Grade 12 Electrode		1200	1200
8.	Tape	3.4m	150	150
			Total	**26,150**

- Labour cost

  25/100x26150= ₦ 6537.5

- Overhead cost

  30/100x26150= ₦ 7845

  Total cost=₦40,532.5

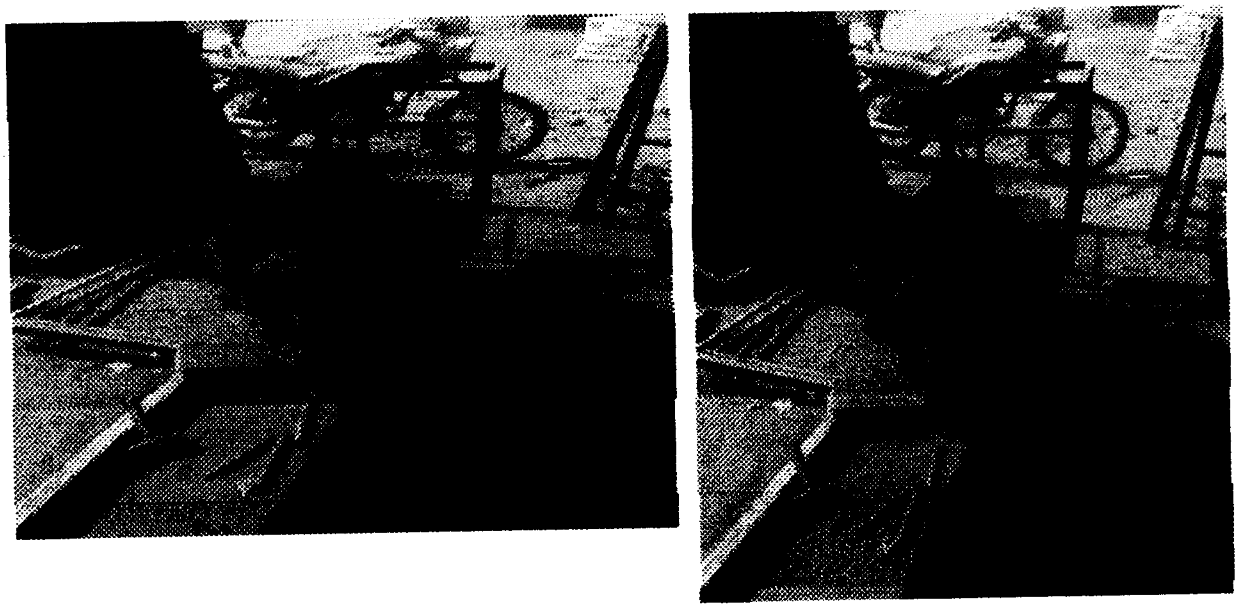


Plate 4.1 Marking of pipe cover sheet

Plate 4.2 Setting and sizing of processing chamber

4.3TESTING PROCEDURE

4.3.1Preparation of cassava

Series of test were conducted using the machine. Cassava tubers were obtained from a farm and peeled manually, thoroughly washed and weighed using weighing balance scale.

4.4 Testing of machine

After preparing the cassava the machine was put on to run idle for about two minuites before the introduction of the cassava already prepared. Table 4.1 shows result of test carried out

Table 4.1 showing test result using a mesh diameter of 4mm and 2mm thickness plate

Number of loading	Mass of cassava input (kg)	Time (sec)	Speed (rpm)	Mass collected (Kg)
First	16.65	151	504	12.06
Second	19.56	238	403.2	13.55

Rate of grating= mass of cassava grated / time

Efficiency= mass of cassava collected/mass of cassava input x 100

For the first loading

Rate of grating= 16.65x3600/151= 396.95364kg/hr

Efficiency= 12.06/16.65x100=72.4%

For second loading

Rate of grating= 19.56x3600/238=295.86555kg/hr

Efficiemcy= 13.55/19.56=69.3%

Table 4.2 showing test result obtained with a 2mm diameter mesh with 2mm thickness sheet

Number of loading	Mass of cassava input (kg)	Time (sec.)	Speed (rpm)	Mass collected (Kg)
First	5.5	105	504	41.2
Second	43	135	403.2	32

For first loading

Rate of grating= 5.5x3600/105=188kg/hr

Efficiency= 4.12/5.5x100=74.9%

For second loading

Rate of grating=4.3x3600/135=114.6kg/hr

Efficiency=3.2/4.3x100=74.4%

4.5 Discussion of result

cassava is grated by the force of impact of cassava on the mesh and chopped by the sides of the mesh to produce pastry and rough or smoothly grated cassava depending on the diameter of mesh hole and thickness of the plate. From the result it can be stated that the higher the speed of the grating drum the higher the rate of grating, also the efficiency of machine is higher at higher drum speed. The texture of the grated Cassava is smoother with smaller diameter hole on the mesh.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The improved home use/small scale cassava grating machine was designed, fabricated and tested. It was found to be effective and efficient and could grate about 300kg/hr.This machine can be used at home-scale for domestic applications and it is affordable since thecost of production is low about N41,438 which will reduce during large scale production.Based on the construction materials selection and quality of fabrication work, the machine isdurable and expected to last for IO years.

The constructed grating machine has been found to be effective and efficient. It can be powered both electrically and manually. Therefore, it can be used by both rural as well as urban dwellers. It is also affordable since the cost of production is low.

Effort should be made to adopt and popularize this design, especially for the benefits of rural people who make up a greater percentage of the nations population. It is also noted that when mass produced, the unit cost would even be lower than it is now.

5.2 RECOMMENDATION

- Different mesh diameter on varying different sheet thickness and drum speed should be used to further verify improved efficiency of machine
- The drum mesh clearance should be made smaller to reduce amount retained
- The efficiency, design mechanism (in terms of grating unit), and speed at which the machine operates can be improved upon in the future .
- It is recommend that the machine should be produced on large scale for small-scaled use(Commercialization)

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