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FACULTY OF ENGINEERING

DEPARPMENT OF AGRO-PROCESSING ENGINEERING

DESIGN AND CONSTRUCTION OF A PEDAL DRIVEN CASSAVA PEELING MACHINE

By

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Abstract

Peeling of different vegetables and fruits has become a necessity prior to consumption. As at today, cassava peeling is still largely carried out manually, it makes the process to be slow, labor intensive, arduous in nature, and low productivity This work focused on the design and construction of a pedal driven cassava peeling machine which can peel a variety of cassava tubers. Most of the common peelers are electrically powered and hence depends on electricity which in Uganda, is presently unreliable in supply or not available at all in most rural areas.

The unreliable power supply, scarcity and high cost of petroleum products necessitate the need to address this issue to certain extent by developing a mechanism that will make life easier in food processing for rural dwellers and improve their economic wellbeing

A pedal driven cassava peeling machine was designed, fabricated and tested. This pedal driven cassava peeling machine consists of pedal chain mechanism connected to the sprocket on the shaft which turn drives the peeling drum; where the cassava tubers are peeled. About 110 kg of cassava tubers can be peeled per hour with a peeling efficiency of 58.7% and the machine is cheap, economically viable and can be used by unskilled workers.

The results obtained show that slight increase in speed and peeling time increases the peeling efficiency, however, further increase beyond the maximum speed (50 rpm) reduces the peeling efficiency of the machine a significant flesh loss is realized from the machine.

Declaration

I *Nkolwa Julius*, do hereby declare to the best of my knowledge, that this project report is an outcome of my original work and that it has not been presented to any institution of learning for an academic award. All the work contained in this report is as a result of my research except where cited.

Signature...

Date......23rd.05.2018..............

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Chapter 1 GENERAL INTRODUCTION

1.0 Introduction

This chapter describes the background information of the project, the problem statement, justification, purpose, objectives and scope of the study. The problem statement describes the research problem and identifies potential causes and a solution. The significance describes the importance of the project. The specific objectives presented and how to achieve the main objective.

1.1 Background

Cassava (Manihot esculeta Crantz) is a perennial woody shrub with outer layer called periderm and the inner layer called cortex with an edible root, which grows in tropical and sub-tropical areas of the world. Cassava originated from tropical America(Vavilov, 1935) and was first introduced in Africa by the Portuguese in the 16th century(Okigbo, 1980). Cassava is the second most important staple and food security crop after banana in Uganda(Haggblade and Dewina, 2010). It is one of the most tolerant crops and can even survive on relatively poor soils.

The cassava root is long and tapered, with a uniform flesh covered in a removable peel, which is about 1 mm thick, rough and brown on the outside. Cassava roots are very rich in starch and contain small amounts of calcium (16 mg/100g), phosphorus (27 mg/100g), and vitamin C (20.6 mg/100g)(Steenkamp and McCrindle, 2014).

Cassava has become the most important crop in the tropical part of Africa in terms of both the total land area devoted to its production and contributes to human diet which is mostly carbohydrate(Chalker and Diouf, 1995). As a subsistence crop, cassava is the third most important carbohydrate food source in the tropics after rice and maize, providing more than 60 % of the daily calorific needs of the populations in tropical Africa(Nartey, 1978).

Cassava was introduced in Uganda between 1862 and 1875, is currently one of the most important staple food crops in the country. It was introduced to Uganda through Tanzania by Arab traders(FAO, 2005). The crop is grown in mixtures of legumes and cereals in small plots of land. It is regarded as the most important staple crop by over 50 percent of farmers surveyed recently in the eastern, central, southern and northern areas of Uganda(Otim-Nape and Zziwa, 1990). In Uganda, cassava is the second most important staple food after banana which is largely grown in the West Nile, Northern and Eastern parts of the country. The major districts that participate largely in cassava growing include; Kumi, Serere, Tororo, Lira, Apac, Mbale, Iganga and Kumi.

Cassava roots are processed at household levels in the rural areas of the major cassava producing districts by traditional methods handed down through time as cassava was adopted as food by the people. Processing at these levels involve mainly the production of 'Garri', fermented and unfermented flour. Cassava peeling is still largely done manually where women and teenage girls are the ones involved in the peeling of the tuber. The process is slow and labor intensive which invariably leads to low productivity. Consequently, the need arises to examine the possibility of using mechanical peeling method so as to reduce spoilage occasioned by delay in processing of cassava tubers.

Cassava has got a few difficulties relating to its processing, its problems seem to be at the post-harvest stage, storage of fresh tuber, mechanization of harvesting and processing. The processing of cassava into flour for home consumption or industrial purposes involves a series of unit operations of which peeling of the tubers also takes part. Cassava peeling is mainly done manually by simple household knives. There has not been any effective and reliable machine for peeling the tubers especially for rural local farmers.

Cassava roots have differences in weight, size and shape. Cassava peels also differ in thickness and texture i.e. some cassava tubers have less thick and soft peels which can easily be peeled off while others are thicker and so hard especially those from drought areas. This makes it difficult to design a machine which can remove all the peelings from the cassava tuber because of the wide differences in properties of roots from various sources.

This project is aimed at designing and constructing a machine capable of peeling cassava tubers with ease. A machine which is economic, easier to operate and effective for cassava peeling

1.2 Problem Statement

Cassava production is needed in several areas in order to enhance food security, means of foreign exchange and tool for rapid industrialization. However, there is drudgery in postharvest handling which include peeling, grating, boiling, drying, milling, sieving, extrusion and frying. Peeling being a challenge in cassava processing is largely carried out manually by the use of a hand knife especially in the rural areas. This makes the process to be slow, laborious in nature and low productivity.

1.3 Significance of the study

The study is intended to design and construct pedal driven cassava peeling machine that will reduce the time spent during the cassava peeling process, easy to operate, reduce on the labor concerned with manual peeling, and increase on the distribution of cassava products.

1.4 Objectives

The project objectives are divided into the main objective and the specific objectives.

1.4.1 Main Objective

Designing and constructing of a pedal driven cassava peeling machine

1.4.2 Specific Objectives

(i) To design the different components of the proposed machine
(ii) To fabricate and assemble all the parts of the machine
(iii)To test for the performance of the prototype

1.5 Scope of the study

This project is limited to designing, construction and testing of the pedal driven cassava peeling machine. The machine is intended to peel already washed freshly harvested cassava tubers of average size. It is also intended to meet the needs of local farmers mostly in rural areas.

1.6 Justification

During cassava processing, men usually engage in machine operations for grinding, pressing and sifting of cassava while women and children are usually responsible for the manual operations such as peeling, washing and frying. Peeling of cassava is done totally manually which leads to high product losses, high time consuming requires physical labor and indoor conditions. The project therefore aims at designing a machine which can reduce on the time and the cortex of the tuber (known as the peel), as shown on Figure 1, is removed for further processing(Olukunle, Ogunlowo, & Sanni, 2010). The Peels can represent 10% to 20% of the fresh root weight, of which the periderm accounts for 0.5% to 2.0%(Jimoh, Olukunle, Manuwa, & Amumeji, 2014). The process of removing the corky periderm and the cortex of the cassava tuber is called peeling. The common methods adopted for peeling cassava tubers are manual method, chemical method, steaming method and mechanical method(Biggs et al., 1986).

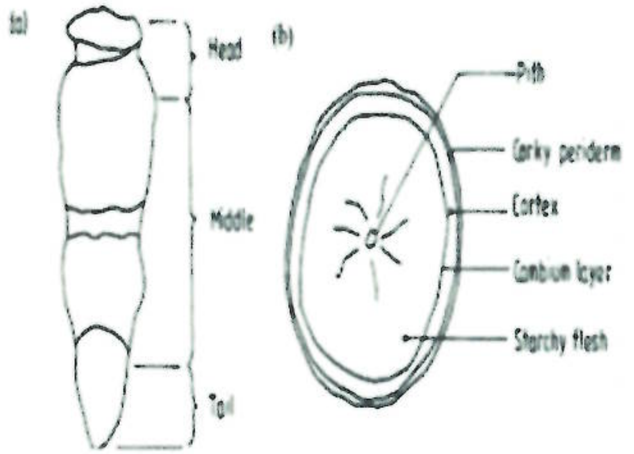

Figure 2-1: Morphology of cassava tuber. (a) General morphology and (b) transverse section (Adetan, Adekoya, & Aluko, 2006)

Cassava Peeling is the only un-mechanized unit operation in cassava production in most areas nowadays despite an ever-increasing demand for the crop(Ugwu & Ozioko, 2015). The tubers of cassava cannot be stored for too long. The root perish soon after harvest and mass processing of the tubers remains the best way to extend the shelf life in large quantities(Jimoh et al., 2014). Cassava processing thus deserves serious attention in order to meet the local and international demand for cassava products. The unit operations involved in the processing of cassava includes peeling, grating, boiling/parboiling, drying, milling, sieving, extrusion and frying. Several processes for the above mentioned operations have been mechanized successfully, however, cassava peeling remains a serious global challenge to design engineers involved in cassava processing(Consultant, 2006).

2.2 Methods used for peeling cassava tubers

There are several methods of peeling cassava, which have been adopted. They include manual, chemical, steaming and mechanical methods. Each has its own advantages and disadvantages.

2.2.1 Manual Method

The manual method of peeling cassava is primitive and burdensome. It is carried out by hand peeling of cassava using sharp edged object like the knife. In varieties which are easy to peel, the peel is slit along the length of one side of the root and the knife-blade and fingers are used to roll back the peels from the fleshy portion of the root. In more difficult varieties to peel, the two layers of peel are whittled with a knife in motion reminiscent of sharpening a pencil. This operation is less satisfactory as it usually results in the removal of some flesh along with the peels and some of the peels are left on the root.

Manual peeling is slow and labor intensive but it still yields the best results. The output of one person is about 25 kg/hour of peeled roots with a loss of 25-30% of weight in the peels(Evuti et al., 2010). Consequently, the need arises to examine the possibility of using mechanical peeling method so as to reduce spoilage occasioned by delay in processing of cassava tubers.

2.2.2 Chemical Method

Chemical method is mostly used for commercial purposes by large cassava processing industries and factories. In this method, a hot solution of sodium hydroxide is used to loosen and soften the peel and thus comes off easily from the tuber. The method is best suited for peeling sweat potato tubers. When used for peeling cassava tubers, it exhibits the following limitations;

(i) high cost of acquiring caustic soda
(ii) the difficulty in controlling the penetration of chemical into the cassava tuber
(iii)the difficulty in the removal of chemical traces as it may be poisonous

2.2.3 Steaming Method

The tubers are subjected to high steam pressure over a short period of time to avoid partial cooking (or eventual cooking). The disadvantage is that the tubers could be subjected beyond the time required, which will lead to cooking. Also, because of the shape of the cassava tuber, there will be unequal distribution of heat. By thermal softening, the firmness, adhesiveness and springiness of the tuber is affected (Sajeev *et al*., 2009). Despite the above demerits, the steaming method has a favorable peeling effect without causing any appreciable loss in the mass of the cassava tubers (Abdullahi *et al.*, 2010).

2.2.4 Mechanical methods

Mechanical peeling involves the use of machines for peeling large number cassava tubers at a time. Various mechanisms have been devised for this purpose which include; the continuous process, abrasive belt conveyors and batch abrasion type e. t. c. These methods of peeling have not been yielding to the desired results hence continuous research in this area is required (Kawano 2000 and Hillocks 2002). The different cassava peeling machines are described in the following sections:

(i) Manually operated cassava peeling machine by Nakaseeta Lydia

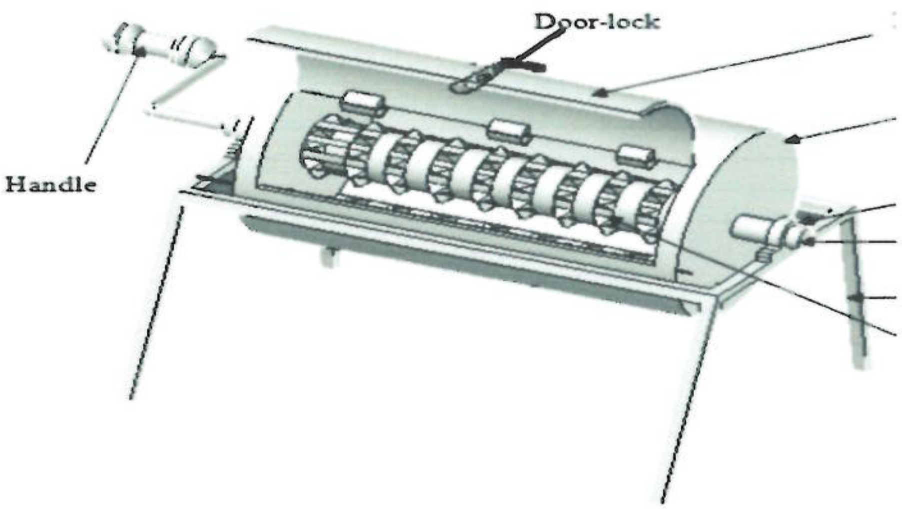

Figure 2-2 Manually cranked cassava peeling machine

This machine was designed and constructed and upon testing it gave a significant efficiency of about 40%. The machine uses two circular metal plates folded to form two peeling drums and punched one outwards and the other inwards. It is operated cranking using the handle and peeling takes place by friction between the cassava tubers and the punched rough surface of the metal plates. However, the punched surfaces could not remove the whole cambium layer of the tuber due to their thickness being so less than that of cassava. In addition to that, working with the cranking handle for a long time would actually be tiresome and disgusting.

2.5 Advantages and disadvantages of Mechanical peeling of cassava

In comparison with other peeling methods, the following are the advantages and disadvantages of mechanical peeling.

Advantages of mechanical peeling

(i) It enhances production of cassava flour as the peeling machine peels more cassava tubers than manual method of peeling.

(ii) It reduces the drudgery during the peeling period as a number of cassava tubers can be peeled within a short time.

(iii)Reduction of the intense labor which is always imposed on the women and a times children.

(iv)The use of mechanized peeling will allow continuous production regardless of the weather condition e.g. rainy and sunny condition compared to the traditional methods of peeling.

(v) The edible portions of the products are kept clean and harmless.

Disadvantages of mechanical peeling

(i) Repair, maintenance and running cost are quite expensive

(ii) The initial cost of acquiring the machine may be quite expensive for the poor farmers

Chapter 3 METHODOLOGY

3.0 METHODOLOGY

The main aim of this project is to design and fabricate machine that can peel more number of cassava tubers at the same time, reduces amount of food content that is lost in peels, saves time and reduces drudgery during peeling. This chapter provides the step-by-step procedure of how the prototype was constructed following the stated specific objectives.

3.1 Design consideration

For the machine to achieve relatively high efficiency, the design designed based on the following;

(i) Relatively of low cost which can suit local farmers growing cassava.
(ii) Constructed using readily available materials on the market.
(iii) Peeling capacity higher than when peeled manually.
(iv) Reduce labor input in the traditional method of peeling.

3.1.1 Machine description

The pedal driven cassava peeling machine comprises majorly the power unit which is operated manually by peddling and the peeling unit.

The peeling unit consists of a cylinder made of wood on which blades for peeling the tubers are attached. 8 mild steel blades were evenly distributed along the diameter of the cylinder. These blades peel the cassava by action of shear resulting from tubers rotating along the blades.

3.1.2 Working principle

Cassava tubers are washed prior to peeling to remove the soil got from the garden. The tubers are weighed and then put into the peeling drum through the opening door. The is then locked and the operator begins to pedal. The operator may be checking the tubers after some time to monitor the progress of the peeling. Pedaling is done at the minimum speed to ensure a high peeling torque. When peeling is done, the door is opened and the cassava is removed.

3.1.3 The prototype

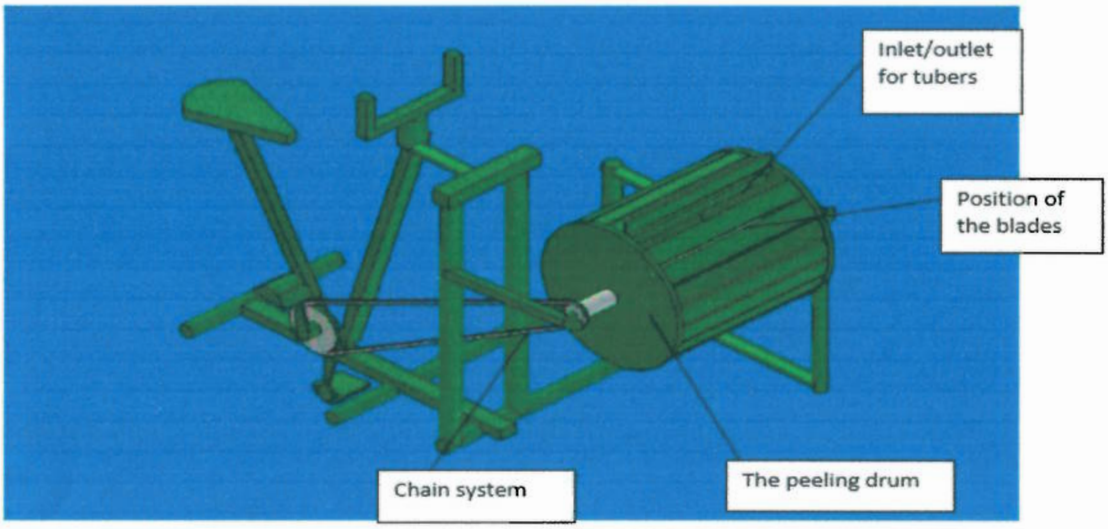

Figure 3-1: components of the proposed machine

3.2 Components of the prototype

The essential components of the machine include; peeling drum, pedal power, peeling shaft and the machine shaft.

3.2.1 The peeling drum

The peeling drum is made of wood. The desired material for the drum is of hard wood. It is cylindrical in shape with pieces of timber arranged in a such a way that a gap is left between successive timber pieces. A door-like opening is left on one side with a lock to enable inlet of unpeeled cassava tubers and outlet of already peeled cassava.

3.2.2 Power unit

This power unit consists of a sprocket, chain and shaft. The chain transmits power from the pedals to the shaft to enable the rotational moment of the drum. The seat enables the operator pedal with ease and therefore achieving a constant speed of rotation of the shaft.

3.2.3 The machine frame

This supports the other components of the cassava peeling machine and provides balance to the machine during operation. It is subjected to the direct weight or load of other members of the machine and also to the torque and vibration from the peeling drum. The desired material for the frame is of high rigidity, toughness and light in weight for potability. For this case hollow sections of mild steel were chosen

3.2.4 Machine shaft

The shaft is made of high carbon steel for strength and flexibility to be achieved during operation. Two blades were welded on the shaft at some angle to direct the tubers as they move inside the drum.

3.3 Design analysis

In order to analyze completely the component parts of the proposed machine, the following will be identified as needed to be determined.

- ❖ Estimation of power required by the machine.
- ❖ Determination of approximate length of the chain.
- ❖ Determination of the total load on the shaft
- ❖ Determination of minimum shaft diameter
- ❖ Determination of the weight of the peeling drum
- ❖ Determination of the diameter of the peeling drum

3.3.1 Design of the Peeling drum

According to Eugene and Theodore (1996), mass of the drum *m* is given by,

$$m_d = \rho_d V_d \quad \text{.......} \quad (1)$$

Where ρ_d is the density of the drum material and V_d the volume.

V_d = [(volume of the cylinder) + (volume of the two circular end plates)]

$$V_d = (\pi D_d l_d t_d) + 2(\frac{\pi D_p^2}{4} t_p) \quad \text{.......} \quad (2)$$

Where V_d is volume of the cylinder

D_d diameter of the cylinder

L_d length of the drum

t_d thickness of the drum

t_p thickness of the two circular ends of the cylinder

D_p diameter of the extreme ends of the cylinder

For the purpose of weight and easy access of tubers in the peeling drum (ergonomic), the peeling drum was considered to have a length (l_d) of 600mm and diameter (D_d) of 520mm

$$V_d = (\pi x 0.52 x 0.6 x 0.02) + 2(\frac{\pi 0.48^2}{4} x 0.02)$$

$$V_d = 0.027m^3$$

Volume of each of the 8 peeling blades was given as

$$V_b = l_b x w_b x t_b$$

Where l_b is the length of the blade = 0.56m

w_b is the width of the blade = 0.02m

t_b is the thickness of the blade = 0.001m

$$V_b = 0.56x0.02x0.001$$

$$V_b = 0.0000112m^3$$

Therefore, weight of the empty drum is given by,

$$W_d = \rho_d V_d g + \rho_b V_b g \quad \ldots\ldots (3)$$

$$W_d = (550x0.027x9.81) + (7850x0.0000112x8x9.81)$$

$$W_d = 152.6N$$

References

ASOGWA, B., UMEH, J. C. & ATER, P. Technical efficiency analysis of Nigerian cassava farmers: A guide for food security policy. Annual Meeting of the International Association of Agricultural Economists, 2006. 12-18.

CHALKER, B. & DIOUF, J. 1995. Dimensions of Need: An atlas of food and agriculture. *Food and Agriculture Organization of the United Nations*.

EVUTI, A. M., FOLORUNSHO, A. D. & JOYS, M. V. 2010. Optimization of some operating parameters for steam peeling of cassava tubers. *Optimization,* 2, 1592-1597.

FAO, I. A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. Proc. Valid. forum Glob. cassava Dev. Strateg.. Rome: International Fund for Agricultural Development/Food and Agriculture Organization of the United Nations, 2005.

HAGGBLADE, S. & DEWINA, R. Staple food prices in Uganda. Prepared for the Comesa policy seminar on "Variation in staple food prices: causes, consequence, and policy options," Maputo, Mozambique, 2010. 25-26.

KHURMI, R. & GUPTA, J. 2005. *Machine design*, S. Chand.

NARTEY, F. 1978. *Manihot esculenta (cassava): cyanogenesis, ultrastructure and seed germination*, Munksgaard.

NWEKE, F. I. 2004. *New challenges in the cassava transformation in Nigeria and Ghana*, Intl Food Policy Res Inst.

OBOH, G. 2006. Nutrient enrichment of cassava peels using a mixed culture of Saccharomyces cerevisae and Lactobacillus spp solid media fermentation techniques. *Electronic Journal of Biotechnology,* 9, 0-0.

OKE, O., REDHEAD, J. & HUSSAIN, M. 1990. *Roots, tubers, plantains and bananas in human nutrition*, FAO Rome.

OKIGBO, B. N. 1980. Nutritional implications of projects giving high priority to the production of staples of low nutritive quality: The Case for Cassava (Manihot esculenta, Crantz) in the Humid Tropics of West Africa. *Food and Nutrition Bulletin,* 2, 1-10.

OLUKUNLE, O. J. Development of a cassava peeling machine. 4th international Conference on Global Food and Product Chain.–Dynamics. Innovations, Conflicts and strategies „Tropentag, 2005. 23-27.

ORIOLA, K. & RAJI, A. 2013. Trends at mechanizing cassava postharvest processing operations. *International Journal of Engineering and Technology,* 3, 879-887.

OTIM-NAPE, G. & ZZIWA, S. 1990. Cassava as a Major Staple Food Crop in Uganda. *Phase I of collaborative study of cassava in Africa. Namulonge research station, Kampala. Report,* 1-48.

STEENKAMP, V. & MCCRINDLE, C. 2014. Production, consumption and nutritional value of cassava (Manihot esculenta, Crantz) in Mozambique: An overview. *Journal of Agricultural Biotechnology and Sustainable Development,* 6, 29-38.

STONE, G. D., ALTIERI, M. A., PENTAL, D., RICHARDS, P., SURYANARAYANA, M., TRIPP, R., WATSON, J. L., WYNNE, B. & STONE, G. D. 2002. Both sides now: Fallacies in the genetic-modification wars, implications for developing countries, and anthropological perspectives. *Current Anthropology,* 43, 611-630.

VAVILOV, N. 1935. The law of homologous series in hereditary variability. *Theory of plant selection,* 1, 75-128.