DEVELOPMENT AND EVALUATION OF A CASSAVA PEELER CUM SLICER

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled "**DEVELOPMENT AND EVALUATION OF A CASSAVA PEELER CUM SLICER**" is a bonafide record of project work done by us during the course of project and the report has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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CERTIFICATE

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Anshid K **Panchamy Balan** **Syamkumar K S**

Dedicated to our beloved parents…

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SYMBOLS AND ABBREVIATIONS

Agric	- Agricultural
%	- Percentage
Cm	- Centimetre
CTCRI	- Central tuber crop research institute
Engg	- Engineering
Et al	- And others
FAPE	- Food and Agricultural Process engineering
Fig	- Figure
G	- Gram
GI	- Galvanised iron
Hp	- Horse power
Hr	- Hour
ISA	- Indian standard angles
J	- Journal
KCAET	- Kelappaji College of Agricultural Engineering and Technology
Kg	- Kilogram
kW	- Kilowatt
kWh	- Kilowatt hour
Mg	- Milligram
Mm	- Millimetre
MS	- Mild steel
N	- Newton
^{o}	- Degree
Rpm	- Revolutions per minute
Rs	- Rupees
S	- Second
Sl. No.	- Serial number
t/ha	- Tonnes per hectare
Wb	- Wet basis

CHAPTER: I

INTRODUCTION

Tuber crops still continue to be major crops contributing significantly to human and animal food apart from finding use in various industrial applications. These crops are adopted to broad agro ecological conditions and yield reasonably well even under marginal environments. Tuber crops fit well into a variety of cropping systems and can be profitably intercropped. In developing countries starchy root and tuber vegetable are the commodity mostly consumed.

Cassava (*Manihot esculanta crantz*) is a major tuber crop belonging to the botanical family Euphorbiaceae. This dicotyledonous perennial plant has great importance in many developing tropical economies such as the tropical parts of Africa, Brazil, Indonesia, Malay etc. In tropical Africa cassava and other tubers like yam form the most staple food crops which are the main source of carbohydrate in the diet. Hence it is an important source of starch. Richest source of energy besides serves as source of certain minerals and vitamins. Its high yield in poor soil and the ability to stay in the soil for long periods after maturity makes cassava an important food security crop in low income countries.

Cassava is cultivated in India about 13 states with major production in South Indian states of Kerala(142000 ha) and Tamil Nadu(65700 ha).Cassava which was introduced into India by the Portuguese during the 17th century as a food a crop, is gradually changing its role as an industrial raw material. The importance of cassava as a food crop was well recognized in Kerala, South India during 20th century when famine struck India at the time of the 2nd world war. Asia stands 2nd cassava producing continent. Approximately 13 % of Asian cassava comes from India.

Boiled cassava tubers, slices of fresh tubers fried in oil, roasted cassava etc are well used in India. Traditional Indian foods such as chappathies, uppuma, puttu etc can also be made from cassava flour.

Although cassava crop has relatively few problems in production, its problem seems to multiply at the post-harvest stage. The processing of cassava tubers for industrial or human use involves different operations of which peeling is a major one. According to Adetan *et al. (2003)* the cassava peel has two layers, the outer layer is called periderm and the inner layer called cortex. Hence the removal of these two layers are necessary because of the presence of toxic cyanide content in those two layers. Cassava peeling has been practiced as far as back when cassava came into existence by using household knives. But this make peeling drudgery.

Prior to other processing operations like boiling, blanching, drying, grading etc. the next unit operation is slicing. Slicing is carried out to reduce the size of product to suit further processing operations and consumer needs. This in general is being done manually. This operation is a tedious process and involves drudgery, cause injury to the operator, lack of uniformity in the size of sliced cassava, increased time consumption and reduction in quality.

In order to eliminate these drudgeries involved in peeling and slicing of cassava an attempt was undertaken at Kelappaji College of Agricultural Engineering and Technology with the following objectives.

1. To develop a cassava peeler cum slicer.

2. Performance evaluation of the developed cassava peeler cum slicer.

CHAPTER: II

REVIEW OF LITERATURE

This chapter includes agronomical characteristics, origin, composition of cassava, Engineering properties, varieties, statistics, processing of cassava. Particular importance is given to the study of different peeling and slicing methods.

2.1 Agronomical characteristics

Cassava (*Manihot esculenta Crantz*) is a tropical plant which has a fibrous root system. Some of these roots develop into root tubers by the process of secondary thickening. These roots develop radials around the base of the plant forming five to ten tubers per plant. These are the main economically useful parts of the plant (Ajibola, 2000). It usually elongated, has depressions and crevices along its length and tapers to one end. In most cases, the middle part has a fairly constant diameter. Whereas the head end has a relatively large diameter, the tail end has a considerably smaller diameter when compared with the middle part. The head and tail ends are generally referred to as the proximal and distal ends respectively. At its proximal end, the tuber is joined to the rest of the plant by a short woody 'neck' (Adetan *et al.*, 2003). A transverse section of the tuber shows that it consists of central core called the pith. This is surrounded by the starchy flesh that forms the bulk of the tuber and constitutes the main storage region. It is white or cream in colour and is surrounded by a thin cambium layer. Covering the cambium layer is the tuber peel. The peel consists of a corky periderm on the outside which is dark in colour and can be removed by brushing in water as it is being done in the washers of large factories. The inner part of the peel contains the cortex. The cortical region is usually white in colour (Adetan *et al.*, 2003).The loosening of the whole peel from the central part facilitates the peeling of the roots. As the tuber continues to increase in diameter, the continuity of the cork layer is broken, so that longitudinal cracks or fissures appear on the surface of the tuber. However, new corks soon form beneath the cracks to restore the integrity of the protective corky layer (Igbeka, 1984). Cassava is a popular, most important food energy and commercial crop in tropical countries. There are numerous varieties of cassava in the world today and these are usually differentiated from one another by their botanical characteristic and level of hydrocyanic acid which causes toxicity in the root. This toxicity vary from place to place, in many instances, a bitter variety may become sweet for example or vice versa. This is as a result of environmental factors such as soil type, soil moisture, soil fertility, tillage practice and vegetation of the farm. The numerous varieties of cassava are usually grouped in two main categories: Manihot palmate and Manihot utilissima, or bitter and sweet cassava (Grace, 2004). Olukunle and Oguntude, (2007) further reported that soil factors would also influence shape and size of the tuber which constitutes major bottleneck in cassava peeling. Cassava has nutritive and commercial benefits which make it attractive especially to the local farmers. First, it is rich in carbohydrates and could be enriched with other food composition such as protein to obtain nourishment. Secondly, it is always available in all seasons, making it preferable to other more seasonal crops such as grains, peas, beans and other crops for food security. Compared to other crops, cassava is more tolerant to low soil fertility, and more resistance to pest and diseases. More importantly too, it produces very well on soil so depleted by repeated cultivation that has becomes unsuitable for other crops. It also tolerates environmental stresses such as short period of drought, strong and desiccating winds (Osundahunsi, 2005)

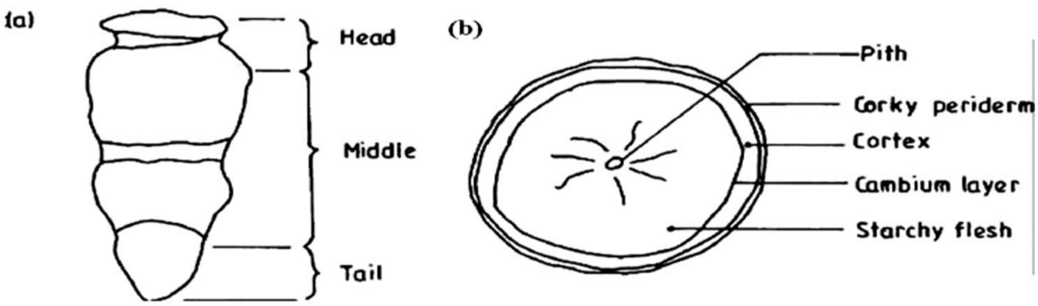

Fig.2.1. Cross sectional view of cassava

2.2 Composition

The peel of the cassava comprises 10-20% of the tuber, of this the cork layer represents 0.5-2% of the total tuber weight and the edible fleshing portion makes 80-90%. Among the minerals in the tuber, phosphorous and iron predominate with minimal amounts of calcium. The tuber is relatively rich in vitamin C (35mg/100g fresh weight) and contain Niacin and vitamins A, B_1 and B_2. In addition to these, the cassava tuber contains small but significant amount of cyanogenic glucosides.

Table 2.1. Average composition of cassava tuber.

Constituents	Percentage (%)
Water	62
Carbohydrates	35
Protein	1-2
Fat	0.3
Fibre	1-2
Mineral matter	1

(Source: Onwueme (1982) The Tropical Tuber Crops)

2.3 Varieties of cassava

There are hybrid varieties of cassava rather than local varieties. Sree athulya, Sree apoorva, Sreevijaya, Sree jaya, Sree pavithra, Vellayni hraswa etc are the varieties released by CTCRI Sreekariyam, Trivandrum recently.

Table 2.2. Yield and duration of different varieties of cassava

Variety	Growth duration (month)	Yield (tons/ha)	Starch content	Cooking quality
H 97	10	25-30	30	Fair
H 165	8	33-38	24	Poor
H 226	10	30-35	29	Fair
Sreevishakam	10	33-38	26	Fair
Sree sahya	11	35-40	30	Fair

(Source: Year book 2015-2016-CTCRI, Trivandrum)

2.4 Origin

Cassava plant originated in north east Brazil with the likelihood of an additional centre of origin in America (Rogers, 1968). Though the plant originated from this place it has spread to various parts of the world. And today it is mainly cultivating in tropical countries.

2.5 Engineering properties of cassava

To mechanize the cassava peeling process, a good knowledge of the engineering properties of the tuber is important (*Adetan et al*., 2003). The absence of sufficient data on the engineering properties of cassava tubers has been one of the factors hindering the successful design of efficient cassava tuber peeling machines. Several researchers (Ezekwe, 1979; Asoegwu, 1981; Odigboh, 1983; Igbeka, 1980, 1984, 1985; Nanda & Matthew, 1996; Nwagugu & Okonkwo, 2009; Sajeev *et al.,* 2009) made appreciable attempts on establishing some of the properties of cassava that affects its processing as well as in the design of cassava handling and processing equipment. Peeling operation is influenced by the engineering properties affecting its efficiency which are largely as the result of crop and machine operational parameters. The crop parameters may include: crop variety, maturity of crop/age, weight of the tubers, tuber diameter, length of tuber,

tuber shape, peel thickness, moisture content, frictional resistance of the tuber, static and dynamic component of tuber shear strength, etc. The machine operational parameters are: peripheral speed of peeling brush/knife, speed of the rotor, speed of conveyor, diameter of the peeling rotor, size and type of tuber guide/monitor, feed rate or loading rate, peeling mechanism and metering mechanism. Some of the physical and mechanical characteristics of the cassava tuber required for the mechanical peeling process model.

Table 2.3 Physical and mechanical properties of cassava

Physical properties	Mechanical properties
• Roundness/ Shape of the tuber. • Tuber weight. • Tuber diameter. • Tuber length. • Peel thickness. • Peel weight. • Aspect ratio. • Coefficient of friction of tuber on hopper/ chamber/peeling element	• Poisson ratio. • Rolling resistance • Shear stress. • Peeling stress. • Cutting force. • Rupture force. • Strength properties. • Penetration force

Odigboh (1976) in reporting on the over 200 varieties of cassava grown in Nigeria, determined some physical properties of some of the cassava varieties such as the roundness, shape and tuber weight. They have cross sections with mean roundness ranging from 0.65 - 1.00 and tuber weight ranging from 25g to 400 g and mainly conical in shape. All these properties were reportedly dependent on the age of the tubers and the time of the year at harvest and had direct effect of the peeling of cassava tubers.

Asoegwu (1981) investigated some breaking characteristics of cassava tubers when subjected to various bending loads as would be encountered at harvest and on peeling. The loading rate and root diameter were reported to have significant effects on the breaking strength, breaking energy and breaking deformation of the tubers (Onwueme, 1978; Ohwovoriole *et al.*, 1988; Olukunle *et al.*, 2010), which would affect the mechanical peeling of cassava. These properties may also affect the tuber loss, mechanical damage of the tubers and the quality performance efficiency of the peelers.

Ohwovoriole *et al.* (1988) determined some physical and mechanical properties of cassava such as the tuber length, weight diameter, peel thickness, Poisson ratio and coefficients of friction and rolling resistance, shear stress, peeling stress, cutting force and rupture stress. They reported that the coefficient of friction of cassava on wood ranged from 0.404-0.663; on mild steel, from 0.364-0.577 while it ranged from 0.213-0.404 on aluminium surface. They also reported some values of coefficient of rolling resistance of cassava tubers on wood, mild steel and aluminium surfaces as 5.57-8.73; 5.27-9.38 and 4.71-7.80 respectively. The values they got for unpeeled cassava tuber for Poisson's ratio, shear stress, peeling stress, cutting force and rupture stress were 0.38, 3.22 N/mm^2, 0.30 N/mm^2, 500 N and 0.95 N/mm^2, respectively. These have to be taken into consideration when designing the cassava peeling machines especially while selecting materials for constructing or fabricating the peelers.

Adetan *et al.* (2003) in determining the machine forces required to peel cassava showed that weight of peel in the cassava roots ranged from 10.6 % to 21.5 %; the tuber surface taper angle ranged from 0° to 22°; the tuber peel thickness ranged from 1.20 to 4.15mm; the tuber diameter ranged from 18.8 to 88.5 mm; and the tuber peel penetration force per unit length of knife-edge ranged from 0.54 to 2.30 N/mm.

Kolawole *et al*. (2007) researched into some strength and elastic properties of cassava tubers using TMS 4(2) 1425 cassava clone. The values they got for the tubers at the moisture content range of 50 – 70 % (wb) ranged from 0.235 to 0.116 N/mm^2 and 0.065 to 0.095 for tensile stress and strain respectively, while values ranging from 0.080 to 0.047 and 0.032 to 0.093 N/mm^2 were reported for compressive strain and stress respectively.

Ilori & Adetan (2013) determined the peel penetration force of cassava tuber. The pressure required to penetrate the peels without damage to the tubers increased as the peel thickness and tuber diameter increased. In the study, peel penetration pressure obtained ranged from 2.20 to 3.65 N/mm^2 for knife-edge thickness of 1.5 mm and from 2.0 to 2.64 N/mm^2 for knife-edge thickness of 2.0 mm. These results show that peel penetration pressure decreases with increase in knife-edge thickness.

Several studies were also conducted on the rheological and textural properties of cassava tubers relevant to the design of its processing machineries (Sajeev *et al*., 2008; Sajeev *et al*., 2009; Sajeev *et al*., 2011). Sajeev *et al*. (2008) reported that the bio yield-force ranged from 73.69 to 92.21 N, firmness from 81.06 to 123.15 N, toughness from 1.13 to 1.74 Nm, shear force from 171.59 to 256 N and shear energy from 2.34 to 3.47 Nm. Sajeev *et al*. (2011) reported significant variations in the textural and rheological properties of different cassava genotypes depending on variety, maturity, growing environment, physico-chemical properties, starch content and their properties.

Meanwhile, recent studies (Ukatu, 2002; Olukunle & Adesina, 2004; Olukunle, 2005; Olukunle *et al.,* 2005; Adetan *et al.,* 2006; Olukunle & Akinnuli, 2013; Ugwu & Ozioko, 2015) reported the various efforts at developing an effective peeler in Nigeria using some of the above tuber properties. Several efforts have been made to develop effective cassava peeling machines in Africa especially in Nigeria (Odigboh, 1976, 1979, 1983; Sheriff *et al*., 1995; Olukunle, 2005; Olukunle *et al.,* 2010; Abdulkadir, 2012; Oluwole & Adio, 2013; Ugwu & Ozioko, 2015). Few attempts at mechanizing cassava peeling operation in Nigeria have resulted in the production of several prototypes. Cassava processing and peeling thus deserves a serious attention in order to meet up with the local and international demand for cassava products. Mechanization of the peeling process will significantly increase the rate of production, quality of products and their availability (Aniedi *et al.,* 2012).

2.6 Statistics

Asian continent is 2nd largest in terms of area (19%) and production (29%) of cassava with a productivity of 16.76 t/ha. Cassava grown in 101 countries. India has 1st rank in the world for productivity of cassava with 27.9 t/ha as against the world average 10.76 t/ha. However India ranks 4th in Asia and 14th in the world for area. And 3rd in Asia and 7th in the world for the production of cassava roots.

Table 2.4. Tapioca: All India area, production and productivity.

Year	Area ('000 ha)	Production ('000 t)	Productivity (kg/ha)
2009-2010	231.90	8059.90	34756
2010-2011	221.00	8076.00	36543
2011-2012	226.70	8746.50	38582
2012-2013	206.96	7236.59	34964
2013-2014	228.28	8139.43	35655
2014-2015	208.00	4373.00	21024
2015-2016 (3rd Adv. Est.)	204.00	4554.00	22324

(Source: Department of Agriculture, Cooperation & Farmers Welfare (Horticulture Statistics Division))

Table 2.5. Production of tapioca in Kerala 2016-2017

Sl. No.	District	Production (in tonnes)
1	Thiruvananthapurm	520143
2	Kollam	440856
3	Pathanamthitta	227557
4	Alappuzha	101377
5	Kottayam	238833
6	Idukki	297870
7	Eranakulam	229893
8	Thrissur	47502
9	Palakkad	55271
10	Malappuram	185880
11	Kozhikode	42128
12	Wayanad	61696
13	Kannur	67051
14	Kasargod	13672
	State total	2529729

(Source: Department of Economics and Statistics, Kerala state)

2.7 Processing of cassava

According to Oriola & Raji (2013) processing of cassava into finished or semi-finished products often involves all or some of the following operations, depending on the desired end-product: peeling, washing, grating/chipping, dewatering, fermentation, pulverizing, sieving, pelletizing, and drying/frying (Kolawole *et al.*, 2010; Jimoh *et al.*, 2014). Almost all processing cassava tuber requires peeling and washing. Major processed form of cassava fall into four general categories: meal, flour, chips and starch. Meal form includes Gari, Farinha de Mandioca and meal of retted cassava. The meal and flour forms account for the bulk of cassava used for human food in tropics. Cassava chips and starch are industrial products. Cassava chips and pellets are mainly used for feeding livestock. For this purpose fresh tubers are peeled washed and cut into sizes of 3-6cm long. The slices are then dried and bagged. Pellets are produced from chips after the chips are dried they are ground and hardened to form cylindrical pellets about 2cm long and upto 1cm in diameter. A slightly different form of cassava which is peeled washed boiled in water and sliced into thin longitudinal slices, then it is kept in water for 1-2 days during which the water is changed once or twice. It is fit for consumption in this stage but most commonly they are removed from water and dried in the sun for several days and fried in oil. Cassava starch is an important product. After peeling and washing the tubers are crushed to produce a pulp. The pulp is suspended in water by means of series of revolving screens, the fibrous material is removed leaving starch milk. The starch milk is then passed though sand cyclone to remove the sand particles and the starch is allowed to settle in settling tank. The starch is then dried to a moisture level of 10-14%. Then it is pulverized and bagged.

2.8 Peeling

Peeling is an inevitable operation in processing of cassava. It is done in order to remove toxic cyanide content present in cassava peel. But this is the most difficult operation in cassava processing.

Different types of peeling methods are discussed below:

2.8.1 Hand peeling

In this method knife is used to peel the cassava manually. It is the most common method used. Roots are cut transversely and longitudinally to a depth corresponding to the thickness of the peel. No enzymatic stimulation and requires minimum investment. But comparatively most difficult method of peeling.

2.8.2 Steam peeling

Tubers subjected to high steam pressure over a short period of time. If it could be subjected beyond the time required which will lead to cooking. During steam peeling, the fruit to be peeled is exposed to high temperatures in a pressurized container for a short time. After that, machines downstream rub off the nearly loose peel and/or wash them. The surface of the peeled fruit is smooth. However, this external layer consists of a “cooking ring” of varying thickness arising from the short but intensive impact of the heat.

2.8.3 Chemical peeling (Lye peeling)

This method is mainly used in the case of peeling sweet potatoes. It makes use of hot NaOH solution (lye) for loosen and soften the tuber. Igbeka argued that it is not suited for cassava because. It may require higher concentration of sodium hydroxide, higher temperature, and more immersion time and operation pressure for cassava roots that have peels that are tougher than those of potatoes

a) When concentration of the Caustic Soda (NaOH) is high, tuber may need to be immersed in acid solution to neutralize residual Caustic soda. This implies an addition running cost and food poisoning cannot be ruled out.

b) If the cassava is to be used for garri or industrial starch production, the method will be ruled out for it results in the formation of objectionable heat ring (Dark colour) on the surface of root flesh and the gelatinization of starch.

2.8.4 Flame peeling

This method of peeling is rarely used because it is particularly suited for some products. The is produce is conveyed through furnace where it is subjected to direct contact with live flame and the charred skins are subsequently removed by high pressure water sprays (Radhakrishnaiah Setty.G.,1993)

2.8.5 Abrasive peeling

The product undergoes a tumbling action, so that its surfaces are subjected to the action of an abrasive material such as carborandum surface thus loosening the skin which is then removed by water sprays.

Radhacharan *et al* (1983) developed a ginger peeling machine based on the principle of abrasive peeling. The abrasive surface was made of coconut fibres. Brushes were mounted on two endless canvas belts. One abrasive surface was moving over two pulleys and the other was kept stationary. Its performance was evaluated in view of peeling efficiency and ginger meat loss.

Igbeka (1985) recommended the use of abrasive belt in a continuous cassava peeler. It operates with cut tuber slices and requires that the slices be near circular in shape.

Oluwole and Adio (2013) developed stationary outer abrasive drum and a rotating inner abrasive drum to achieve a peeling effect.

2.8.6 Mechanical peeling

In the design work carried out Odigboh, he designed three models of cassava peeling machine (models I, II and III. In model I an oil drum was punched about two-third millimetre diameter holes per square cm of its surface and eccentrically mounted on a shaft with a 200mmby 150mmopening to load cassava inside the drum. Cassava tubers and a predetermined quantity of some inert materials, such as quartziferous pebbles or pieces of 3.2-4.8 mm hard quarry stone are loaded into the drum which is then rotated at 40rpm. The rubbing action removed the peels from the cassava tubers, leading eventually to the complete and uniform peeling. Water is sprayed to wash away the finely abraded peels to prevent fouling and dulling of the abrasive surface. In model II balls of expanded metals were used to replace pebbles. Model III had four abrasive cylinders of expanded metal mounted inside the main peeling drum driven by a planetary gear arrangement to rotate about their axes at four times the rpm of the main drum, in addition to balls of expanded metals also loaded into the drum which is then rotated at 40 rpm.

Dwija *et al* (2000) developed and tested a power operated, low cost, efficient cassava peeler at KCAET Tavanur. Machine consist of frame assembly feeding chute, peeling rotor, feed pressing mechanism, outlets and power transmission unit. Peeling achieved by the scraping action of the rotor.

Adetan *et al.* (2005) designed and fabricated an experimental mechanical cassava peeler with spring-loaded assembly following the characterization of some properties of the root. With the introduction of different sizes of tubers, the peeler had 15 % broken tubers. Adetan *et al*. (2006) developed and validated a model which was able to predict the peel removal efficiency of the machine with a certainty level of 95.46 %. Using the abrasive drum principle, Akintunde *et al.* (2005) designed a cassava peeling machine which peel tubers already soaked in water to soften the cortex. Meanwhile, the peeling was done by two perforated drums rotating in opposite directions. They reported a peeling efficiency of 83.0 % and tuber loss of 5.4 % with an output capacity of 40 kg/hr

Olukunle *et al* (2007). Developed a cassava peeler that consist of continuous tuber feeding systems, peeling mechanisms, such as spiral flights, abrasive brush and pressure application platform

Olukunle and Akinnuli (2013) developed an automated cassava peeler which includes: metering device, conveyor, tuber guide etc. The machine impacts a rotary motion on the tuber through shear or abrasion effect. Modelling aspect was introduced to enhance the efficiency of the machine

2.9 Slicing

Slicing is the process done in order to reduce the size of the product which helps for further processing operations. Cassava slicing machine is an economic alternative to the manual slicing of tubers and it reduces tedium associated with manual slicing and increases the average turn out per hour.

Balasubramanian *et al* (1993). A developed a motorised cassava chipper and tested in Tamil Nadu Agriculture University. Machine consists of a chipping disc with knives driven by a disc shaft from a power source.

Kachru *et al*.(1994) Central Institute of Agriculture Engineering ,Bhopal developed a multiple string banana slicer to avoid the drudgery and any injury to workers and enhance the capacity and maintain quality gadgets with stainless steel string arrangement was developed in order to study the performance of banana slicing.

CHAPTER: III

MATERIALS AND METHODS

The fabrication procedure of the mechanical cassava peeler cum slicer and test procedure adopted are described in this chapter.

3.1 Components and general layout of the machine

1. Frame assembly

2. Feeding chutes

3. Peeling rotor

4. Slicer disc

5. Outlets

6. Feed pressing mechanisms

7. Power transmission

3.1.1 Frame assembly

The main frame assembly house and support the various components and subassemblies of peeler cum slicer unit. The frame assembly was fabricated using ISA section 35x35x5 mm.

3.1.2 Feeding chute

This peeler cum slicer consists of two feeding chute. One was fabricated and fixed to facilitate easy and safe feeding and free movement of tubers into the rotor assembly of peeler and another feeding chute to feed the peeled cassava for slicing into the rotating disc assembly.

The peeler consists of two parts. The upper part 30cm in length is inclined at an angle of 30^0 with the horizontal and the lower part 10cm in length is parallel to the rotor axis. The peeling rotor is provided with a casing of gauge GI leaving a gap of 15mm so that the rotor is freely rotates inside the casing. The top portion of the casing is made in the form of a rectangular block shape with both ends open of size 130x110mm for the cassava feed to get on to the peeling rotor from the feeding chute and to come out after getting peeled.

The slicer is 16cm long stainless steel hollow cylinder with diameter 7.5cm and thickness 0.2mm is mounted on the frame assembly unit. It is mounted at a height of 63.6cm from frame assembly bottom and placed horizontally parallel to assembly. Peeled cassava is placed inside this feeding chute having a slot of size 11x4.05 cm. The clearance between rotating disc of the slicer and feeding chute is 7mm.

3.1.3 Peeling rotor

This forms the heart of the machine 300mm long cylindrical rotor was made of MS ISA section 25x6mm, bend into ring form. The diameter of the rotor and therefore , of the ring is 300mm. thirty six cutting blades made by grinding MS flats with moderately sharp edges were welded on both ends of knives at a spacing of approximately 26mm and at a peripheral angle of 60^{O} parallel to the horizontal axis of the rotor. The cutting blades have a bevel angle of 15^{O}. The blades were also provided with a helix angle of 6^{O} in order to enhance the forward motion of the tuber. The casing rings of the rotor with blades was welded to central solid shaft 25mm diameter and 430mm length using three MS flats at each end. This forms the rotor which is mounted on to the top of frame assembly using roller bearings.

3.1.4 Slicer disc

This forms the main part of slicer unit. A metallic disc of diameter 28.6cm with a thickness of 6mm which is coated with chromium forms the slicer disc. A slot of size 7.7 cm in length and width 2.35 cm made on the slicer disc. A sharp blade of length 11.6cm and width 2.85cm was attached to the disc with a clearance of 1.5mm with the slicer disc. The disc is rotated on a central shaft 63.8cm length. And it is supported on the 28.6cm diameter shaft which is properly welded behind the slicer disc. Slicing is achieved by the rotating action of slicer disc and cutting action of the blade which is attached to the disc by using nuts and bolts above the slot with suitable clearance of about 1.5mm depending upon the requirement.

3.1.5 Outlets

The cassava is conveyed to the other end of the rotor casing inside the top rectangular block of the casing aided by the angles of the knives and also by the action of the pressing mechanism and the angle of the MS rods kept beneath the pressing sheet. The peeled cassava that come out of the outlet is collected in collecting boxes made o 22 gauge GI collecting box of 370x280x300mm size. The peel removed from cassava fall down through the gaps between the knives and between the casing and rotor and came out through the outlet provided at the front of the machine and falls into a 22 gauge GI collecting box 370x280x300mm size.

Peeled cassava is fed into feeding chute of slicer and the outlet is set up for the collection of sliced cassava pieces.

3.1.6 Feed pressing mechanism

For efficient peeling and easy conveyance of the peeled cassava towards outlet, a feed pressing mechanism is provided inside the top rectangular bock of the rotor casing. This consists of 18 gauge rectangular GI sheet of length 300mm and width 90mm slightly curved along the minor axis. 11 numbers of mild steel rods of diameter 6mm and length is spot welded on to the bottom of this rectangular sheet at an angle of 25^0 and at a spacing of 28mm. This sheet is connected to the pedal placed at the bottom right hand side of the frame by means of proper linkages. So that it can move up and down inside the top rectangular block of the casing. The pedal is ergonomically kept so that while pressing he pedal, the curved sheet move up so that cassava can get on to the rotor. Then pedal can be released so that the curved sheet presses the cassava with moderate pressure in order to enable the knives of the water to remove the peel fully. The linkages and the sheet is so connected that in no case the curved rectangular pressing sheet touch the rotating blades.

The pressing mechanism of the slicer is a spring loaded shaft. A shaft of length 30.5cm is inserted in a spring of length 10 inches, internal diameter 21mm, thickness 1.5mm. It is attached with a circular metal pieces at top and bottom having thickness of 4.32 mm and 1.4cm respectively. Peeled cassava is placed inside the feeding chute. The spring wound shaft is pulled back and released slowly till it touches the feed. The shaft then presses the tapioca towards the slicing blade in the rotating slicing disc.

3.1.7 Power transmission

A single face 0.5 hp, 1440 rpm induction motor was used as the prime mover. The direction of rotation of motor was reversed so that it rotates in anti-clockwise direction. Drive from the motor was directly given to both peeling rotor and slicer rotating disc with the help of a double pulley of diameter 6.7cm through a v-belt. Single pulley of diameter 25.5cm is attached to peeler rotor shaft. The speed of peeling rotor was 397rpm. The rotor rotates in anticlockwise direction.

Single pulley of diameter 30.4cm is mounted on slicer shaft. The speed of slicing disc is 300rpm. Rotor rotates on clockwise direction. Shaft of length 63.8cm which is attached to pulley transmit motion from pulley to rotary slicer disc, it will rotate and cutting action takes place with the help of blade of length 11.6cm and width 2.85cm attached to the disc with a clearance of 1.5mm with disc plate.

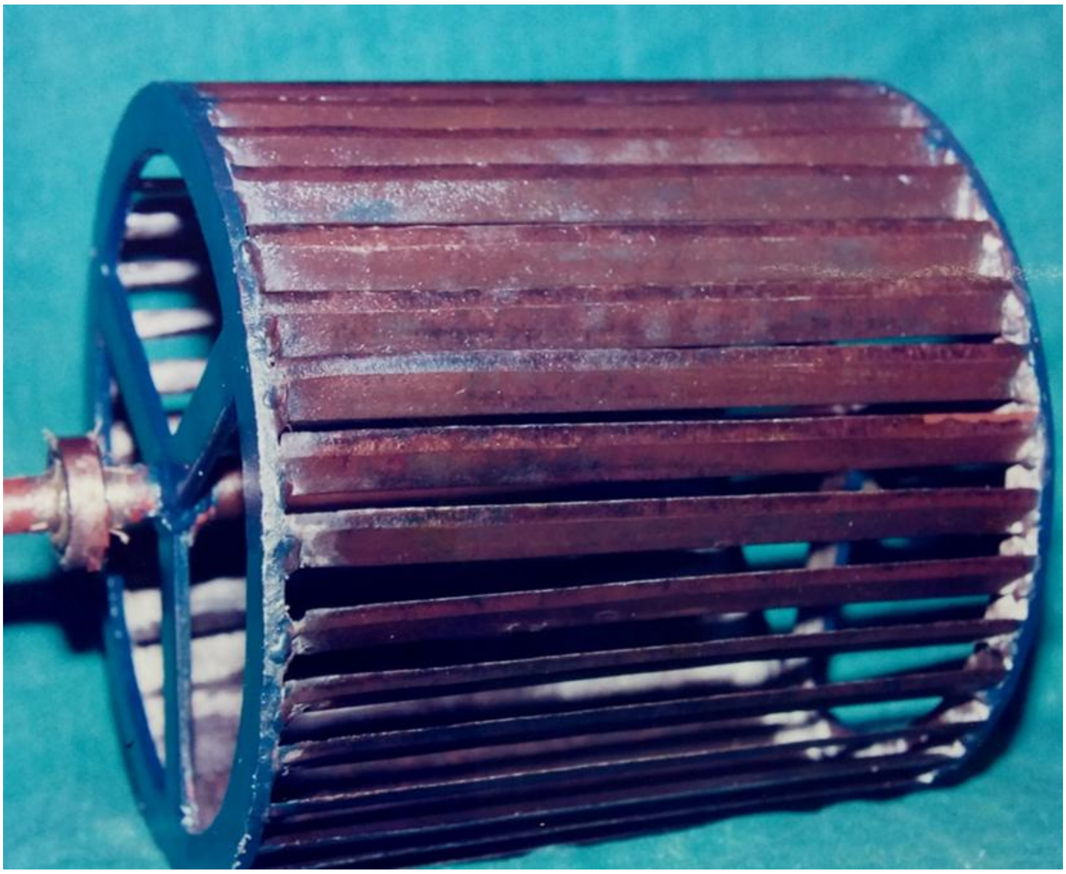

Plate 1. Peeling rotor

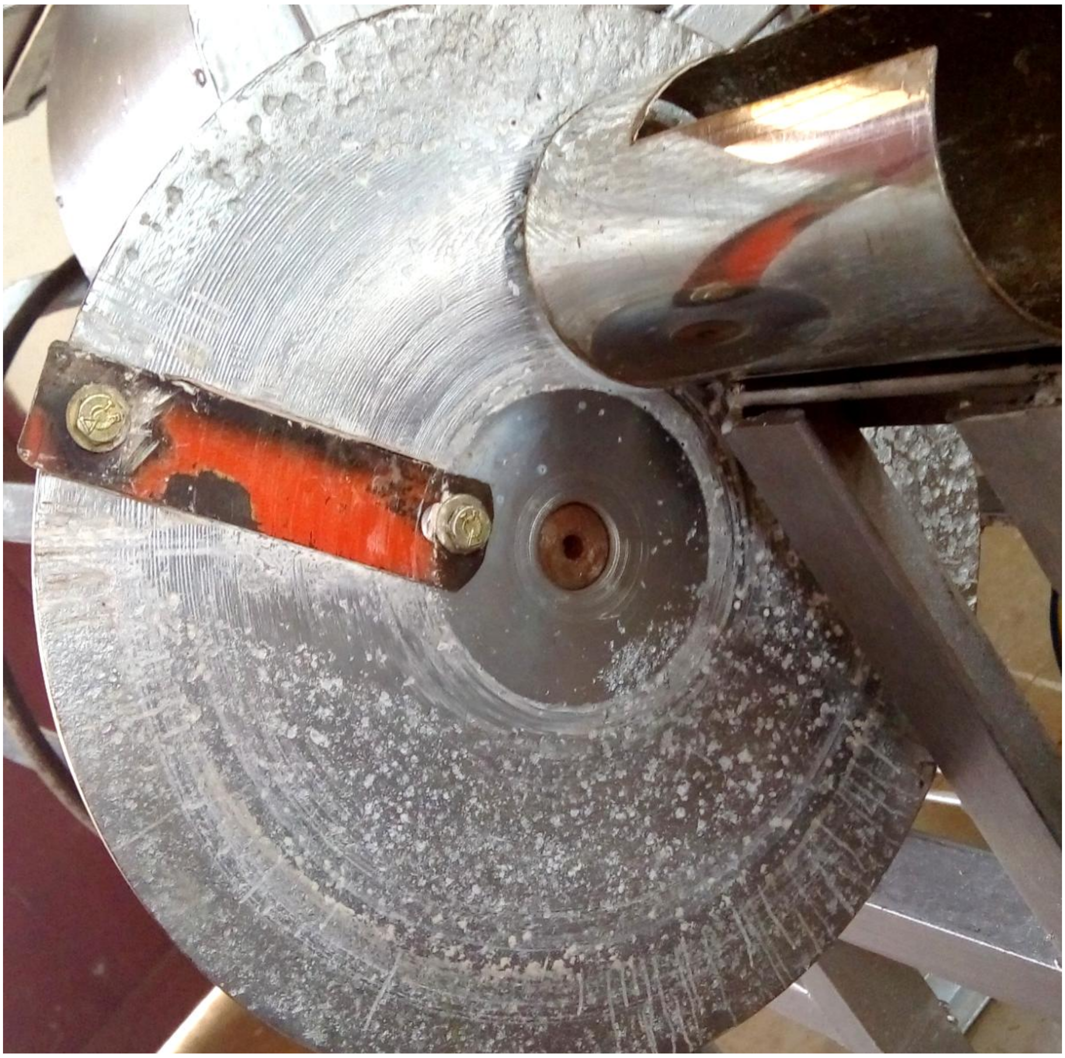

Plate 2. Slicer disc

Plate 3. Feed pressing mechanism top portion

Plate 4. Pedal operating portion of feed pressing mechanism

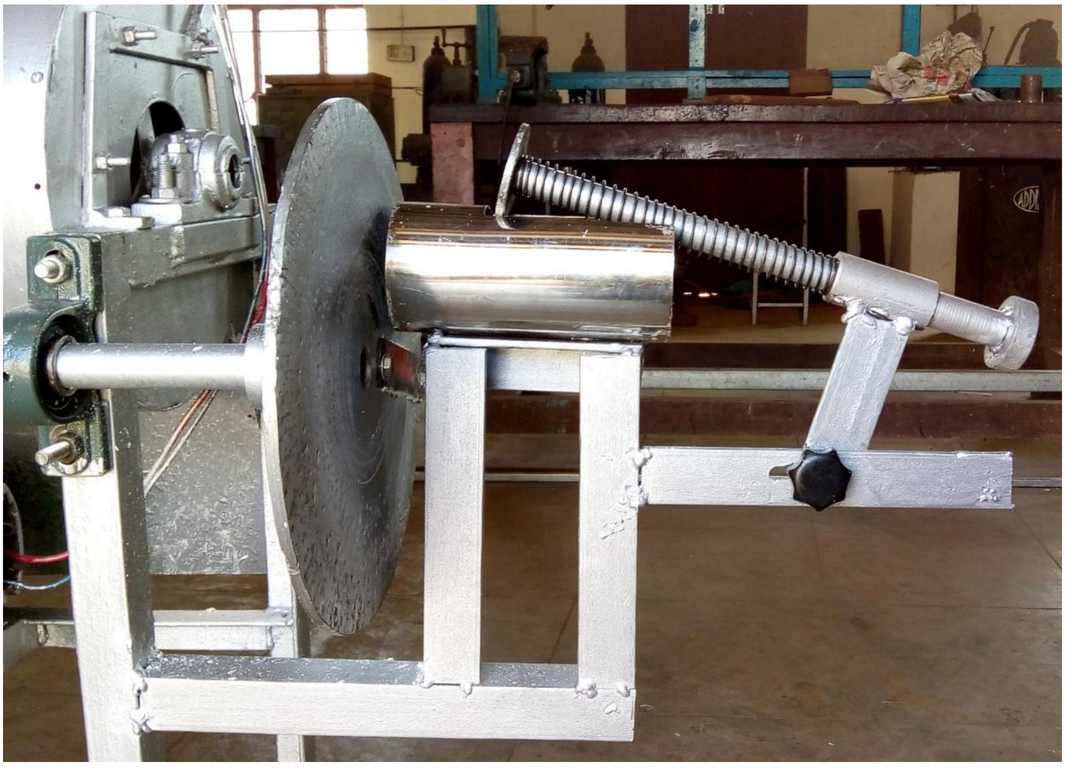

Plate 5. Feed pressing mechanism of slicer sub assembly

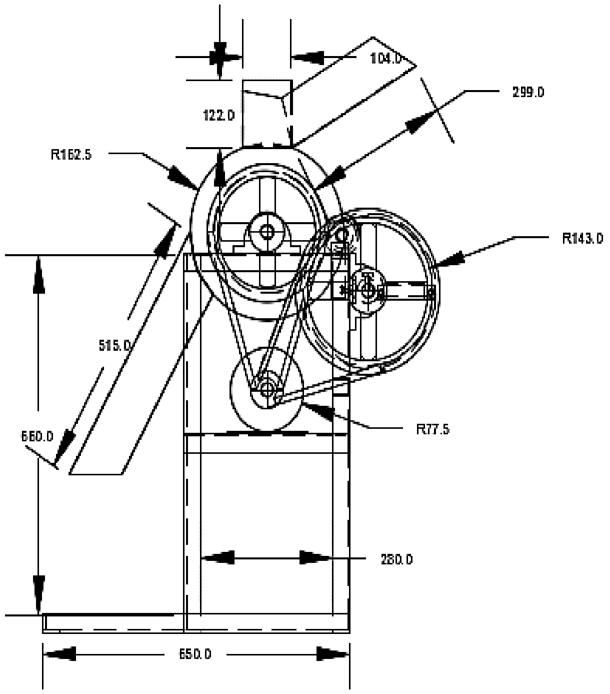

Fig 3.1. Side view of cassava peeler cum slicer

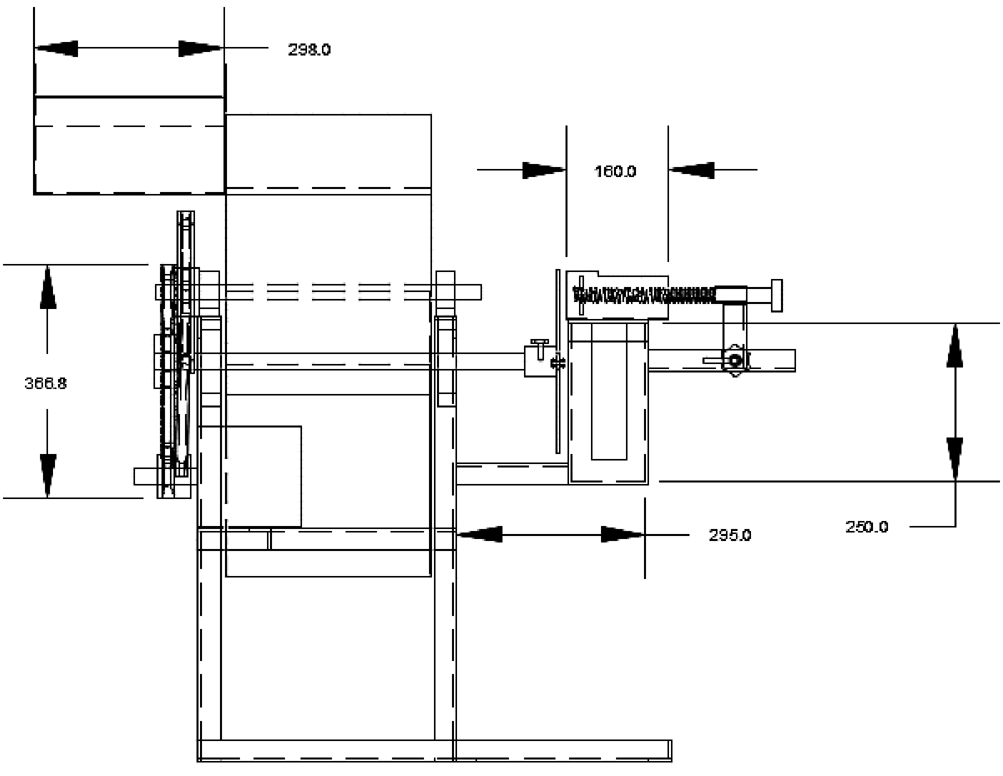

Fig 3.2. Front view of cassava peeler cum slicer

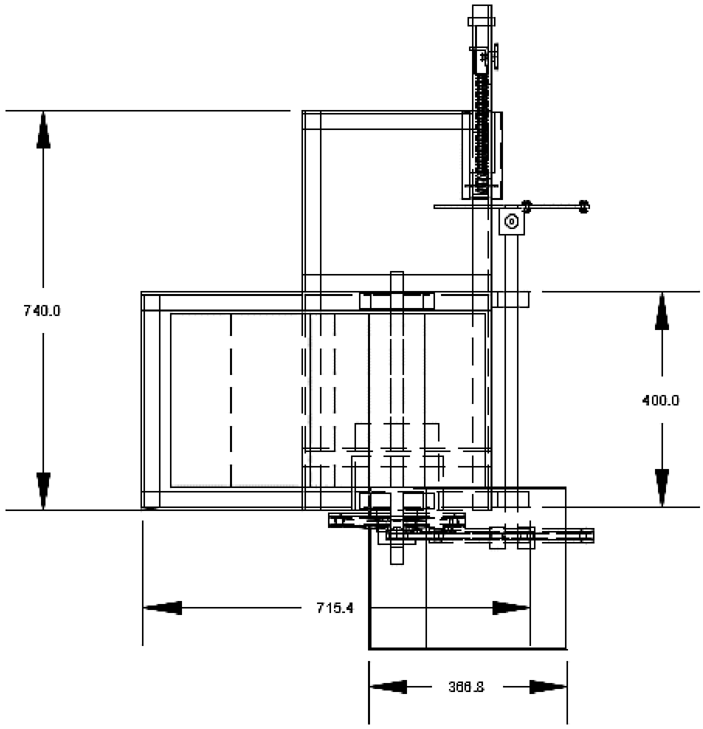

Fig 3.3. Top view of cassava peeler cum slicer

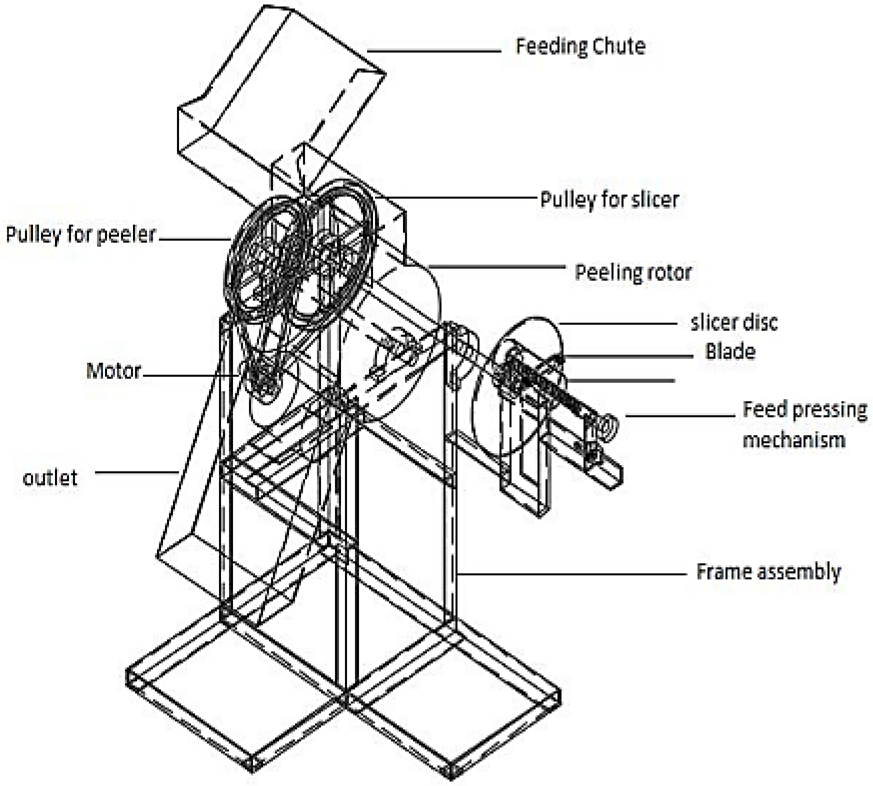

Fig 3.4. General layout of the machine

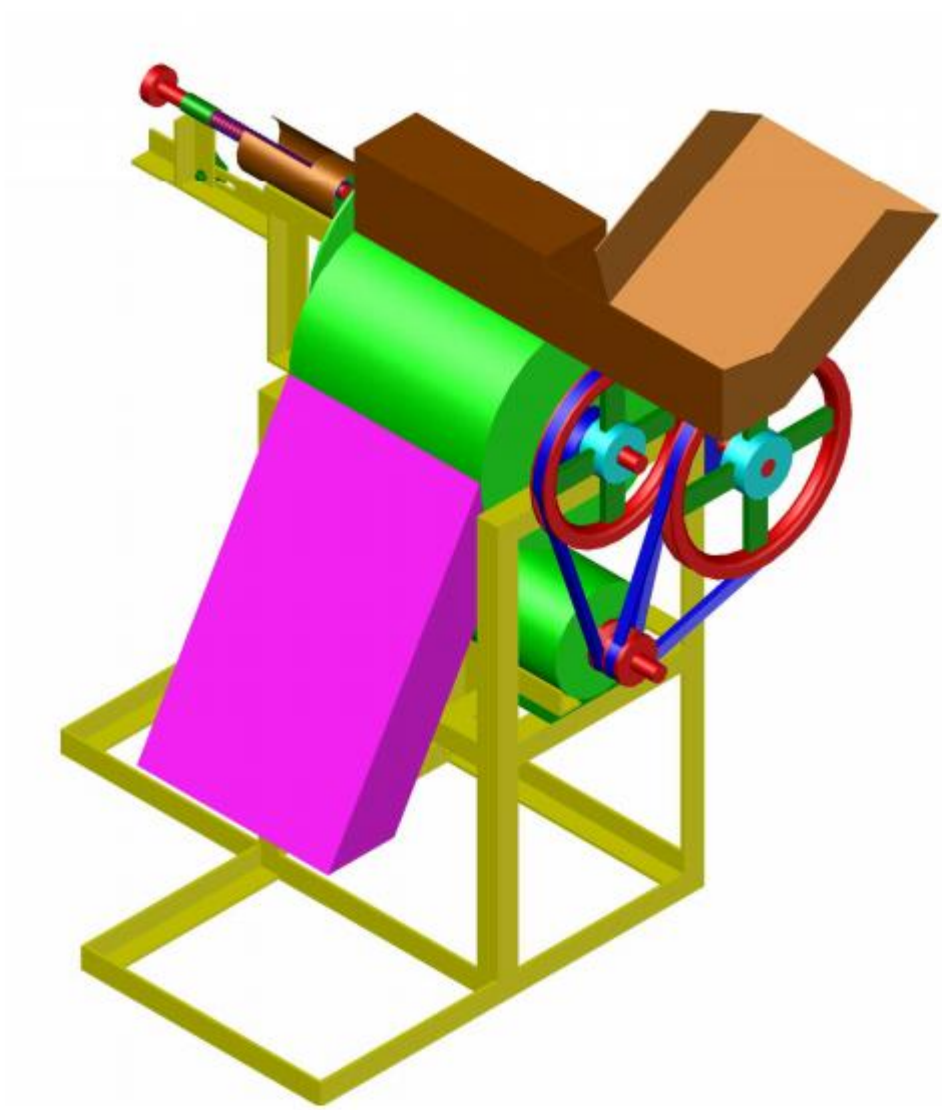

Fig 3.5. Isometric view of cassava peeler cum slicer

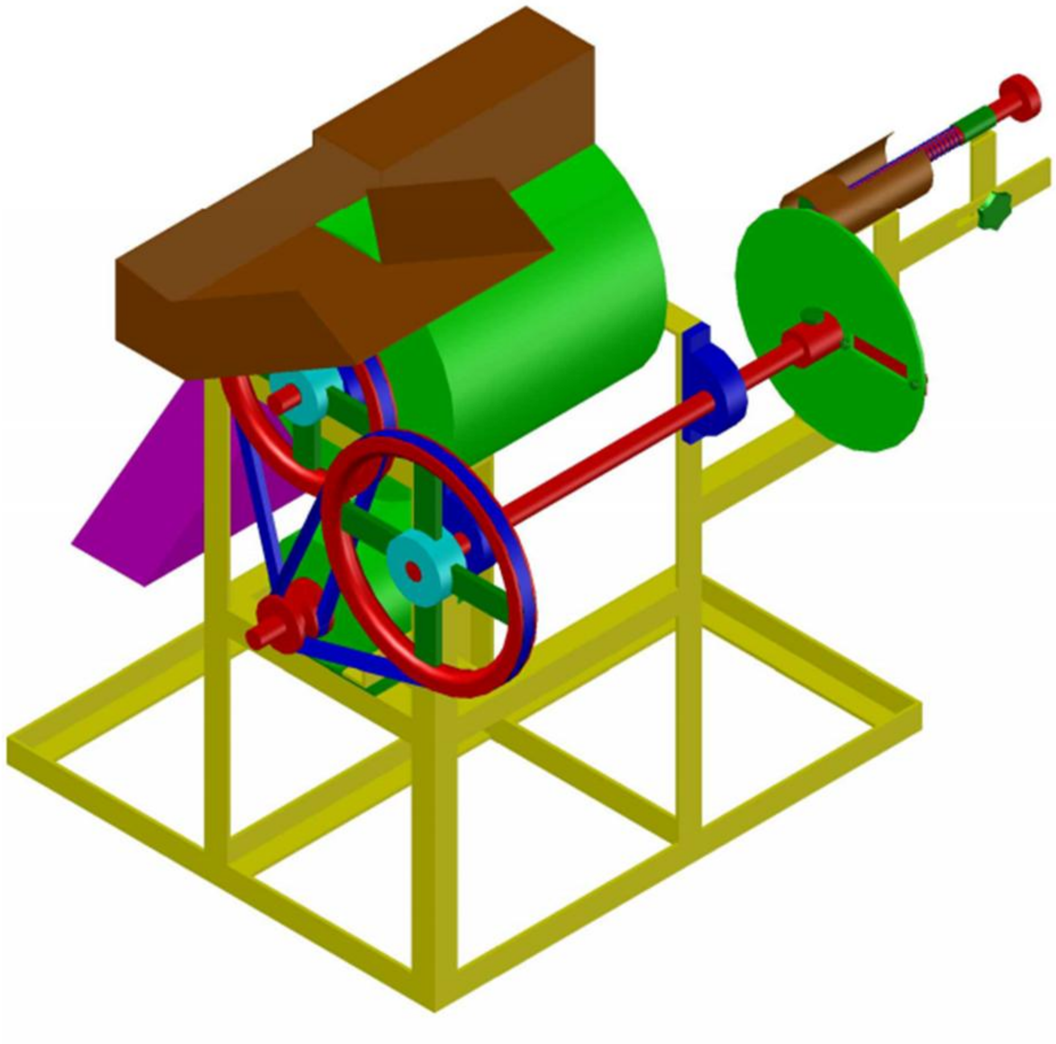

Fig 3.6. Isometric view of machine

Plate 6. Raw tubers, peeled tubers and sliced tuber pieces from machine

3.2 Performance evaluation

Matured cassava tubers brought from the local market were used for conducting the experiment. The average moisture content of the tubers were 65% (wb).

3.2.1 Experimental procedure

The woody end of the tubers were chopped off and then they were fed through the feeding chute towards the peeling rotor. Peeling was achieved by cutting, rubbing and scraping action of the blades on the rotor. Preliminary studies shown that peeling rotor has a speed of 397 rpm and gave better results in terms of capacity and efficiency. Required pressure can be applied on the cassava with the help of pedal operated feed pressing mechanism. The helical angle provided in the blades and the steel rod welded beneath the feed pressing mechanism helped in conveying the cassava tuber from inlet and to the outlet end of the peeling rotor. Peeled cassava is then collected in the GI trays kept down this end. The separated peel from cassava is conveyed through the peel outlet placed at an angle of 35^{O} to the vertical and collected in the GI tray placed beneath it. Time required for peeling was noted and the capacity, efficiency, material loss and energy required to operate the machine were then calculated. A comparison between manual and mechanical peeling was also carried out.

Slicing was achieved by cutting action of blade on disc and the pressure applied by spring loaded feed pressing mechanism. Preliminary examination have shown that a slicing disc speed of 300 rpm gave better results in terms of capacity and efficiency. Therefore a disc speed of 300 rpm in the clockwise direction was chosen for experiments. The peeled cassava was manually inserted in to the feeding chute of slicer. With the pressure applied by spring loaded feed pressing mechanism, the cassava was conveyed towards the rotating slicer disc with cutting blade fitted as explained. A clearance of 7mm is provided between the feeding chute and slicer disc for facilitating slicing of cassava. Clearance of about 1.5mm is provided between the blade and slicer disc which helps for slicing the cassava in required thickness acceptable for frying it for making chips. The slicing is achieved by the rotation of the slicer disc and sliced cassava pieces can be collected from the outlet provided. The sliced cassava is collected in the GI trays kept down near the outlet. The time required for the operation was noted and the capacity, slicing efficiency, percentage damage and energy required to operate the machine was then calculated. Inorder to compare the thickness of the machine sliced cassava with that of sliced cassava by manual method, samples were collected from the market at Kuttipuram where cassava is sliced manually by skilled workers for chips preparation. This was then compared with that of the thickness of the developed machine.

3.2.2 Capacity of peeler

The capacity of the peeler, which is the number of kilogram of peeled cassava produced by the machine in one hour, was calculated by noting the weight of peeled cassava produced and the time taken for the same. It was then expressed in kg/hr.

3.2.3 Peeling efficiency

The initial weights of five different samples of cassava was taken. Then each sample was subjected to peeling action. After peeling, the weight of the peeled product and the peel obtained were noted. The peel remaining on the cassava was removed manually for each of the samples and the weights were noted. Peeling efficiency was then calculated using the formula,

Peeling efficiency = (X-Y)/X x 100

Where,

X = Weight of the peel on cassava (g)

Y = Weight of peel remaining on cassava which is removed by hand peeling after mechanical peeling (g)

3.2.4 Material loss

Material loss for each sample of cassava was calculated based on the following formula.

Material loss (%) = Z/ (W+Z)

Where,

Z = Weight of the flesh obtained from the peel (g)

W = Total weight of cassava after mechanical peeling (g)

3.2.5 Capacity of slicer

The capacity of the slicer, which is the amount of cassava sliced in kilogram by the machine in one hour, was calculated by noting the weight of sliced cassava produced and the time taken for the same. It was then expressed in kg/hr.

3.2.6 Slicing efficiency

The initial weights of five different samples of cassava was taken. Then each sample was subjected to slicing action. After slicing, weight of sliced and damaged portion obtained were noted. The slicing efficiency was then calculated by the formula,

Slicing efficiency = (X-Y)/X * 100

Where,

X = weight of sliced cassava pieces (g)

Y = weight of damaged cassava pieces (g)

3.2.7 Percentage damage

Percentage damage for each sample of cassava was calculated based on the following formula.

Percentage damage (%) = Z/W * 100

Where,

Z= weight of damaged cassava pieces (g)

W= total sliced weight of the sample (g)

3.2.8 Energy requirement for cassava peeler cum slicer

Energy required at no load and loaded conditions were determined by using an energy meter. The energy meter was connected in series with motor by running the unit without load and with load. Readings were noted and recorded.

3.2.9 Thickness of sliced cassava

Thickness of sliced cassava pieces were found for comparing with thickness of cassava slices produced in chips producing industry where cassava is sliced manually. Both outer and middle thickness of cassava is noted and compared. Thickness was measured by using screw gauge for getting required precision.

CHAPTER: IV

RESULTS AND DISCUSSION

This chapter deals with the results of experiments conducted to evaluate the performance of the developed cassava peeler cum slicer.

4.1 Performance evaluation

The experiment model was evaluated for its overall capacity, slicing efficiency, damaged percentage and energy requirement.

4.1.1 Capacity of the slicer

The average capacity of the slicer was found to be 33.61kg/hr. The results are shown in Table 4.1

It was observed that the capacity of the slicer varies with the uniformity of size, shape, variety and maturity of the cassava fed. In all cases a slicing disc speed of 300 rpm is chosen as optimum speed. Further increase in rpm was found to damage the slices of cassava which reduces the slicing efficiency of the machine.

Table 4.1. Capacity of slicer

Sl. No.	Weight of the sliced cassava(g)	Time taken for slicing(s)	Capacity (kg/hr)
1	275.6	27.1	36.611
2	200.45	21.2	34.038
3	212.81	22.9	33.45
4	251.27	30	30.152
5	261.42	27.8	33.85
		Average	33.61

4.1.2 Slicing efficiency

The Slicing efficiency of the machine can be calculated using the formula given in section 3.2.6. The average slicing efficiency of cassava slicer was found to be 90.832%.the results are shown in Table 4.2. It was observed that cassava which is freshly harvested and devoid of roots and deformation resulted in a slicing efficiency of 98.27% and for less quality cassava it was 83.1%.

Table 4.2. Slicing efficiency of the cassava peeler cum slicer.

Sl. No.	Weight of sliced cassava (g)	Weight of damaged cassava (g)	Slicing efficiency (%)
1	183.7	21.2	88.45
2	127.7	2.2	98.27
3	118.5	19.3	83.71
4	140.2	20.1	85.66
5	202.5	3.9	98.832
		Average	90.832

It was revealed from the experiment that the slicing efficiency depend on raw material factor such as maturity and moisture content. The uniform the size and shape higher will be the efficiency. Removal of top and bottom pieces of cassava will enhance the efficiency due to elimination of woody portion of cassava.

Besides, the skill of operator, in uniformly feeding each cassava tubers, while they are getting sliced on the rotating slicer disc is an important factor in determining the slicing efficiency.

4.1.3 Percentage damage

The percentage damage can be found out using the formula given in section 3.2.7. It was revealed that the percentage damage depends mainly on the characteristics of cassava such as size, shape, morphology, maturity, moisture content etc. The average percentage damage was found to be 6.34 % at a slicer disc speed of 300 rpm. Results of the experiments carried out for finding out the percentage damage is given the Table 4.3.

Table 4.3. Percentage damage

Sl. No.	Weight of sample taken (g)	Weight of damaged pieces (g)	Percentage damage (%)
1	204.9	21.2	10.3
2	129.9	2.2	1.6
3	137.8	19.3	14
4	160.3	20.1	12.5
5	206.4	3.1	1.5
		Average	7.6

4.1.4 Energy requirement of machine

Energy required for the machine under no load and loaded condition at an optimum slicer disc speed of 300 rpm and optimum peeler disc of 397rpm was determined and it is found to be 0.516 kWh and 0.5387 kWh respectively for a power range of 380 watts.

4.1.5 Thickness

Thickness of sliced cassava pieces prepared from slicer was found and compared with that of which is prepared manually. Both the outer and middle portion thickness of slices from developed machine and traditional method was noted and tabulated in Table 4.4.

Table 4.4 Comparison of thickness of cassava sliced mechanically and manually

Sl. No.	Machine sample		Manually sliced sample	
	Outer thickness (mm)	Middle thickness (mm)	Outer thickness (mm)	Middle thickness (mm)
1	1.5	1.0	2.2	1.54
2	2.2	1.7	2.3	1.53
3	2.1	1.5	2.23	1.51
4	2.0	1.4	2.25	1.53
5	2.1	1.6	2.21	1.52
Average	1.98	1.44	2.238	1.526

It was found that the average outer thickness and middle portion thickness of manually sliced cassava was 2.238mm and 1.526mm respectively whereas for mechanical slicing the values were found to be 1.98mm and 1.44mm respectively. It can be concluded that the chips produced by mechanical slicing is of lesser thickness and is good for chips making process for getting good consumer acceptability in terms of texture.

4.1.6 Capacity of peeler

The average capacity of machine was found to be 456.462 kg/hr. The results are shown in Table 4.6

It was observed that capacity of peeler is also depend on the factors which influencing the capacity of slicer assembly. The capacity can be further increased by cutting the long tubers into pieces with almost uniform diameter and feeding it continuously. In all cases a peeling rotor speed of 397 rpm was chosen as the optimum speed. Though further increase in, rpm may result in slight increase in capacity, the efficiency of peeling is reduced drastically.

Table 4.5 Capacity of cassava peeler

Sl. No.	Weight of cassava peeled (g)	Time taken for peeling (s)	Capacity (Kg/hr)
1	1000	8	450
2	1000	10.5	342.85
3	1000	6.5	553
4	1000	8.4	428.57
5	1000	7.1	507.04
		Average	456.462

4.1.7 Peeling efficiency

The peeling efficiency of the machine was calculated using the formula given in section 3.2.3. The average peeling efficiency of the machine was found to be 91.01%. The results are shown in Table 4.7.

Table 4.6 Peeling efficiency of the machine

Sl. No.	Weight of the peel (g)	Weight of the peel remaining on cassava (g)	Peeling efficiency (%)
1	152	14	90.79
2	155	13	91.61
3	154.5	13.4	91.33
4	151.5	14.5	90.43
5	153	13.9	90.92
		Average	91.01

Peeling efficiency is depend upon the raw material factors such as size, shape and variety and operating factors such as skill of the worker and the pressure applied on the cassava through the pedal operated feed pressing mechanism. The uniform the size and shape the higher the efficiency. Similarly, certain varieties such as Mundan, Malayan etc.

On which the peel is very firmly attached to the flesh and general have crevices etc. found to reduce the peeling efficiency slightly. To counter act this it is recommended that the cassava is cut into pieces.

4.1.8 Material loss

The material loss or the starch loss of the tuber during mechanical peeling was found using the formula given in 3.2.4. It was revealed that, the material loss depends mainly on the skill of the operator in applying pressure by the feed pressing mechanism. The average starch loss was found to be negligible and was only 0.284% at a peeling drum speed of 397rpm. The results of the experiments done for finding out the starch loss was given in Table 4.8

Table 4.7 Material loss

Sl. No.	**Weight of the peeled cassava (g)**	**Weight of flesh obtained from peel (g)**	**Material loss (%)**
1	1000	5	0.5
2	1000	1.5	0.15
3	1000	3	0.3
4	1000	3.8	0.38
5	1000	0.9	0.09
		Average	0.284

CHAPTER: V

SUMMARY AND CONCLUSION

Tuber crops are rated as the richest source of energy besides serving as a source of certain vitamins and minerals because of their high degree of photosynthesizing efficiency and the subsequent synthesis of carbohydrates. Root and tuber crops are grown everywhere in the world. Cassava is the most utilized tuber crop as food, feed and industrial raw material. Since the major portion of toxic cyanide content of cassava is present in its peel, the cassava tuber is almost invariably peeled before it is utilized. In most cassava processing industries, peeling is carried out manually by employing women labour using special kitchen knives. This method is time consuming, laborious, less efficient and tedious. To overcome these limitations, a mechanical cassava peeler was developed. The next processing step which have more industrial application is slicing of cassava. For making chips the slicing or chopping of cassava is of great importance. It is also a tedious, time consuming and labour intensive process. So for the easy and less time consuming slicing of cassava especially for small scale industry purpose cassava slicer was developed which is attached along with the peeler frame assembly thus mechanical cassava peeler cum slicer was developed.

A peeling rotor of 30cm diameter and 30cmlength form the heart of the developed cassava peeler. Thirty six number of cutting blades which scrape off the tuber surface during its operation have been mounted along the circumference of the rotor parallel to the longitudinal axis of the drum with the helix angle 60^{O}. A pedal operated feed pressing mechanism is provided at the top of peeling rotor inside the casing to facilitate efficient peeling and easy conveyance of peeled cassava towards the outlet. Separate outlets are provided for the peel as well as for the peeled cassava tubers at appropriate locations. The machine is operated by a 0.5 hp, 1440 rpm single phase induction motor through pulley and v-belt. The operating speed of the peeling rotor is 397 rpm.

The capacity of machine was found to be 456.462 kg/hr, which is higher than the existing conventional method. The peeling efficiency is about 91.01% and material loss is only about 0.26%.

Though the machine gave high capacity and efficiency, the parameters can be further improved by cutting the cassava tubers into pieces having almost uniform size and shape and improving the skill of the worker in feeding the machine uniformly and applying pressure on the tuber uniformly through the pedal operated feed pressing mechanism.

A cassava slicer was attached to the frame assembly which bears the cassava peeler. A double pulley of diameter 6.7cm is attached to the motor. And it is connected to a pulley of diameter 30.4cm with a v-belt. And a shaft of length 63.8cm and diameter 25mm is faced to 22mm diameter and fitted to this pulley. Shaft is supported by the means of bearings of length 13.8cm, diameter 25mm and thickness 1.3cm. A rotating disc plate of diameter 28.6 cm diameter and 0.5mm thickness called slicer disc which bears the cutting blade of length 11.5cm and width 2.85cm is connected at the end of the shaft. A feed chute and feed pressing mechanism is provided for efficient slicing. A supporting section using angle pieces is provided. The peeled cassava is fed into the feeding chute provided and with the help of spring loaded feed pressing mechanism the cassava is sliced in the form suitable for making chips under the cutting action of blade attached to it.

The machine is operated by same 0.5hp, 1440 rpm single phase induction motor through pulley and v-belt which is used for peeler. The slicer disc is rotating at a speed of 300 rpm. Capacity of machine is found to be 33.61 Kg/hr. Slicing efficiency is 90.832%. Percentage damage was 7.68%. Energy requirement of the machine in no load and full load condition was found to be 0.516 kWh and 0.5387 kWh respectively in average.

The slicing efficiency can be increased by using good quality cassava with optimum moisture content. The removal of woody ends will also increase the efficiency. And the skill of labours for feeding it continuously. From the experimental results, it was obvious that newly developed machine is technically and economically suitable for farm level and industry level operations.

Suggestions for further improvement

Some suggestions that may help future research work in modifying this machine are listed below.

1. A cutting mechanism of woody or rootish end of tapioca can be made prior to peeling.
2. Direct conveying mechanism from peeler to slicer can be done

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Appendix – 1

CALCULATION OF OPERATING COST

Cost of machine (including motor)	=	Rs. 11000
Capacity of machine	=	456.462 kg/hr (peeler)
	=	33.61 kg/hr (slicer)
Power required to operate the peeler	=	0.5 HP
Assumptions		
i. Use full life of the unit	=	10 years
ii.Working hours per day	=	8 hours
No. of working days per year	=	2400 hours
Salvage value	=	10%
Interest rate	=	12%
Repairs and maintenance	=	10%
A. Fixed cost		
Depreciation	=	(11000-1100) / (10x2400)
	=	0.4125/hr
	=	990/year
Interest on investment	=	((C+S)/ (2xHx100))x12
	=	((11000+1100)/(2x2400x100))x12
	=	0.3025/hr
	=	726/year
Repairs and maintenance	=	11000/ (10x2400)
	=	0.4584/hr
	=	1100.16/year
Total fixed cost	=	1.1734/hr

	=	2816.16/year
B. Variable cost		
Cost of electricity	=	$((456+33.3)/10^3)$x2400x5x0.5317
	=	3124.24/year
	=	1.31/hr
Wage of labour	=	500/day of 8 hour
	=	62.5/hr
Labours required (one two operate peeler one to operate slicer and one to proper collection)	=	3
Total labour cost	=	187.5/hr
	=	450000/year
Total variable cost	=	188.81
Total annual cost	=	Fixed cost + Variable cost
	=	Rs. 189.98/hr
Total quantity of cassava tuber peeled and sliced /year	=	1176172.8 kg
	=	1176.172 tonnes
Cost of peeling and slicing of cassava tuber	=	Rs. 387.65/ton

DEVELOPMENT AND EVALUATION OF A CASSAVA PEELER CUM SLICER

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ABSTRACT

Submitted in partial fulfillment of the requirement for the degree

BACHELOR OF TECHNOLOGY

IN

AGRICULTURAL ENGINEERING

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Food and Agricultural Process Engineering

Kelappaji College of Agricultural Engineering & Technology

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ABSTRACT

A power operated well efficient cassava peeler cum slicer was developed at K.C.A.E.T Tavanur. The machine consists of frame assembly, peeling rotor, slicer disc, feeding chutes, feed pressing mechanisms, outlets, and power transmission system. Peeling is achieved by scrapping action of the peeling rotor. Thirty six cutting blades which scrape off the peel, have been mounted along the circumference of the rotor with a blade angle of 60^{O}. The capacity and peeling efficiency of the machine was found to be 456.62kg per hour and 91.01% respectively at an optimum peeling rotor speed of 397rpm. Slicing is achieved by the action of rotating slicer disc holding the blade rotating in clockwise direction. The capacity and efficiency was found to be 33.6kg per hour and 90.832% respectively at an optimum slicer disc speed of 300rpm. The machine was found to be technically and economically feasible for the industry level operation.