DEVELOPMENT AND PERFORMANCE EVALUATION OF PLANTAIN PEELER CUM SLICER

By

ASWATHI, K.B

INDULEKSHMI

PROJECT REPORT

Submitted in partial fulfillment of the requirement for the degree

Bachelor of Technology

In

Agricultural Engineering

Faculty of Agricultural Engineering

Kerala Agricultural University

Department of

Post Harvest Technology & Agricultural Processing

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR-679 573, MALAPPURAM

KERALA, INDIA

2010

DECLARATION

We here by declare that this project report entitled **“Development and Performance Evaluation of Plantain peeler cum slicer”** is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

Aswathi, K.B
(2006-02-011)

Indulekshmi
(2006-02-021)

Place: Tavanur
Date:

CERTIFICATE

Certified that this project report entitled **"Development and Performance Evaluation of Plantain peeler cum slicer"** is a record of project work done jointly by Aswathi,K.B and Indulekshmi under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship to them.

Er. Rajesh, G.K
Assistant Professor
Dept. of PHT & AP
K.C.A.E.T, Tavanur

Place: Tavanur
Date:

ACKNOWLEDGEMENT

Words are no substitute for thoughts and feelings. It is more so when we, the project team, wish to express our sincere thanks to our project guide, **Er. Rajesh, G.K,** Asst. Professor, Department of Post Harvest Technology and Agricultural Processing, KCA.E.T, Tavanur. Without his constant encouragement, timely advice, patience and readiness to spare and share his treasure of knowledge and experience, this project work would not have progressed to the stage of completion in time. It is with a deep sense of gratitude that we express out heartfelt thanks to him.

With deep sense of gratitude and due respect, we express our heartfelt thanks to **Dr. Sivaswami**, Dean, K.C.A.E.T, Tavanur for his professional guidance and constructive suggestions offered during this study.

Word would not suffice to express gratitude to all staff members of PHT & AP especially **Dr. Ganesan, V**, Professor and Head of Department of PHT & AP, **Dr. Santhi Mary Mathew**, Professor, **Dr. Sudheer, K. P**, Associate professor**, Dr. Habeebur Rehman,** Project coordinator K.V.K, Malappuram**, Dr. Deepu Mathew,** Asst. Professor, **Dr. Sajeev.M.S,** Senior Scientist, CTCRI, Sreekaryam**, Mrs. Thasna**, and **Mr. Jabsheer** for their valuable guidance and constructive criticisms.

We are in short of words to acknowledge the self-less services of **Mr. Ashraf** and **Mr. Manohar Krishna**, Technicians without their help this venture would have been impossible for us. We thankfully remember the services of **Mr. Sudheer**, **Mr. Mohammed**, **Mr. Shajimon, Mr. Shebin** Technicians for their immense help.

We exploit this opportunity to thank **Library staff, all our batch mates and students of K.C.A.ET** for their sharing and caring which always motivated us throughout the venture.

Words do fail to acknowledge **our parents** support, encouragement and help gone a long way in making this attempt a successful one.

Above all, we bow our head before the **Almighty**, whose grace and blessings have empowered us to complete this toil.

Aswathi, K.B

Indulekshmi

DEDICATED TO OUR

PROFESSION OF

AGRICULTURAL ENGINEERING

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

%	percentage
/	per
&	and
^0C	degree Celsius
η	efficiency
A	Ampere
Al	aluminium
DC	direct current
et al	and other people
g	gram
GI	Galvenized iron
ISA	Indian Standard Angle
K.C.A.E.T	Kelappaji College of Agricultural Engineering and Technology
kg	kilogram
kg/h	kilogram per hour
kg/cm	kilogram per centimeter
kN	kilo Newton
mm	milli meter
mg	milli gram
M ha	million hactare
MT	Million tonnes
MS	mild steel
N	Newton
NHB	National Horticultural Board
PHT & AP	Post Harvest Technology and Agricultural Processing
rpm	rotation per minute

Rs	Rupees
s	seconds
SS	Stainless steel
t	tonne
V	Volt
viz	namely

INTRODUCTION

Chapter I

INTRODUCTION

Fruits and vegetables play an important role in human diet and nutrition. They are indispensable sources of essential dietary nutrients, vitamins and minerals besides providing crude fiber. The production of fruits and vegetables in India during 2008-09 is 68.46 and 129.07 MT, respectively (Agricultural Engineering Data Book, 2010). Though India is the largest producer of fruits and vegetables next to China, , the lack of processing and storage of fruits and vegetables results in huge wastes estimated about 35 %, which is approximately Rs 30,000 crores annually (Ministry of Food Processing Industries, 2009). Therefore the thrust should be to process and convert such perishable commodities into value added products that can be stored for extended periods there by reducing losses and making them available through out the year.

The long-term objective of our country's economic development is a good balance between a strong industrial sector and a resilient agricultural sector. The development of micro, small and medium scale rural agro industry is seen as a strategic step towards achieving this goal. There are large numbers of micro and small scale food processing enterprises run by farmers, which produce a wide variety of processed foods. Processed foods /snack foods may be described as mini meals in between main meals. Snacks like banana chips, jack fruit chips, coconut chips etc are light to eat and serve a variety of useful purposes in our day to day life. Banana chips making has already developed into a cottage and small scale industry in Kerala and the product is in high demand in India as well as abroad, especially in Middle East countries. There is great potential for this to be developed further, exploiting the domestic and fast increasing export demand.

Banana (*Musa paradisiaca*) is one of the oldest tropical fruits cultivated by man from prehistoric time in India with great socio-economic significance, interwoven in the cultural heritage of the country. It is indigenous to Asia, originated in the mountainous region of Indo-China. From there it has spread to tropical parts of America, Africa, Australia, Philippines and Hawaii. It is the fourth important food crop in terms of gross value after paddy, wheat and milk products and forms an important crop for subsistence farmers. Globally, banana is grown in around 4.5 Mha with a production of 72.5 MT. India is the largest producer of banana with an annual production of around 26.20 MT during 2008-09 from an area of 0.709 Mha which contributes 31 % of the total fruit production. Among the different states, Tamilnadu produces the maximum with 6.1 MT during 2007-08 from an area of 0.114 Mha. Though this state has the highest banana production level in the country, it does not enjoy the highest productivity level, which is bagged by Maharashtra (NHB, 2008-2009). In Kerala banana is cultivated in the entire state and is an integral part of homestead farming system. Banana is a vegetable as well as fruit apart from being used for the preparation of various value added products. It provides a more balanced diet than any other fruit or vegetable. It is also a desert fruit for millions apart from a staple food owing to its rich and easily digestible carbohydrates with a calorific value of 67 to 137 Calories/100 g fruit (Chandler, 1995). The green banana which becomes palatable after cooking is popularly referred as plantains, and is a staple food in coastal region of the country especially in Kerala, while the fresh fruit we consume is referred as dessert banana.

. Among the different varieties of banana Nendran is the most popular. Production of nendran variety of banana in Kerala during 2006-07 is 463.766 MT from an area of 0.059 M ha (Farm guide, 2009). The unripe banana of proper maturity is widely used for making chips. It can also be added to soups and stews, boiled and mashed, baked with meat or added to sweet desserts. Banana wafers is a popular snack food in South India especially in Kerala. It has good internal as well as external demand. The wafers can be prepared throughout the year since banana is available at cheap price in all seasons. The commercial chip production involves mainly four unit operations such as peeling, slicing to small wafers, frying and packaging. Each of these unit operations are done manually in small house hold sectors. Banana chips making has not emerged as a large scale industry though it has a large market potential because of the lack of appropriate mechanical equipments for peeling and slicing.

Peeling and slicing of the well matured unripe plantain is a difficult operation for an unskilled person and is also time consuming. Peeling is the removal of skin from green mature plantain. Slicing is carried out to reduce the size of product so as to enable it to suit the processing and consumer requirements. At present, peeling and slicing of plantain is done manually by stainless steel knives. This conventional method poses danger to operator's finger by inflicting injury. Frying quality of chips depends greatly on the uniformity of the wafers. The existing conventional method does not produce chips of uniform size. The output capacity of the system is less and the whole process is time consuming and labour intensive.

In order to eliminate the drudgery involved in manual peeling, avoid injury to workers, increase efficiency, and maintain high quality standards and hygiene to the prepared chips, an attempt was made at Kelappaji College of Agricultural Engineering and Technology, Tavanur, to develop a plantain peeler cum slicer with the following objectives:

1. Study of existing methods used for peeling and slicing of *Nendran* variety plantain for the preparation of chips.
2. Determination of physical and mechanical properties of plantain.
3. Development of a mechanical plantain peeler cum slicer
4. Performance evaluation of the plantain peeler cum slicer in terms of capacity, peeling efficiency and material loss.
5. Comparative evaluation of the mechanical and manual peeling cum slicing operation.

REVIEW OF LITERATURE

Chapter II
REVIEW OF LITERATURE

2.1 Agronomy

Banana is a tropical plant that grows in the warm, humid and rainy climate of tropical regions on both sides of the equator. Heavy rain fall and constantly high temperature are ideal for banana cultivation. In India, it grows well in Kerala, Tamil Nadu, Maharashtra, West Bengal, Bihar, Assam etc. Banana requires a rich, free working, soft, deep and retentive soil containing plenty of organic matter. All important agricultural soils of India are suitable for growing banana provided they are sufficiently deep and well drained with uniform crumb structure. The land should be deeply ploughed, harrowed and leveled and pits of half cubic meters should be dug at required distance for planting the crop. The distance of planting varies according to the height and spread of variety and growth conditions. The beginning of south west monsoon in June is the best time for planting banana in most parts of western and northern India.

Propagation of banana is done with rhizomes called suckers or pups. The plant matures its fruit from 12 to 18 months after planting depending upon the variety and dies soon after harvest. Under favourable conditions the plant starts flowering in 9 to 12 months after planting and takes 3-4 months to mature its fruit. Banana being a climateric fruit, it ripens best if harvested at full maturity.

2.2 Varieties

Cultivated varieties are broadly divided into two groups: table and culinary. Among the former are ‘Poovan’ in Madras also known as ‘Karpura Chakkare-keli’ in Andhra Pradesh; ‘Mortaman’, ‘Champa’ and ‘Amrit Sagar’ in West Bengal; ‘Basrai’, ‘Safed Velchi’, Lal Velchi’ and ‘Rajeli’ in Maharashtra; ‘Champa’ and ‘Mortaman’ in Assam and Orissa; and ‘Rastali’, ‘Sirumalai’, ‘Chakkare-keli’, ‘Ney Poovan’, ’Kadali’ and ‘Pacha Nadan’ in southern India. ‘Basrai’, which is known under different names, viz., ‘Mauritius’, ‘Vamankeli’, ‘Cavendish’, ‘Governor’, ‘Harichal’, is also grown in central and southern India. Recently, the ‘Robusta’ variety is gaining popularity in Tamil Nadu and Karnataka. The ‘Virupakshi’ variety (Hill banana) is the most predominant variety in the Palni Hills of Tamil Nadu. Among the culinary varieties, Nendran, ‘Monthan’, ‘Myndoli’ and ‘Pacha Montha Bathis’ are the leading commercial varieties in southern India, ‘Gros Michel’ is a recent introduction into southern India; it is suitable for cultivation only under garden-land conditions and is generally fastidious in its cultural requirements. It is not, therefore, in favour with the cultivators.

2.3 Food value

Banana is a highly nutritious fruit which contains an ample proportion of nutritive constituents which are easily digested and absorbed, while available at reasonable cost. It is one of the most easily assimilated fruits. It has a rare combination of energy value, tissue building elements, proteins, vitamins and minerals. It is a good source of calorie being richer in solids and lower in water content than any other fresh fruit. A large banana supplies more than 100 calories. It contains a large amount of easily assimilable sugar, making it a good source of quick energy and an excellent means of recovery from fatigue. The food value of raw banana per 100 g edible portion as reported by Potty et al., (1994) is represented in Table 2.1.

Table 2.1 Food value of raw banana

Food value (per 100 g edible portion)	
Moisture	70 %
Protein	1.2 %
Fat	0.3 %
Minerals	0.8 %
Fibre	0.4 %
Carbohydrate	27.2 %
Calcium	17 mg
Phosphorus	36 mg
Iron	0.9 mg
Vitamin C	7 mg
Energy	116 calories

Banana constitutes almost a complete balanced diet in combination with milk and is used as a dietary food against intestinal disorders because of its soft texture. It is the only raw fruit which can be eaten without distress in chronic ulcer cases. It neutralizes the over-acidity of the gastric juices and reduces the irritation of the ulcer by coating the lining of the stomach. Bananas are of great value both in constipation and diarrhoea as they normalize colon functions in the large intestine to absorb large amounts of water for proper bowel moments. Their usefulness in constipation is due to their richness in pectin, which is water-absorbent and this gives them a bulk producing ability. Being high in iron content, bananas are beneficial in the treatment of anemia. They stimulate the production of haemoglobin in the blood

2.4 Nendrans of South India

Nendrans are bananas of moist tropical sea coast. It is the most important variety grown in Kerala from time immemorial. There are many types in Nendran namely, Attu Nendran, Nana Nendran, Thiruvodan, Nedu Nendran, Chengazhikodan, Kudiravali, Valethan, Kelethan and Myndoli. It is known as plantain in most parts of the world. Nendran fruit is large, being about 9 to 10 inches long with thick skin representing the biggest sized edible fruit in banana. The fruits are loosely packed in bunch, flesh is firm and starchy. The fruit has fairly good keeping quality and can be used for both culinary purposes and as dessert. Jacob (1952) reported that the moisture content of Nendran is lower compared to other varieties of plantain Table 2.2.

Table 2.2 Biochemical properties of Nendran compared to other varieties of banana

Biochemical properties	Nendran (%)	Other varieties (%)
Moisture content	64.20	73.75-78.16
Reducing sugars	23	10.02-19.76
Non – reducing sugars	2.52	0.20-5.02
Acid	0.41	1.00-1.22

Nendran contains the greatest amount of sugars and much less acid content compared to other varieties. Many delicious products can be prepared from ripe as well as unripe Nendran.

2.5 Value addition in banana

Bananas are not seasonal fruits and are available in plenty through out the year. Being highly perishable, around 30 % of the total production of banana goes waste from the time of harvesting till they reach the consumers. Hence it is necessary to save them from the sizeable amount of losses. Plantains have great potential for value addition and diversification to give a boost to food industry, create employment opportunities and give better returns to the farmers. The various processed products of banana are banana figs, banana flour, starch, stem candy, powder, chips and fermented products like brandy, beer and ethanol. Some of these products, their uses and methods of preparation are described below.

2.5.1 Banana Fig

It is prepared out of all Nendran varieties. Preparation involves thoroughly ripening their skin until their skin gets blackened. They are then peeled, spread on bamboo mats and exposed to sun for 7 days on high platforms. The dried fruits make a delicious sweet meal or they may be made into jam.

2.5.2 Ripe fruits

Ripe fruits of Nendran are consumed after steaming or frying in oils. The 'halwa' made out of Nendran is a great delicacy. The ripe fruits are peeled, cut into chunks or split into two longitudinal halves and fried in oil

2.5.3 Banana flour

Banana flour also known as banana meal is made from fully mature unripe bananas. The unripe green fruits are dipped in scalding water for five minutes to enable easy peeling of green skin. The peeled fruits are then split into halves and dried. When the moisture is reduced to 15 % or less, the dried fruit is ground and run through sieves of 120 mesh to the inch. It is rich in carbohydrate and minerals and more easily digestible than any cereal starch. The flour is utilized as food for children.

2.5.4 Banana chips

Banana chips are delicious product which has international acceptance. This is made by peeling and cutting the unripe fruit into thin wafers and frying in oil. They keep well for 2-3 months without deterioration in quality.

2.5.4.1 Peeling

Peeling is the first unit operation to be carried out for processing of banana. It involves the removal of outer skin of the fruit. In India, peeling is performed manually with stainless steel scouring knives. The shape of the plantain is awkward to peel with a knife and lead to cuts on the fingers if the knife slips. Also, if excessive pressure is applied to the plantain while holding it steady for peeling, the edible portion can become bruised. Thus, it should be performed carefully. Different methods developed for peeling fruits and vegetables are mentioned below.

2.5.4.1.1 Hand peeling

It is usually done manually by women using special knives. The peel is cut longitudinally and transversely to a depth corresponding to the thickness of the peel, which can then be easily removed. This method requires minimum investment and no enzyme stimulation as in the case of heat and lye peeling methods. Major disadvantages are high labour cost and chances of contamination with micro organisms. The rate and quality of operation depends on experience and the efficiency of operation varies from person to person.

Plantain peeler

Edwin Rodriguez (1995) developed a plantain peeler which comprises a handle to be grasped by the hand of the person. A curved peeling tip extends outwardly from an end of the handle to fit under the skin of the green banana, in which both ends are cut off and the skin has a plurality of lengthwise slits. A curved shield extends at a rearward angle up from a top surface of the curved peel. It has an efficiency of 98 %.

E-Z Plantain peeler

Edwin Rodriguez (1999) modified his plantain peeler and renamed it as E – Z Plantain peeler. It is a hand held tool made of durable plastic with a stainless steel blade protector. This tool was specifically designed to facilitate the tedious and antiquated way of peeling green plantains. The utensil protects the nail and cuticle from becoming sore.

Plantain safety peeler

Lenscott, F. Ruiz (2001) developed plantain safety peeler. It consists of a safety cutter for peeling green bananas wherein a handle portion is provided adjacent a head portion which carries a peeling element with dual opposing peeling blades. The dual opposing peeling blades are relatively widely spaced apart to allow the peeling element to cut through the tough, thick skins of the green banana. It is also provided with an elongated retractable cutting blade which is used to first cut off either end of the green banana to allow it to be easily peeled.

2.5.4.1.2 Steam peeling

In steam peeling, the raw material is exposed for a short period of time to steam under pressure in a retort which revolves slowly. After steaming, the pressure is released quickly, causing a steam flush under the skin, thus breaking the surface, facilitating peeling.

Steam-peeling processes employed for various products have been described by Edit and Mac Arthur (1944). In this process, the produce to be peeled is washed and pre-heated for about three minutes. The softened tissue is then eroded from the produce by high pressure water sprays in a washer.

Harris and Barber (1957) have reported that the depth and uniformity of the peel depend upon the steam pressure used and the rapidity of diffusion of steam among the produce being peeled.

Harris and Smith (1985) patented a process of peeling by thermal blast for rapid removal of outer coverings from food products with minimal damage to edible portions of the product. The blast process is accomplished by containing the product for a brief period in a heated, closed vessel pressurized with super heated steam, and then instantaneously releasing the pressure.

2.5.4.1.3 Lye Peeling

Lye- peeling is generally carried out by passing the produce to a tank of heated sodium hydroxide solution and subsequently removing the skin by high pressure water sprays in a rotary washer. Sometimes, an acid dip is used followed by a washing operation. A short lye treatment is also used in advance of an abrasive peeler, to increase capacity and to reduce the weight loss. This process requires smaller floor space. The major disadvantages are high peeling losses, loss of damaged material and pollution of large volume of water.

2.5.4.1.4 Flame Peeling

Though flame peeling method is rarely used, it is particularly suited to some products. The 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. (Radhakrishnan Setty, 1993).

2.5.4.1.5 Abrasive Peeling

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

Jiji *et al*., (1994) developed a hand operated brush type ginger peeling machine. Two abrasive surfaces one stationary and the other moving were made by means of canvas belts. The brush was made manually with nylon.

Anie *et al*., (1996) developed a mechanical abrasive roller type cylinder peeling machine and studied the performance by varying the pre-treatment condition and speed of the roller. The machine consists of an abrasive unit, driving unit, collector unit and frame. Abrasion unit does the work of peeling when ginger rhizomes are pressed manually on to the rotating rollers.

2.5.4.1.6 Mechanical peeling

Mechanical peeling consists of a safety cutter for peeling of fruits and vegetables, and is carried out on equipment designed specially for each type of products.

Leslie Black (1984) developed a banana peeling machine in which the skin of a banana is engaged by impinging spikes on the periphery of three resiliently supported rotatable wheels with separating and cutting means to assist the skin being pulled away from the flesh to effect peeling of the banana.

Bindu *et al*., (1999) developed a pineapple peeler, corer, cum slicer. The peeling and coring unit consists of two concentric stainless steel cylinders, which on lowering, peels and cores the pineapple. The machine can be used to peel pineapples of any size using peeling cylinders of varying diameters with minimum material loss (about 2 %). In the slicing unit, the blades move in between the rings of the holding unit and slice it. The thickness of the cut slices can be varied by using bushes between knives. The peeling efficiency of the machine was 99 %.

Dwija *et al*., (2000) developed cassava peeler with a peeling efficiency of 99.52 %. This consisted of a peeling rotor with thirty six number of cutting blades mounted along the circumference of the rotor parallel to the longitudinal axis which scrape off the tuber surface during its operation.

Anaiboni (2003) developed a plantain peeler. The peeling mechanism consists of four arcuate blades arranged in a circular manner that would force the peel from the plantain as it pass through it.

2.5.4.2 Slicing of fruit

Chipping or slicing of banana into thin wafers of about 1.5 to 2.0 mm thick is one of the important unit operations in plantain processing. The quality of chips depends upon the size and uniformity of the wafers. Crispness is one of the textural characteristics which determine the consumer acceptance of the product. Crispness can be controlled by maintaining uniformity of chip thickness and proper frying.

2.5.4.2.1 Traditional methods

The most widely practiced method of chipping banana in the country is done manually by stainless steel knives to produce thin wafers. A few entrepreneurs use manually operated platform type manual slicer by holding plantain and moving across the sharp edge of the slicer.

2.5.4.2.2 Mechanical methods

Nanda (1985) developed a hand operated vertical feed cassava chipping machine consisting of two concentric mild steel drums, the annular space between which is divided into compartments for feeding the tubers. The rotating discs at the bottom of it carry the knife assembly. A pair of bevel gears is provided to operate the machine manually with a crank handle. Later on a pedal operated machine has been developed to increase the output as well as operational convenience.

Balsubramanian *et al*., (1993) developed and evaluated a motorized cassava chipper. The machine consisted of 18 chipping discs with knives driven by a disc shaft from power source. The tubers can be vertically fed from top and chips are collected at the bottom. The capacity of the chipper is 270 kg/h. The chip recovery was assessed at 92 % for 1 mm chips at 295 rpm. The cost of chipping was estimated at Rs.18/t.

Kachru *et al*., (1994) developed a multiple string banana slicer to avoid the drudgery and injury to workers and enhance the capacity and maintain quality gadgets within stainless steel string arrangement. This had a hollow frame of mild steel; 250 mm length, 130 mm wide and 70 mm height. About 126 SS rings (28 gauge) 7.5 mm in length were tied across the longitudinal side at 5 mm above the bottom edge of the frame.

During the experimentation, peeled banana was kept on a 10 mm raised platform and the frame with strings moved down manually so as the strings pierced into the fruit pulp to cut the slices. Due to the blunt edge of the string, a force of about 28 N was required to pierce a single string into the banana. When so many strings acted over one fruit at a time, the force requirement for strings to pierce into the fruit was very high (about 3.5 kN) which resulted in compression of fruit from the bottom leading to the distortion of pulp. Also due to the pulp, removal of slices after cut was very difficult.

Kachru *et* al., (1996) developed an electrically operated rotary slicer for raw banana. The horizontal type-chipping machine consists of a slicer disc attached with blades. An MS shaft is used to drive the slicing disc. A stainless steel semicircular feeding chute is used for feeding the peeled banana and chips are directly discharged into the pan by centrifugal action. It has an efficiency of 90 % and produces chips of uniform thickness.

Liju (1997) developed a vertical feed mechanical chipper. The feeding mechanism has a pressing attachment which consists of a mild steel rod with a wooden end plate at disc and which is lifted up. The raw peeled banana is fed through the slots made in the feeding pipes. The pressing mechanism is then released and the rotating disc with blade cuts the banana into round slices of uniform shape and thickness. The stopper attachment on the pressing mechanism prevents the wooden end plates from damaging the plates. Chipping efficiency of the machine is 96 % and effective capacity of slicing is 223 kg peeled raw bananas per hour.

Dayana Paul *et al*., (2007) developed a potato slicer which consists of feeding unit, a slicing mechanism and a driving mechanism. The potatoes, fed manually in to the hopper fall by gravity in to the cylinder at the bottom dead centre of the piston. They are pushed horizontally to the stationary blade as the piston moves towards the top dead centre and thus sliced. The wooden bush on the piston helps in pushing all the slices out of blade assembly. The machine can be used to slice potatoes with minimum percent damage (about 4.02 %). The slicing efficiency of the machine is 95.93 %. The developed slicer could produce slices at capacity six times higher than manual slicing.

MATERIALS

AND

METHODS

Chapter III

MATERIALS AND METHODS

The fabrication procedure of the plantain peeler cum slicer, the details of the components and the procedures adopted for evaluation are described in this chapter.

3.1 Study of existing methods used for plantain peeling

Prior to the development of plantain peeler, a survey was conducted in Malappuram and the adjacent districts viz., Kozhikode, Thrissur and Palakkad to study the existing methods of plantain peeling and slicing.

3.2 Mechanical and physical properties

Before the fabrication, important physical and mechanical properties of plantain were studied. The plantains having a moisture content of 80 % were graded according to their size for the determination of the properties. The moisture content of plantain was determined by placing a sample of 10 g in a hot air oven, at 65 ^{0}C for 24 hours. The peel and pulp were weighed to determine the pulp to peel ratio (Kachru, R.P *et al*., 1994). The size and peel thickness were determined using screw gauge having a least count of 0.001 mm. The diameter of the banana with and without peel was recorded. The load required to cut a cross-sectional slice of peel and pulp was found out by texture analyzer.

Based on the physical and mechanical properties of mature plantain, design parameters were obtained for the development of a mechanical peeler.

3.3. Development of Model I

The various parts of the machine are

- Cylindrical guide – This is the feeding unit of the peeler and made of G I pipe of 45 mm diameter and having 130 mm length.
- Circular peeling blade with throat – The main part of the peeler is the peeler blade. It was a circular blade made of high carbon steel of 25 mm diameter .The blade was welded on a conical throat.

- Splitter – Three splitting blades of M S flat of length 130 mm having thickness1 mm was welded over the throat of the peeling unit. The purpose of the splitter was to split the banana peel in to three sections of 12mm. width.
- Pushrod- A pushrod of stainless steel 304 grade was used to push the banana through the circular blade.
- Frame assembly– Frame assembly supports the entire unit satisfactorily. This is made of MS plate of size 5 mm x 20 mm x 320 mm

Plate 3.1 Model I

3.4 Development of Model II (Improved model)

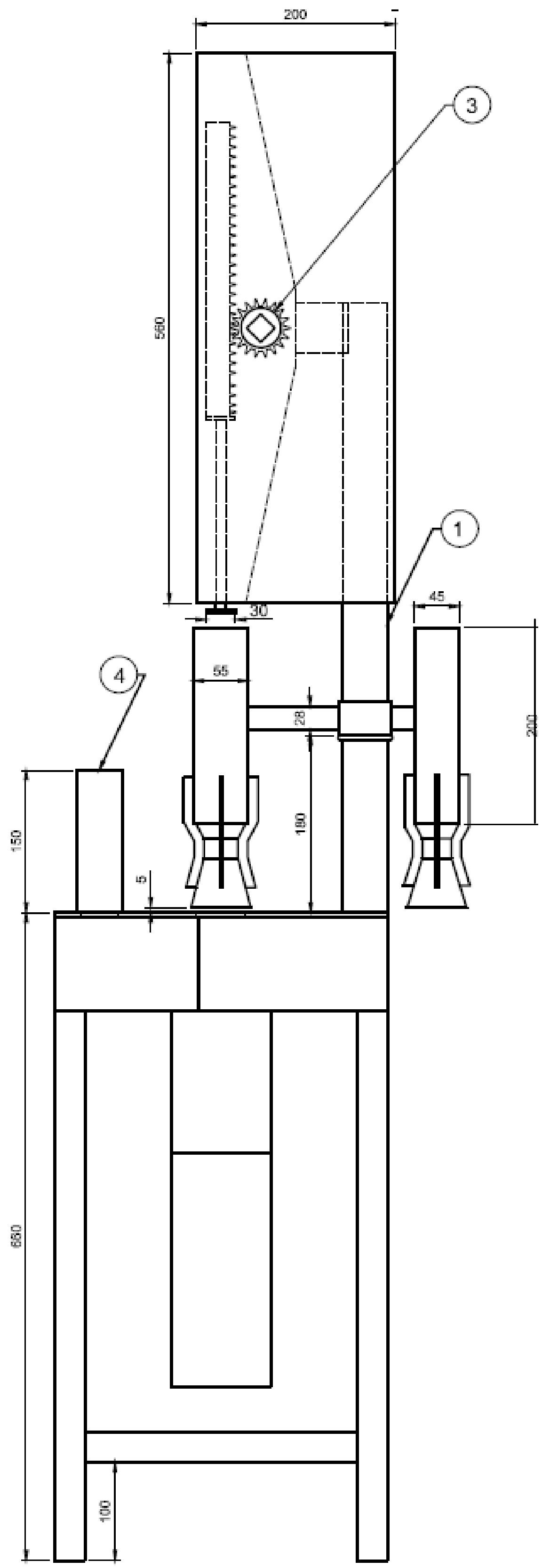
The banana peeler which was fabricated earlier (Model 1) was of a single peeler unit for a fixed sized banana. In order to make it more easy, effective and more human friendly, a machine was fabricated to peel 3 grades of banana (small, medium and large) using three peeling units of different sized blades.

3.4.1 General Layout and Details of Model II

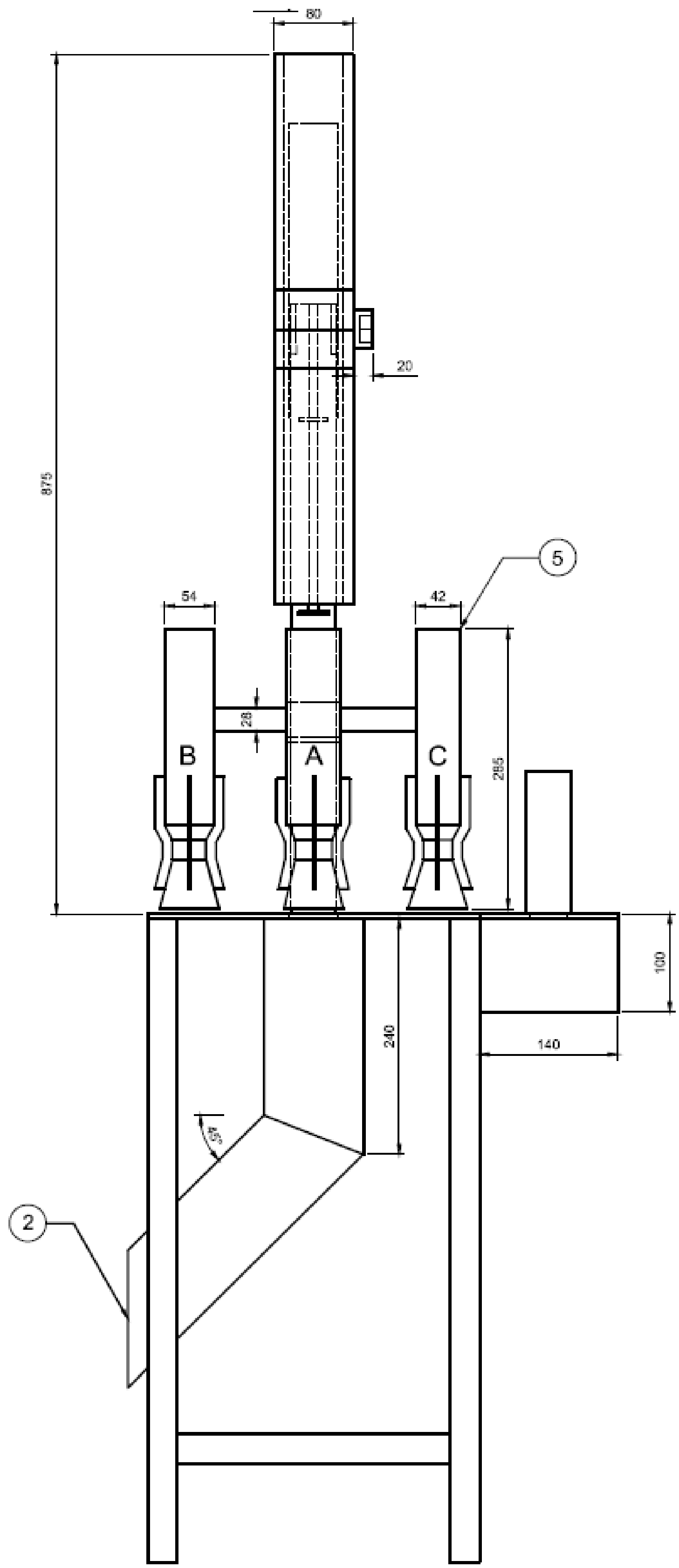
The fabricated machine has the following components:

1. Feeding unit
2. Peeling unit
3. Pushing unit
4. Collection unit
5. Slicing unit
6. Frame assembly

Plate 3.2 Fabricated plantain peeler cum slicer



RIGHT SIDE VIEW



FRONT VIEW

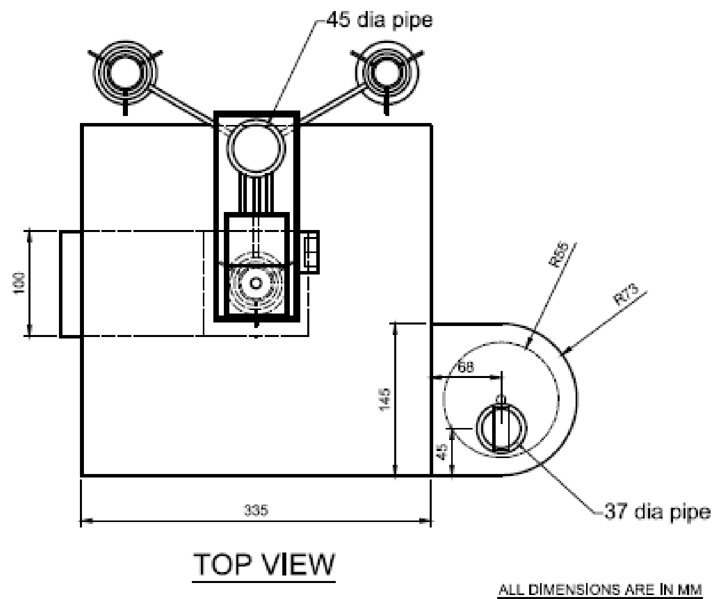


Table 3.1 Components of Model II

Sl No.	Particulars
1.	Frame Assembly
2.	Outlet chute
3.	Pushing unit
4.	Slicing unit
5.	Feeding and Peeling unit

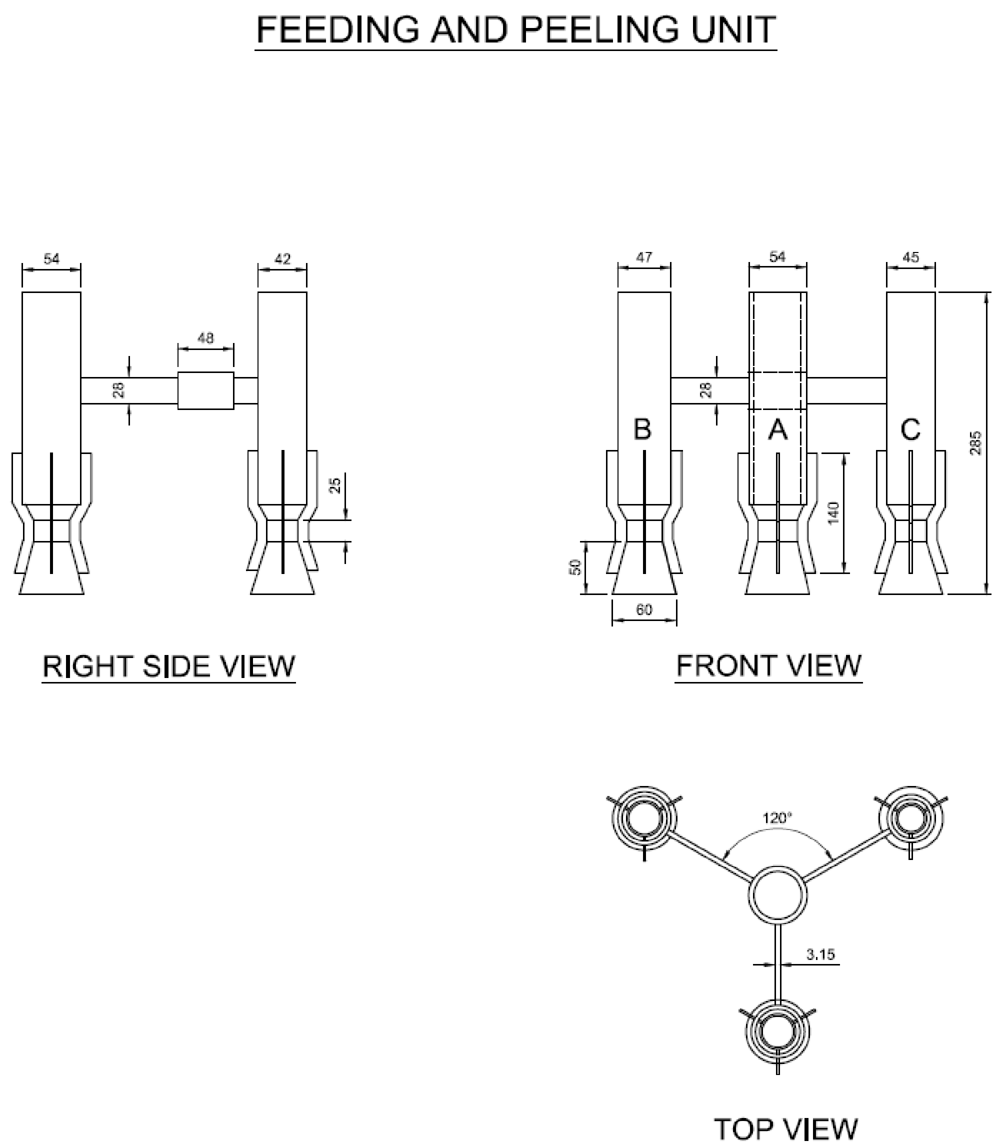
Fig 3.1 Line diagram of assembly unit

3.4.1.1 Feeding unit

The feeding unit consists of 3 cylindrical guides of different diameters placed 120º apart fixed to a sleeve using 3 equal length MS flats of 28x3.15x750 mm. A cylindrical sleeve of diameter 48 mm and length 34 mm was mounted on 500 mm vertical pillar. The rotation of the cylindrical guide is possible by rotating the sleeve. Three stainless steel pipes of diameters 42, 47 and 54 mm, height 200 mm each and thickness 2 mm were used for the fabrication of cylindrical guide.

3.4.2 Peeling unit

It is the main unit of the peeler which separates the peel from the pulp. Three high carbon steel blades of width 25 mm were bent to form circular type openings of diameters 28, 32 and 37 mm for respective cylindrical guides through which plantain passes during the peeling operation. Each cylindrical guide was connected to a conical throat of 50 mm height and 60 mm base diameter using splitter blades. The peeling blades were welded over these conical throats. Three splitting blades of medium carbon steel with length 140 mm and thickness 1 mm was welded over each throat of the peeling unit to split the peel after the peeling operation.

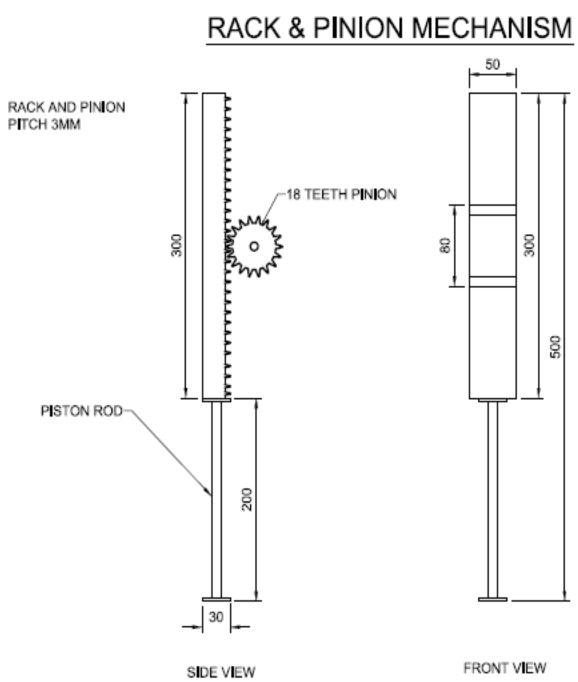


All dimensions are in mm

Fig 3.2 Line diagram of feeding and peeling unit

3.4.1.2 Pushing unit

The main parts of pushing unit are i) piston ii) rack and pinion and iii) ratchet and pawl. The lowering and lifting of the piston is done by this unit. Ratchet and pawl is a device consisting of a toothed wheel engaged with a pivoting, spring loaded finger called a pawl that permits it to move in one direction and preventing motion in opposite direction. The teeth are uniform, having a moderate slope on one edge and a much steeper slope on the other edge. When the wheel rotates in one direction, the pawl slides over the teeth, and in opposite rotation, it catches in the teeth. The rack is a flat, toothed part of 3 mm pitch and 300 mm long. The pinion is a gear having 18 teeth. It converts the applied rotary motion to linear motion. The upward and down ward motion of the piston inside the cylindrical guide was performed by these two mechanisms.



All dimensions are in mm

Fig 3.3 Line diagram of pushing unit

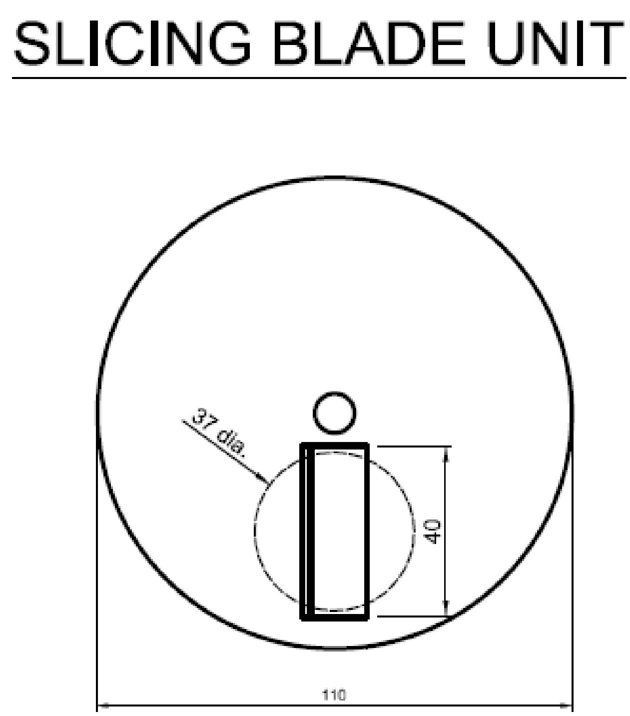
Plate 3.3 Ratchet and pawl

3.4.1.3 Collection unit

The collection unit consists of outlet chute and a collecting tray. The outlet chute was made of 16 gauge G.I sheet with 45^0 inclination towards the horizontal to facilitate easy discharge. Collecting tray of 300x300x300 mm was made from Al sheet of 1 mm thickness. The peeled plantain slides downward through the outlet chute into the collecting tray.

3.4.1.4 Slicing unit

Slicing unit consists of a cylindrical guide, slicing disc and blade. Peeled plantain was fed to the slicing unit through the cylindrical guide of 37 mm diameter and 150 mm length. 40 x 15 mm SS blade was mounted over 110 mm diameter disc of 1.8 mm thickness. Slicing was achieved by rotating the disc at 300 rpm. The slicing unit was powered with 10 A, 12 V, DC motor with 32 kg/cm torque.

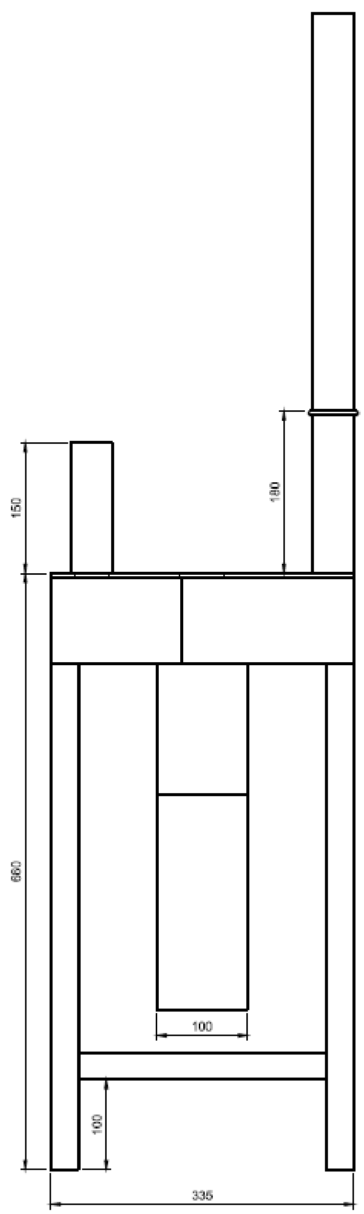


All dimensions are in mm

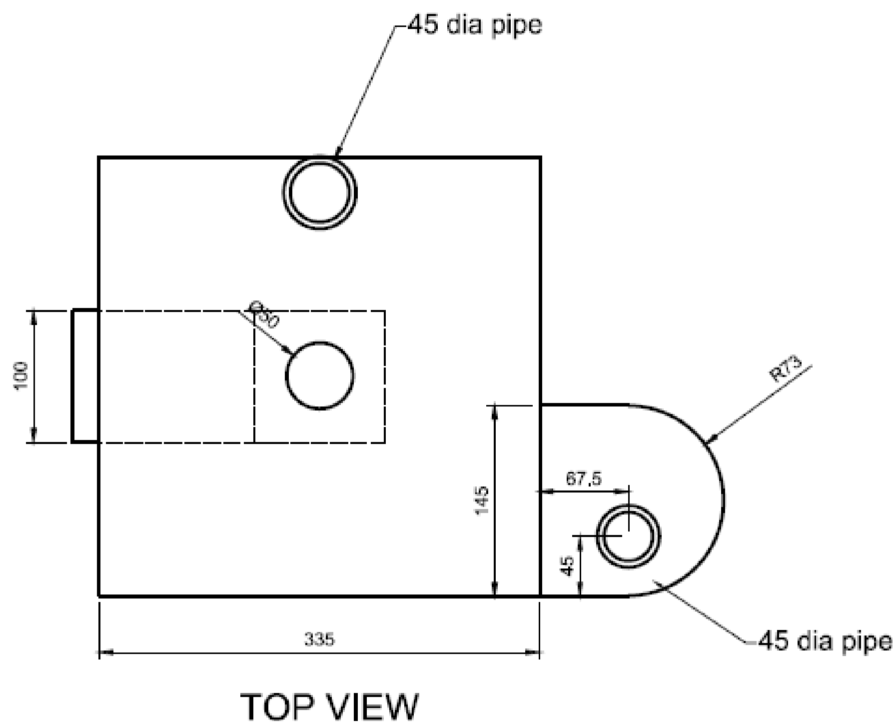
Fig 3.4 Line diagram of slicing unit

3.4.1.5 Frame assembly

The frame supports the entire machine component to perform its operation satisfactorily. It was fabricated using ISA 31 x 6.3 mm MS section. On to this frame assembly, units like pushing unit, feeding unit, peeling unit, peeled plantain outlet and slicing unit were mounted.



RIGHT SIDE VIEW



All dimensions are in mm

Fig 3.5 Line diagram of the frame assembly

3.4.2 Performance evaluation of peeling unit of Model II

Matured *Nendran* procured from the local market were used for conducting the experiment. The plantains were graded into 3 sets according to their size. The two ends of the matured plantain of *Nendran* variety were chopped off and then fed through the respective cylindrical guides of diameters 42, 47 and 54 mm. Peeling was achieved by the cutting action of the circular blade followed by splitting of the peels by the splitter. The peeled plantains falls down through the inner throat and were collected in the collecting tray. The split peels slides through the outer conical throat and were placed in the discard tray. The time required for the operation was noted and the capacity was calculated. All the experiments were replicated five times and the average value was found. A comparison between manual and mechanical peeling was also carried out.

Plate 3.4 Peeling unit in operation

3.4.2.1Capacity

The capacity of the peeler which is the kilogram of peeled plantain produced by the machine in one hour was calculated by noting the weight of the peeled plantain produced and the time taken for the same. It was then expressed in kg/h. For a skilled labour a time lag of 10 s was accounted between successive feeding and actual capacity was calculated in kg/h.

3.4.2.2 Peeling Efficiency

The initial weights of the different samples of plantain were 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 plantain 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 100 / X

Where, X = Weight of the total peel on plantain (g)

Y = Weight of peel remaining on plantain to be removed manually after mechanical peeling (g)

3.4.2.3 Material loss

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

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

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

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

3.4.3 Performance evaluation of slicing unit

The peeled samples were then fed to the cylindrical guide of the slicing unit to achieve slicing operation. The slices were then collected in a tray kept below the blade set. The time required for the operation was noted and operating capacity, percentage damage and slicing efficiency was then evaluated.

Plate 3.5 Slicing unit in operation

3.4.3.1 Overall Capacity (OC)

The operating capacity of the fabricated slicer was calculated by weighing all the cut slices irrespective of damage per unit time.

3.4.3.2 Slicing Efficiency

The efficiency of slicer was evaluated by weighing the damaged and round slices separately and using the expression.

$$\text{Slicing Efficiency, } \eta = \frac{\text{Wt. of all slices - Wt. of damaged slices}}{\text{Wt. of all slices}} \times 100$$

3.4.3.3 Percentage damage (% D)

The percentage damage of the slicer was evaluated using the expression

$$\text{Percentage damage, \% D} = \frac{\text{Wt. of damaged slices}}{\text{Wt of all slices}} \times 100$$

3.4.3.4 Effective capacity (EC)

After having noted the efficiency and overall capacity of the machine, the effective capacity can be found out by the expression.

$$EC = OC \times \eta/100$$

3.5 Comparative evaluation of the manual and mechanical peeling cum slicing operation.

The performance of the fabricated machine was compared with that of manual operation for which raw plantains were peeled and sliced using conventional stainless steel knives.

RESULTS

AND

DISCUSSIONS

Chapter IV

RESULTS AND DISCUSSIONS

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

4.1 Study of existing methods used for plantain peeling

Survey revealed that no mechanical plantain peeler has been developed so far and peeling of plantain is still done traditionally by stainless steel scouring knives. The slicing of plantain is also done manually using a platform type slicer by holding plantain and moving across the sharp edges of the slicer**.**

4.1 Traditional methods of peeling

4.2 traditional methods of slicing

4.2 Physico-Mechanical property

The details of the properties are shown in Table 4.1. The pulp to peel ratio of *Nendran* variety varies between 1.95 and 1.97 with an average value of 1.96. The peel thickness varied from 2.01 mm to 2.07 mm, the average being 2.04 mm. The maximum and minimum average diameters for Nendran banana with peel were 39.8 and 22.29 mm. These values for without peel were 32.64 and 23.62 mm respectively. The maximum load required to cut a cross-sectional slice of peel and pulp was 45 N and 25 N respectively.

Table 4.1 Physico-mechanical properties of Nendran banana

Sl. No.	Properties	Average value
1	Pulp to peel ratio	1.96
2	Peel thickness	2.04 mm
3	Maximum diameter with peel	39.8 mm
4	Minimum diameter with peel	22.29 mm
5	Maximum diameter without peel	32.64 mm
6	Minimum diameter without peel	23.62 mm
7	Maximum load to cut a cross sectional slice of peel	45 N
8	Maximum load to cut a cross sectional slice of peel	25 N

4.3 Test models

The developed models were tested for different samples of plantains and the results are discussed in terms of capacity, peeling efficiency and material loss.

4.3.1 Performance evaluation of Model I

The capacity, peeling efficiency and material loss for this model was calculated as 13.88 kg/h, 73.38 % and 18.71 % respectively. This model removed almost entire peel, but a certain amount of the pulp was wasted along the peel. Since the diameter of the circular blade provided was fixed, it gave varying performance with different sized plantains.

4.3.2 Performance Evaluation of peeling unit of Model II

The fabricated machine was evaluated for its capacity, peeling efficiency and material loss.

4.3.2.1 Capacity

The over all capacity was found to be 34.21, 49.74 and 68.48 kg/h for 42, 47and 54 mm diameter cylindrical guides. The corresponding actual capacities were calculated as 18.54, 25.98 and 36.87 kg/h. Results are shown below in tables 4.2, 4.3, and 4.4.

Table 4.2 Capacity of the peeler (for 42 mm diameter feeding cylinder)

Sl.no.	Wt. of peeled plantain (g)	Time taken for peeling (s)	Over all capacity (kg/h)	Actual capacity (kg/h)
1.	117.27	14.05	30.04	17.55
2.	116.84	13.13	32.03	18.18
3.	114.31	10.25	40.14	20.32
4.	106.77	12.95	29.68	16.74
5.	112.83	10.37	39.16	19.94
		Average	34.21	18.54

Table 4.3 Capacity of the peeler (for 47 mm diameter feeding cylinder)

Sl.no.	Wt. of peeled plantain (g)	Time taken for peeling (s)	Over all capacity (kg/h)	Actual capacity (kg/h)
1.	148.07	11.27	47.29	25.06
2.	160.54	12.21	47.33	26.02
3.	149.64	10.42	51.69	26.38
4.	151.53	10.33	52.80	26.83
5.	147.42	10.70	49.59	25.63
		Average	49.74	25.98

Table 4.4 Capacity of the peeler (for 54 mm diameter feeding cylinder)

Sl.no.	Wt. of peeled plantain (g)	Time taken for peeling (s)	Over all capacity (kg/h)	Actual capacity (kg/h)
1	221.49	13.45	59.28	34.00
2	218.04	12.78	61.41	34.45
3	229.28	10.53	78.38	40.20
4	220.52	11.67	68.02	36.63
5	225.45	10.77	75.35	39.07
		Average	68.48	36.87

From the tables it is evident that the capacity of the machine increases with the diameter of feeding cylinder. Maximum capacity was obtained using 54 mm diameter cylindrical guide and minimum for 42 mm. This is because the size of the plantain increases with weight. But there is no significant change in time taken for peeling plantains through a single cylindrical guide. The trend is same for actual capacity also.

4.3.2.2 Peeling efficiency

The peeling efficiency of the machine was calculated using the formula given in 3.4.2.2. The average peeling efficiency of the machine using 42, 47 and 54 mm cylinders were obtained as 89.19, 88.27 and 89.37 % respectively. The results are shown in Table 4.5, 4.6 and 4.7.

Table 4.5 Peeling efficiency (for 42 mm diameter feeding cylinder)

Sl.No	Weight of the peel (g)	Weight of the peel remaining in plantain after peeling (g)	Peeling efficiency (%)
1.	54.08	6.38	88.2
2.	56.50	6.24	88.95
3.	52.85	6.29	88.09
4.	45.94	4.8	89.55
5.	53.67	4.73	91.18
		Average	89.19

Table 4.6 Peeling efficiency (for 47 mm diameter feeding cylinder)

Sl.No	Weight of the peel (g)	Weight of the peel remaining in plantain after peeling (g)	Peeling efficiency (%)
1.	78.43	9.72	87.60
2.	87.98	10.43	88.14
3.	67.25	9.14	86.40
4.	71.60	7.48	89.55
5.	72.28	7.47	89.66
		Average	88.27

Table 4.7 Peeling efficiency (for 54 mm diameter feeding cylinder)

Sl.No	Weight of the peel (g)	Weight of the peel remaining in plantain after peeling (g)	Peeling efficiency (%)
1.	84.12	9.39	88.83
2.	85.78	8.72	89.83
3.	86.14	7.56	91.22
4.	80.45	10.97	86.36
5.	86.13	8.05	90.65
		Average	89.37

From the results it was revealed that there is no significant variation in the efficiency of peeling operation. For a particular cylindrical guide, peeling efficiency increases if the plantain correctly fits into the guide. Lower peeling efficiency was observed in plantains with slightly curved shape.

Plate 4.3 Plantains after mechanical peeling

4.3.2.3 Material loss

The material loss or the flesh loss of the plantain during mechanical peeling was found, using the formula given in 3.4.2.3. The results of the experiments done is given in table 4.4.3

Table 4.8 Material loss during peeling operation (for 42 mm diameter feeding cylinder)

Sl No.	Weight of the peeled plantain (g)	Weight of pulp obtained from peel (g)	Material loss (%)
1.	117.27	17.26	12.82
2.	116.84	17.41	12.96
3.	114.31	15.66	12.04
4.	106.77	17.42	14.02
5.	112.83	19.18	14.52
		Average	13.27

Table 4.9 Material loss during peeling operation (for 47 mm diameter feeding cylinder)

Sl No.	Weight of the peeled plantain (g)	Weight of pulp obtained from peel (g)	Material loss (%)
1.	148.07	20.82	12.32
2.	160.54	25.39	13.65
3.	149.64	19.46	11.50
4.	151.53	25.05	14.18
5.	147.42	24.51	14.25
		Average	13.18

Table 4.10 Material loss during peeling operation (for 54 mm diameter feeding cylinder)

Sl No.	Weight of the peeled plantain (g)	Weight of pulp obtained from peel (g)	Material loss (%)
1.	221.49	36.20	14.04
2.	218.04	38.38	14.96
3.	229.28	42.12	15.51
4.	220.52	33.74	13.26
5.	225.45	41.00	15.38
		Average	14.63

It was revealed that, the material loss also depends on the shape and size of the plantain. The average percent material loss for 42, 47 and 54 mm cylinders were calculated as 13.27, 13.18 and 14.63 % respectively. For a particular cylindrical guide, it was found that the percent material loss increases with weight of the plantain. This is due to the constant size of the peeling blade.

4.3.3 Performance evaluation of slicing unit

The slicing unit was evaluated for its overall capacity, slicing efficiency, percent damage and effective capacity. Results are furnished in the following tables.

Table 4.11 Overall capacity of slicer

Sl No.	Wt of peeled plantain (g)	Time taken for slicing (s)	Over all capacity(kg/h)
1.	54.08	6.38	88.20
2.	51.34	5.47	89.34
3.	52.85	6.29	88.09
4.	45.94	4.8	89.55
5.	45.2	3.99	91.17
		Average	89.27

Table 4.12 Slicing efficiency of slicer

Sl No.	Wt. of all slices (g)	Wt. of damaged slices (g)	Efficiency (%)
1.	323.03	29.47	90.87
2.	260.45	28.61	89.01
3.	340.65	37.55	88.97
4.	345.79	39.41	88.60
5.	350.95	40.74	88.39
		Average	89.16

Table 4.13 Percentage damage of the slicer

Sl No.	Wt. of all slices (g)	Wt. of damaged slices (g)	Percentage damage (%)
1.	323.03	29.47	9.12
2.	260.45	28.61	10.98
3.	340.65	37.55	11.02
4.	345.79	39.41	11.39
5.	350.95	40.74	11.60
		Average	10.82

Plate 4.4 Sliced plantains

The overall capacity, slicing efficiency, percentage damage and effective capacity of the plantain slicer was found to be 89.27 kg/h, 89.16 %, 10.82 % and 79.59 kg/hr respectively using the formula given in 3.4.3.1, 3.4.3.2, 3.4.3.3 and 3.4.3.4.

4.4 Comparative evaluation of manual and mechanical peeling cum slicing operation.

Table 4.14 Comparison of manual and mechanical peeling cum slicing operation

Sl No.	Total time required for peeling one sample of 150 g(s)		Total time required for slicing one sample of 150 g(s)	
	Manual	Mechanical using 47 mm feeding cylinder	Manual	Mechanical
1.	36.5	11.4	29.8	6.8
2.	35.9	10.7	28.5	5.2
3.	36.0	10.9	28.8	5.7
4.	36.2	11.2	29.5	6.4

As illustrated in table results of manual peeling indicates that a skilled labourer can peel 14.8 kg plantains per hour and slice 18.52 kg/h. Under the same conditions, the fabricated peeler could peel 48.9 kg/h and slice 89.63 kg/h .Thus it was established that the peeling and slicing of plantains using the fabricated machine is found to produce a capacity nearly four times more effective than manual peeling and slicing. Besides, peeling and slicing efficiency is high. Also, even and uniform slices can be obtained by the fabricated machine. This machine eliminates the drudgery involved in manual peeling and slicing operations and saves time. The machine is simple in construction and operation and requires only one person to operate it.

SUMMARY

AND

CONCLUSION

Chapter V

SUMMARY AND CONCLUSION

India is the largest producer of banana which contributes 31 % of the total fruit production. Banana is a vegetable as well as fruit apart from being used for the preparation of various products. The green banana which becomes palatable after cooking is popularly referred as plantains, and is a staple food in coastal region of the country especially in Kerala, while the fresh fruit we consume is referred as dessert banana. The unripe banana of proper maturity is widely used for making chips. Banana wafer is a popular snack food in South India especially in Kerala. It has good internal as well as external demand. Nendran which is leading in the commercial chip preparation involves mainly four unit operations such as peeling, slicing to small wafers, frying and packaging. At present, peeling and slicing of plantain is done by traditional methods using stainless steel knives. The efficiency of the system is less and the process is time consuming and labour intensive. Hence, an attempt was made at Kelappaji College of Agricultural Engineering and Technology, Tavanur to develop a plantain peeler cum slicer.

A preliminary survey in the areas of intensive chips making revealed that commercial scale peeling of plantain is done manually by stainless steel scouring knives. The slicing of plantain is also done manually using a platform type slicer by holding plantain and moving across the sharp edges of the slicer. This conventional method poses danger to operator's finger by inflicting injury. Also, the frying quality of chips depends greatly on the uniformity of the wafers. The existing method does not produce chips of uniform size.

Before the fabrication, the physical and mechanical properties of green mature plantain like length, diameter, skin thickness, pulp to peel ratio, load required to cut a cross sectional slice of peel and pulp etc were studied. Based on these properties, two models of plantain peeler were developed. The banana peeler which was fabricated earlier (Model 1) was of a single peeler unit for a fixed sized banana. The capacity, peeling efficiency and material loss for this model was calculated as 13.88 kg/h, 73.38 % and 18.71 % respectively. Since the diameter of the circular blade provided was fixed, it gave varying performance with different sized plantains. In order to make it easier, effective and more human friendly, Model II was fabricated to peel 3 grades of banana (small, medium and large) using three peeling units of different sized blades. The developed plantain peeler cum slicer (Model II) consists of a) feeding unit, b) peeling unit, c) pushing unit, d) slicing unit and e) frame assembly. The feeding unit facilitates easy and safe feeding for free movement of plantains. It consists of 3 cylindrical guides of diameters 42, 47 and 54 mm and height 200 mm each placed 120º apart fixed to a sleeve using 3 equal length MS flats of 28x3.15x750 mm. A cylindrical sleeve of diameter 34 mm and length 48 mm was mounted on 500 mm vertical pillar. Peeling unit consist of peeling blades, conical throats and splitters. Peeling was achieved by the cutting action of the circular blade followed by splitting of the peels by the splitter. The pushing unit comprises of piston, rack and pinion and ratchet mechanism. The lowering and lifting of the piston is performed by these two mechanisms. The collection unit consists of outlet chute and a collection tray. The peeled plantain slides downward through the outlet chute into the collecting tray. Slicing unit consists of a cylindrical guide, slicing disc and blade. Slicing was achieved by rotating the disc at an rpm of 300. The slicing unit was powered with 10 A, 12 V, DC motor with 32 kg/cm torque.

Experimental trials were conducted at Kelappaji College of Agricultural Engineering and Technology, Tavanur to evaluate the performance of the plantain peeler cum slicer. The peeler unit was tested for capacity, peeling efficiency and material loss. The actual capacity of the peeling unit was calculated as 18.54, 25.98 and 36.87 kg/h respectively for small, medium and large sized plantains. The average peeling efficiency and material loss of the peeling unit were obtained as 88.94 % and 13.69 % respectively. The slicing unit was evaluated for its overall capacity, slicing efficiency, percent damage and effective capacity. The overall capacity, slicing efficiency, percent damage and effective capacity of the plantain slicer was found to be 89.27 kg/h, 89.16 %, 10.82 % and 79.59 kg/h respectively. Total operating cost of the fabricated plantain peeler cum slicer was calculated as 39.67 kg/h.

The capacity of the developed peeler cum slicer was four times higher than manual operation. This machine produced even uniform sized slices. The machine requires one person to operate it. It is simple in construction and operation and therefore technically feasible and economically viable.

Modifications of the machine can further improve the performance. Some suggestions that may help future research work are given below.

a) The peeling unit could be motorized so as to increase its capacity.

b) Provisions may be made in the cylindrical guide to adjust the diameter.

c) Provisions may be made to peel curved plantains

REFERENCES

REFERENCES

- Anaiboni, E.L. (2003). Plantain peeler. U.S Patent No. 6,591,742 ,U.S Patent and Trademark office, Washington, DC.
- Anie, J., Nizar, P.K.and Sathyan, K. (1996). Development and testing of a semi mechanical ginger peeler. Unpublished B.Tech (Agrl.Engg) Project report submitted at Kerala Agricultural University.
- Anonymous (2010). Agricultural engineering data book, Central Institute of Agriculture Engineering, Bhopal.pp:27
- Balasubramanian, D., V.M., Sreenarayanan, V.V. and Viswanathn, R.(1993). Design, development and evaluation of cassava chipper. *Agricultural Mechanization in Asia, Africa, and Latin America*. 24(1):60-64.
- Bindu, K.G., Bindu Kochugovindhan and Vidhu, K.P. (1999). Development and testing of a pineapple peeler, corer cum slicer. Unpublished B.Tech (Agrl.Engg) Project report submitted at Kerala Agricultural University.
- Chandler, S. (1995). The nutritional value of banana, pp: 468-480, In:Bananas and plantains (S. Gowen, ed),Chapman and Hall, U.K.
- Dayana Paul, Rajesh Mohan and Simi Poulose (2007). Development and evaluation of potato slicer. Unpublished B.tech (Agrl.Engg) Project report submitted at Kerala Agricultural University.
- Dwija, L.R., Gisha, G. Nair, Rajesh, P.D. (2000). Development and testing of a cassava peeler, Unpublished B.Tech (Agrl.Engg) Project report submitted at Kerala Agricultural University.
- Edit, C.E. and Mac Arthur, M. (1944). Peeling of fruits and vegetables for processing. Foods in Canada. 4(7):31.
- Edwin Rodriguez (1999). Development of plantain peeler. U.S. Patent No.5,497,552, U.S Patent and Trademark office, Washington, DC.
- Farm guide (2009), FIB Govt. of Kerala.
- Harris and Barber, J.M. (1957). Improved Methods and Techniques in peeling Sweet potatoes, Proc.Assoc.S.Agr. Workers, 54 th Annual Convention, pp: 185.

- Harris, H. and Smith, P. (1985). Methods for Thermally Blasting Outer Covering from Food products. Hort. Science, 23(1).
- Jacob (1952).Madras banana: a monograph superintendent, Govt. Press, Madras.
- Jiji, E., Sandya, K.V and Sheeja J.T. (1994). Development and testing of hand operated brush type ginger peeling machine. Unpublished B.Tech (Agrl.Engg) Project report submitted at Kerala Agricultural University.
- Kecharu, R.P., and Nachikhet Kotwaliwale, Balsubramanian, D .(1994). Mechanical and Physical properties of Banana. *Journal of Food Engineering*.26(3):369-378.
- Kacharu, R.P., Balsubramanian, D and Nachiket Kotwaliwale (1996), Design, development and evaluation of rotary slicer for raw banana chips. *Agricultural Mechanization in Asia, Africa, and Latin America* .27(4).
- Leslie Black (2000) .Banana peeling machine, U.S Patent No.4,446,782, U.S Patent and Trademark office, Washington, DC.
- Liju, K. (1997). Development and performance evaluation of banana chipper Unpublished B.Tech. (Agrl.Engg) Project report submitted at Kerala Agricultural University.
- Lenscott, F.Ruiz.(2003). Development of plantain safety peeler. U S Patent No. 6,671,964, U.S Patent and Trademark office, Washington, DC.
- Nanda, S.K. (1985). Research report submitted at Central Tuber Crops Research Institute, Trivandrum.
- Potty, V.H. (1994).Trends in food consumption and food industry development; A global perspective. Indian Food Industry .14(4)
- Radhakrishnan Setty, Vijayalakhmi, M.R and Usha Devi, A. (1993). Methods for peeling fruits and vegetables; A critical evaluation. *Journal of Food Science and Technology* 300(3):155-162
- Sudheer, K.P and Indira,V (2007),Post Harvest Technology of Horticultural Crops, New India Publishing Agency, New Delhi. Pp: 2.
- http://www.nhb.gov.in
- http://www.pprc.gov.in

APPENDICES

APPENDIX I

CALCULATION OF OPERATING COST

Initial cost (C)

Fabrication cost of plantain peeler cum slicer including cost of material	= Rs 15,000
Average life of machine	= 10 years
Working hours per year	= 1500
Salvage value	= 10 % of initial cost

A) Fixed cost

1. Depreciation

$$= \frac{C-S}{L \times H}$$

$$= \frac{(15,000-1500)}{(10 \times 2000)}$$

$$= 0.675$$

2. Interest on investment@ 12%

$$= \frac{(C+S) \times 12}{(2 \times H \times 100)}$$

$$= \frac{(15,000 + 1500) \times 12}{(2x\ 2000 \times 100)}$$

$$= 0.495 / h$$

Total fixed cost = 1.17 / h

B) Variable cost

1. Labour wages

Wages of labour = Rs. 300 / day of 8 h

2. Cost of electrical energy

Unit cost of electricity	= Rs 3 / kwh
Energy consumption of machine	= 0.1 kwh
Cost of electricity	= Rs 0.3 /h

3. Repair and Maintenance cost

@ 10% of initial cost p.a.	= (15,000 x 10)/(2000x100)
	= 0.75 / h
Total variable cost	= 38.50 / h
Total operating cost	= 39. 67 / h

APPENDIX II

SPECIFICATIONS OF THE MACHINE

Weight of the machine = 43 kg

Dimensions of the feeding cylinder

Sl No	Inner diameter (mm)	Thickness (mm)	Length (mm)
1	42	2	200
2	47	2	200
3	54	2	200

DEVELOPMENT AND PERFORMANCE EVALUATION OF PLANTAIN PEELER CUM SLICER

By

ASWATHI, K. B

INDULEKSHMI

PROJECT REPORT

Submitted in partial fulfillment of the

requirement for the degree

Bachelor of Technology

In

Agricultural Engineering

Faculty of Agricultural Engineering

Kerala Agricultural University

Department of

Post Harvest Technology & Agricultural Processing

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR-679 573, MALAPPURAM

KERALA, INDIA

2010

ABSTRACT

Peeling and slicing of green mature plantains of *Nendran* variety is labour intensive and costly. At present, it is carried out manually and no means of mechanical peeling and slicing device has been commercialized till now. The conventional method of peeling and slicing is done by using stainless steel knives. This poses danger to operator's finger by inflicting injury and also does not produce chips of uniform size. Prior to the development of banana peeler, a survey was conducted in Malappuram and the adjacent districts to study the existing methods of banana peeling and slicing. Also an investigation of the physical and mechanical properties of green mature plantain was under taken. Based on these properties, plantain peeler cum slicer was developed. The peeling unit of the fabricated machine consists of feeding cylinders, peeling blades, conical throat and splitters. The green plantain fed into the feeding cylinder was pushed down by a pushing mechanism. Peeling was achieved by the cutting action of the circular shaped blade that would force the peel from the plantain as it passes through the mechanism. Slicing unit consists of a cylindrical guide, slicing disc and blade. Slicing was achieved by rotating the disc at an rpm of 300. The slicing unit was powered with 10 A, 12 V, DC motor with 32 kg/cm torque. The actual capacity of the peeling unit was calculated as 18.54, 25.98 and 36.87 kg/hr respectively for small, medium and large sized plantains. Average peeling efficiency and material loss were obtained as 88.94 % and 13.69 % respectively. The overall capacity, slicing efficiency and effective capacity of the plantain slicer was found to be 89.27 kg/h, 89.16 % and 79.59 kg/hr respectively. The capacity of the developed peeler cum slicer was four times higher than manual operation. Total operating cost of the fabricated plantain peeler cum slicer was calculated as 39.67 kg/h.