DEVELOPMENT AND PERFORMANCE EVALUATION OF POWER OPERATED PLANTAIN PEELER

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"Development and Performance Evaluation of Power Operated Plantain Peeler"** 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 of any degree, diploma, fellowship or other similar title of any other University or Society.

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FOOD ENGINEERING

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SYMBOLS AND ABBREVIATIONS

%	percentage
/	per
&	and
^{0} C	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
FAPE	Food & Agricultural Process Engineering
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 a vital role in human healthy diet and nutrition. They are main sources of vitamins, minerals, phytochemicals especially antioxidants and dietary fiber. The intake of dietary fiber lowers the cardiovascular risk and obesity. India is the second largest producer of fruits and vegetables in the world after China. India produced approximately 86 million metric tonnes of fruits and 170 million metric tonnes of vegetables during 2014-2015. The area under cultivation of fruits and vegetables during this period were 6 million hectares and 9 million hectares, respectively (National Horticulture Board, 2015).

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. The 102 million metric tonnes of bananas produced worldwide in 2012 were worth an estimated US $28 billion which contributes 31 percent of the total fruit production (National Horticulture Board, 2015).

Banana is the second most important fruit in India after mango. India leads the world in banana production with an annual production of 29.7 million tonnes during 2014-15. It is grown in an area of approximately 8 lakhs hectares accounts for 13 percent of the total area and 33 percent of the production of fruits. Maharashtra is the leading producer of banana in India followed by Tamil Nadu, Gujarat and Karnataka (National Horticulture Board, 2015). In Kerala banana is cultivated in the entire state and is an integral part of homestead farming system. Banana is cultivated in an area of 63 thousand hectare with an annual production of 5.5 lakh tonnes during 2013-2014 (Agricultural statistics, 2013-14). Banana is a vegetable as well as fruit apart from being used for the preparation of various value added products. 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.

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 is 463 Metric Tonnes from an area of 0.059 Metric hectares .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.

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 or 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.

Peeling 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. At present, peeling of plantain is done manually by stainless steel knives. This conventional method posses danger to operator's finger by inflicting injury. 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 power operated plantain peeler with the following objectives:

1. To determine the engineering properties of plantain.
2. To develop a power operated plantain peeler.

3. To evaluate the performance of the developed power operated plantain peeler in terms of capacity, peeling efficiency and material loss.

REVIEW OF LITERATURE

Chapter II

REVIEW OF LITERATURE

2.1 Agronomy

Banana (*Musa paradisiaca*) is called as “Apple of Paradise” because it is the one of oldest cultivated fruit known to mankind, it is also the most nutritious. It is originated in hot tropical regions of south-east Asia. India ranks first in production of mango (40%) and banana (17%) of world production. India is the largest producer of banana and plantains in the world with a production of 16.82 million tonnes from an area of 0.49 million hectares. In India it accounts for 33% of total production of fruits and 12% of area under fruit crops. Cavendish is the major cultivar covering 62% of production of banana, followed by Mysore (16%), Bluggoe (6%), Nendran (Plantain 5%), Silk (4%), Pome (4%) and other (3%). The cultivation of banana is mainly distributed in states of Tamil Nadu, Maharashtra, Karnataka, Andhra Pradesh, Assam, Gujarat, Bihar, Madhya Pradesh and West Bengal. The production of banana is the highest in Tamil Nadu followed by Maharashtra, Karnataka, Andhra Pradesh, Gujarat, Madhya Pradesh, Bihar, Assam and West Bengal. The Indian average productivity is 34.3 tonnes/hectares while the highest productivity within India is in Maharashtra with productivity of 60 tonnes/hectares followed by Tamil Nadu with 53 tonnes/hectares. (Sonawane *et al.*, 2011)

Banana is a tropical plant, requires warm humid climate. It can grow successfully at sea level to an altitude of 1500 m. A mean temperature of 26.7° C and rainfall of 100 mm/month are satisfactory for its cultivation. Deep, well drained, friable, loamy soil with adequate organic matter is the ideal condition for its cultivation.

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 ‘AmritSagar’ in West Bengal; ‘Basrai’, ‘SafedVelchi’, LalVelchi’ and ‘Rajeli’ in Maharashtra; ‘Champa’ and ‘Mortaman’ in Assam and Orissa; and ‘Rastali’, ‘Sirumalai’, ‘Chakkare-keli’, ‘Ney Poovan’, ’Kadali’ and ‘PachaNadan’ 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 Tamilnadu and Karnataka. The ‘Virupakshi’ variety (Hill banana) is the most predominant variety in the Palni Hills of Tamilnadu. Among the culinary varieties, Nendran, ‘Monthan’, ‘Myndoli’ and ‘PachaMonthaBathis’ 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 nutritious fruit with many health benefits. According to the United States Department of Agriculture, every 118 grams portion of raw edible banana (medium size), contains 105 calories, 27 grams of carbohydrates, and very low fat. Banana is also a good source of vitamin B6 (22%), potassium (12%), vitamin

C (17%), magnesium (8%), etc. The nutritional content may vary based on the soil and weather conditions at the planting sites, the ripening stage of the fruit, and on the cooking methods.

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 diarrhea 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 hemoglobin 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.

Table 2.1 Biochemical properties of *Nendran* variety 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 banana.

2.5 Value addition in banana

The bulk of the banana, cooking banana and plantain are eaten either as raw, in the ripe state, or as a cooked vegetable, and only a very small proportion are processed in order to obtain a storable product. Bananas are not seasonal fruits and are available in plenty throughout the year. Being highly perishable, around 30 per cent 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. The ripe banana is utilized in a multitude of ways in the human diet, from simply being peeled and eaten out of hand to being sliced and served in fruit cups and salads, sandwiches, custards and gelatins, being mashed and incorporated into ice cream, bread, muffins and cream pies.

2.5.1 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

2.5.2 Banana flour

Flour can be made from green unripe banana, cooking banana or plantain. Fruits are hand-peeled and sliced or chopped into pieces about 5-10 mm thick. The slices will be dried in the sun by spreading out the slices on mats, on bamboo framework, on cement floors, or on a roof or sheets of corrugated iron or simply on a swept bare ground. Various designs of solar dryers can also be used, or they may be dried in ovens, over fires, in a cabinet dryer or tunnel dryer.

2.5.3 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.

2.5.4 Canned slices

For canning, banana slices are stored in syrup. Best quality slices are obtainable from fruit at an early stage of ripeness. The slices are processed in syrup of 25° Brix with pH of about 4.2 and in some processes calcium chloride (0.2%) or calcium lactate (0.5%) are added as firming agent.

2.5.5 Banana chips

Typically, unripe banana or plantain may be thinly sliced vertically or transversely (1.2-0.8 mm thick) .The slices are immersed in a sodium or potassium meta-bisulphate solution (to improve the colour of the final product or to prevent discolouration) and fried in hydrogenated oil at 180-200°C. The fried slices are dusted with salt and antioxidant (e.g. butylated hydroxyl toluene to delay rancidity). Alternatively slices may be dried before frying and the antioxidant and salt are added with the oil. Fried chips should have moisture content of about 1.5 to 2.0%.

2.5.6 Jam and Jelly

In one method for the preparation of jelly, fully ripe or over-ripe fruits are used. Fruits are hand-peeled and cut into 2 cm pieces or slices. The slices are boiled for 1 hr in 60° Brix sugar syrup at the rate of 1 lb of banana to 1 pint of syrup (454 g to 0.5681). This is then strained and the clear solution is boiled until it sets. The pH should be adjusted to 3.5. Pectin may be added to improve the set. A commercial formula for producing banana jam is as follows, 200 lbs of sugar, 10 gallons of water and 12 ounces of cream of tartar. These are heated to 110°C and then 2.5 gallons of lemon juice (lime juice or citric acid can be used to replace the lemon juice to reduce the pH of the jam to 3.5) are added. The mixture is heated to 107°C until the correct consistency is obtained.

2.6 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.

2.6.1 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.

2.6.2 Plantain peeler

George J bagg (1914) developed a simple machine which shall produce very effective separation of the pulp from the peel or skin, and which shall be rapid in operation and shall adapt itself automatically to fruit of different sizes. A banana, fed in through one of the 20 chutes , is engaged by the corresponding feed rolls and fed thereby to the revolving cutter which splits the banana lengthwise, at the same time carrying it forward to and beyond the spreader. The two halves of the split banana being turned over with their pulp sides uppermost by this spreader being then engaged by the teeth of the first feed roll, whereby the halves of the banana are fed forward to the roll, which in like manner feeds them forward to the pulp-gathering head . The blades of this head divide the pulp of the banana into small pieces which remain temporarily between and filling the spaces between blades, the peel of the banana being separated from the surface of the said head and deflected downward by the peeling blade.

Leslie (1984) black 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 adjacent a narrowest gap location to assist the skin being pulled away from the flesh to effect peeling of the banana. The object of this invention is to propose a banana peeling machine that can effect a peeling of a banana with a minimal amount of manual labour and can achieve this both quietly and economically and that a machine can be produced that can be reliable mechanically. Aanaiboni E. Lenor(2003) developed a The device would Consist of a Slicing mechanism and a peeling mechanism integrated into a housing with discard tray at the bottom and a plastic backsplash Surrounding the peeling mechanism. The peeling mechanism would consist of four accurate blades arranged in a circular manner that would force the peel from the plantains it passes through the mechanism. A discard tray would be provided at the bottom of the device to catch the peel, a tip retrieval opening would be provided in the housing behind the slicing mechanism, and a plantain retrieval passage would be provided in the housing behind the peeling mechanism.

Alavarez *et al*. (2010) developed a device Which separates banana pulp from its peel, suitable for large-scale processing, is disclosed. The device consists of upper and lower conveyor belts, a roller installed above the upper belt, and a pressure generating element (e. g., a roller or a plate) installed below the lower belt. The belts are/installed so as to converge in the direction of their movement. The axis of the roller is oriented between the longitudinal direction of the lower belt and its transverse direction.

Rajesh *et al.* (2010) 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. Slicing unit consists of a cylindrical guide, slicing disc and blade. Slicing was achieved by rotating the disc at 300 rpm. Average peeling efficiency and material loss were obtained at 88.94% and 13.69%, respectively. Diameter of feeding cylinder was significant at 1% (P<0.01) level for overall capacity of machine. The overall capacity, slicing efficiency and effective capacity of the plantain slicer was found to be 89.27 kg/hr, 89.16 kg/hr and 79.59 kg/hr, respectively. The capacity of the developed peeler cum slicer was four times higher than manual operation.

2.6.3 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.

2.6.4 Plantain safety peeler

Lenscott, F. Ruiz (2001) developed plantain safety peeler. It is a further primary object of the present invention is to provide a plantain or green banana peeler which is simple in design, easy to manufacture and inexpensive, making it readily available to all consumers. 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.

2.6.5 Steam peeling

To eliminate charring, but to keep the effects of high temperature of the infrared or flame, superheated steam is used. The steam pressure that is used in wet heat is about 10 atm and it leads to the softening of skins and underlying tissues. When the pressure is suddenly released, steam under the skin expands and causes the skin to puff and crack. Then the skins washed away with jets of water at high pressure (up to 12 atm).

Kunz (1978) patented a method and device for peeling pumpkin by using wet stream. While the pumpkins are shifting on endless conveyors, they are cut into halves and are placed with the pulp facing downwards. After that they are exposed to pressurized wet steam.

Smith (1984) developed a method of superheated steam peeling of apples by refining conventional caustic and steam peeling methods. He found that steam peeling with saturated steam followed by flash cooling by injection of water increased yields, saved labour, eliminated the need for expensive caustic solutions and caustic disposal, and finally resulted in high quality for apples for further processing.

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.

2.6.6 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.

2.6.7 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 (RadhakrishnanSetty, 1993).

2.6.8 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.

Jain *et al*. (2007) 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.

2.6.9 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.

Alavarez *et al.* (2010) developed a device Which separates banana pulp from its peel, suitable for large-scale processing, is disclosed. The device consists of upper and lower conveyor belts, a roller installed above the upper belt, and a pressure generating element (e.g., a roller or a plate) installed below the lower belt. The belts are/installed so as to converge in the direction of their movement. The axes of the roller is oriented between the longitudinal direction of the lower belt and its transverse direction.

Tagare *et al.* (2013) developed a sugar cane peeling machine it is aimed at providing a base for the commercial production of a sugarcane peeling machine, using locally available raw materials at a relatively low cost. The successful fabrication of a sugarcane peeling machine is one of the major, if not the major, challenge in sugarcane processing.

Sekhar *et al.* (2014) developed potato peeling machine is very useful for all food makers, small restaurants. This comprises of components like handle, gear train, bearings, lead screw, cutting tool and wooden base.

Thomas S Stephens (2014) developed an avocado peeling machine. The machine consists of two drums, both rotating downward toward the nip. One has a solid outside surface, the other has a perforated outside surface. Pitted avocado halves are placed one at a time with the seed cavity toward the perforated drum. As the drums rotate, the solid drum presses the meat of the avocado through the 1/4 inch holes in the perforated drum. A doctor blade mounted inside the perforated drum cuts the meat from the peel, and a doctor blade on the outside of the perforated drum removes the peel.

MATERIALS AND METHODS

Chapter III

MATERIALS AND METHODS

The engineering properties required to develop a plantain peeler are described in this chapter. Also, the methodology for fabrication of the power operated banana peeler and the procedures adopted for evaluation are also mentioned in this chapter.

3.1 Raw materials

Matured plantains (*Nendran* variety) were procured from a progressive farmer at Tavanur. Materials used for the fabrication of the peeler were purchased from Thrissur. Harvested plantains were collected in corrugated fiber boards and transported to the laboratory with care. The plantains were stored at a temperature of 15-17ºC and relative humidity 85 percent for conducting the preliminary experiments.

3.2 Determination of physical and mechanical properties of plantain

Prior to the fabrication of the peeler, important physical and mechanical properties of plantain were studied. Plantain having a moisture content of 80±2 percent were graded according to their size for the determination of the properties. The moisture content of plantain was determined as per AOAC(1984) method by placing samples of 5 g in a hot air oven, at 80ºC and dried to constant weight, which took about 24 hours. The moisture content is expressed as percentage wet basis (wb). The experiments were replicated three times and the average value was reported.

$$\text{Moisture content (\% wb)} = \frac{(Wi - Wd)}{Wi} 100 \quad \text{------------------------------------(3.1)}$$

Where,

w_i -initial weight of the plantain, g

w_d- dry weight of the plantain, g

The peel and pulp were weighed to determine the pulp to peel ratio (Kachru, R.P *etal*.,1994). The pulp to peel ratio was computed using the equation given below.

$$\text{Pulp to peel ratio} = \frac{\text{weight of the pulp,g}}{\text{weight of the peel,g}} \quad \text{---(3.2)}$$

The thickness of peel was determined using screw gauge having a least count of 0.001mm. The diameter of the banana with and without peel was recorded using a steel rule. The load required to cut a cross-sectional slice of peel and pulp was found out by texture analyzer.

3.3. Development of a Power Operated Plantain Peeler

A power operated plantain peeler was developed and fabricated in the Kelappaji College of Agricultural Engineering and Technology, Tavanur workshop. It consists of the following components.

1. Feeding unit

2. Peeling unit

3. Pushing unit

4. Collection unit

5. Power transmission assembly

6. Frame assemb

Plate 3.1. Power Operated Plantain Peeler

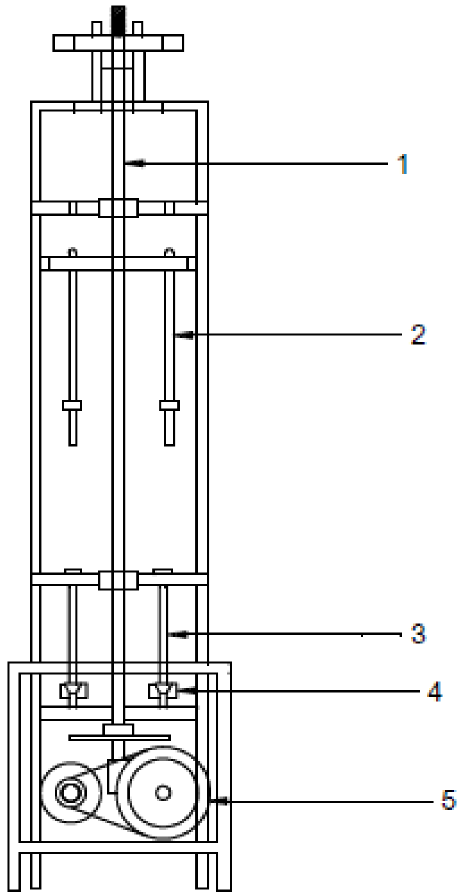
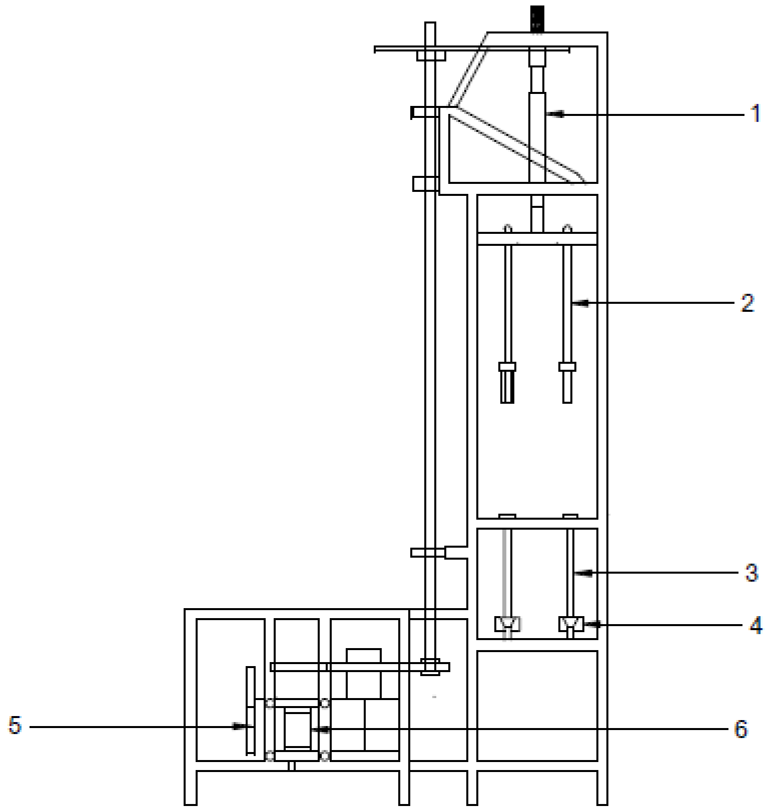


Fig 3.1 Elevation of power operated plantain peeler

1. Screw shaft
2. Pushing rod
3. Feeding cylinder
4. Conical throat and blade
5. Pulley



Fi3.2. Side view of power operated plantain peeler

1. Screw shaft
2. Pushing rod
3. Feeding cylinder
4. Conical throat and blade
5. Pulley
6. Power transmission assembly

3.3.1 Feeding unit

The feeding unit consists of 4 cylindrical guides of different diameters placed 90º apart permanently fixed to a flat plate of 266.7×266.7mm. Four MS hollow cylinders having diameters 44, 47, 47, and 55 mm, height 200 mm and thickness 2 mm were used for the fabrication of cylindrical guide.

3.3.2 Peeling unit

It is the supreme unit of the peeler which separates the peel from the pulp. Four high carbon steel blades of width 25 mm were bent to form circular type openings of diameters 25, 32.5, 32.5 and 40 mm for respective cylindrical guides through which plantain passes during the peeling operation. Each cylindrical guide was connected to an inverted conical throat of 50 mm height and 60 mm base diameter using splitter blades. The peeling blades were welded over these conical throats. Four splitting blades of medium carbon steel with length 50.8 mm and thickness 2 mm was welded over each throat of the peeling unit to split the peel after the peeling operation.

3.3.3 Pushing unit

Pushing rod consists of piston rod, screw shaft and pulley. The lowering and lifting of the piston is achieved by screw shaft mechanism. Screw shaft with outer square threads meshed with cast iron pulley with inner threads. It converts the rotary motion of pulley into linear motion of screw shaft. The length and diameter of the screw shaft are 960 mm and 38 mm, respectively. Also, the width and depth of the screw and the screw pitch are 2 mm, 2 mm and 6 mm, respectively. Screw shaft was meshed through the internally threaded circular passage of rectangular housing, which in turn attached to the peeler arm.

3.3.4 Power transmission unit

Power transmission system was used to transmit power from electric motor to peeling unit. It consists of electric motor, gear box, belt and pulley.

3.3.5 Electric motor

A 1.0 hp single phase reversible electric motor of 1425 rpm was selected as the power source.

3.3.6 Speed reduction gear box

The speed of the plantain peeler was optimized using gear box. The speed reduction gear was connected with motor to reduce the motor speed in the ratio 5:1 rpm.

3.3.7 Belt and pulley

Belt and pulley were used to transmit power from one shaft to another by means of pulleys and belts respectively. 5 V-grooved pulleys (3 pulleys of 150 mm diameter, 200 mm and 50 mm) made up of cast iron were used for power transmission. The diameter of pulley was selected based on optimized speed of the developed machine. The three B-type V-belts made up of rubber material were used for power transmission, which includes two 1000 mm length and 1200 mm lengths, respectively. The length of belt was selected based on centre to centre distance between sheaves and diameters of driver and driven pulleys.

3.3.8 Collection unit

The outlet chute was made of SS sheet with 45º inclination towards the horizontal to facilitates easy discharge. A collecting tray of 270 x 270 x 50 mm was made from SS sheet of 1 mm thickness.

3.3.9 Frame assembly

Main frame was required to support the entire component of the developed machine and to withstand against vibration during the operation. It consists of main frame and a supporting frame. The main frame was fabricated from MS iron square channel having dimensions of 50×50×3 mm for holding peeler assembly and supporting frame bears the power transmission system. The length, width and height of main frame were 270, 270 and 2150 mm, respectively. Gear box and electric motor were assembled on supporting frame using nuts and bolts.

3.4 Performance evaluation of the power operated plantain peeler

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 44, 47,47 and 55 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.

3.4.1 Capacity

The capacity of the peeler is the quantity of plantain peeled by the machine in one hour. It was calculated by noting the weight of the plantain peeled and the time taken for the same. It was expressed in kg/h. A time lag of 10 s was accounted between successive feeding and actual capacity was calculated in kg/h.

3.4.2 Peeling Efficiency

The initial weights of the plantain samples were noted. 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 and the weights were noted. Peeling efficiency was then calculated using the formula.

$$\text{peeling efficiency} = \frac{X-Y}{X}100 \quad \text{--------------------------------(3.3)}$$

Where,

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

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

3.4. 3 Material loss

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

$$\text{material loss (\%)} = \frac{Z}{W+Z} \text{--} \quad (3.4)$$

Where,

Z = Weight of pulp obtained from the peel (g) after mechanical peeling

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

RESULTS AND DISCUSSIONS

Chapter IV

RESULTS AND DISCUSSIONS

This chapter deals with the results of experiments conducted to determine the engineering properties of the raw plantain, N*endran* and performance evaluation of the developed power operated plantain peeler.

4.1 Engineering properties of the raw plantain, *Nendran*

The physical and mechanical properties of the raw matured plantain is presented in Table 4.1. The average peel thickness of plantain was measured as 2.36 mm. The pulp to peel ratio of *Nendran* variety varies between 1.75 and 1.77 with an average value of 1.76. The maximum and minimum diameters for Nendran banana with peel were 40.3 and 23.29 mm, respectively. The corresponding values for without peel were 33.55 and 24.67 mm, respectively. The maximum load required to cut a cross-sectional slice of peel and pulp was 47N and 27 N, respectively.

Table 4.1 Physico-mechanical properties of matured banana (*Nendran* variety)

Sl.no	Properties	Average value
1	Pulp to peel ratio	1.76
2	Peel thickness	236.mm
3	Maximum diameter with peel	40.3mm
4	Minimum diameter with peel	23.29mm
5	Maximum diameter without peel	33.55mm
6	Minimum diameter without peel	24.67mm
7	Maximum load to cut a cross sectional slice of peel	47N
8	Maximum load to cut cross sectional slice of pulp	27N

4.2 Performance Evaluation of Power Operated Plantain Peeler

The performance of the machine is the basic criteria to evaluate its ability. The performance of the developed power operated plantain peeler was evaluated in terms of its capacity, peeling efficiency and material loss.

4.2.1 Capacity

The overall capacity of the developed machine was optimized using three grades of plantain *viz.*, small, medium and large and is shown in Table 4.2, 4.3 and 4.4. The time taken for the peeling operation for all grades of plantain was 35 s. The overall capacity of the machine for 42 mm diameter feeding cylinder varied from 5.98 to 7.15 kg/h with an average value of 6.62 kg/h. Similarly, the overall capacity of the machine for 47mm and 54mm diameter feeding cylinders varied from 12.44 to 14.09 kg/h and 15.07 to 17.45, respectively. The average overall capacities for 42mm, 47mm and 54mm diameter feeding cylinders were estimated to be 6.62, 13.23 and 16.81 kg/h, respectively. Maximum capacity of 16.81 kg/h was obtained using 54 mm diameter feeding cylinder and minimum capacity of 6.62 kg/h for 42 mm diameter feeding cylinder.

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

No	Weight of the plantain(g)	Time taken for peeling (s)	Capacity (kg/hr)
1	65.5	35	6.70
2	62.3	35	6.40
3	68.6	35	7.05
4	66.1	35	6.18
5	61.5	35	6.32
6	58.2	35	5.98
7	69.6	35	7.15
Average capacity			6.62

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

No	Weight of the plantain(g)	Time taken for peeling (s)	Capacity (kg/hr)
1	125.5	35	12.90
2	137.0	35	14.09
3	125.7	35	12.92
4	134.4	35	13.82
5	132.6	35	13.63
6	121.0	35	12.44
7	124.8	35	12.83
Average Capacity			13.23

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

No	Weight of the plantain(g)	Time taken for peeling (s)	Capacity (kg/hr)
1	168.6	35	17.34
2	155.7	35	16.01
3	169.7	35	17.45
4	179.9	35	18.48
5	159.5	35	16.40
6	164.7	35	16.94
7	146.6	35	15.07
Average capacity			16.81

From the table values, it is understood 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 weight of the plantain increases with diameter and the time taken for peeling operation was constant for every plantain.

4.2.2 Peeling efficiency

The peeling efficiency of the machine was estimated using the formula given in 3.3 The peeling efficiency of the machine using 42, 47 and 54 mm diameter feeding cylinder are presented in Table 4.5, 4.6and 4.7. The peeling efficiency of the machine using 42 mm diameter feeding cylinder varied from 95 to 98 per cent with an average value of 96.65 percent. Similarly the peeling efficiency for 47 and 54 mm diameter feeding cylinder varied from 90.38 to 94.94 percent and 89.50 to 92.72 with an average values of 92.93 and 91.20 percent, respectively.

Table 4.5 Peeling efficiency of plantain peeler(42mm diameter feeding cylinder)

Sl No	**Weight of the peel(g) X**	**Weight of peel remain on the plantain after peeling(g) Y**	**Peeling efficiency(%) (X-Y/X)×100**
1	67.9	1.5	97
2	146.6	5.6	96
3	103.4	1.9	98
4	68.0	3.4	95
5	73.5	3.1	95.5
6	62.9	1.2	98
7	101.6	2.9	97.1
Average Peeling Efficiency			96.65

Table 4.6 Peeling efficiency of plantain peeler (47mm diameter feeding cylinder)

No	Weight of the peel(g) X	Weight of the peel remain on plantain after peeling(g) Y	Peeling efficiency(%) (X-Y/X)×100
1	112	6.2	94.46
2	90.3	5.6	93.79
3	95.7	9.2	90.38
4	93.3	7.1	92.39
5	60.3	5.1	91.54
6	77.7	5.4	93.05
7	102.8	5.2	94.94
Average Peeling Efficiency			92.93

Table 4.7 Peeling efficiency of plantain peeler(54mm diameter feeding cylinder)

No	Weight of the peel(g) X	Weight of the peel remain on plantain after peeling(g) Y	Peeling efficiency(%) (X-Y/X)×100
1	61.9	5.3	91.43
2	54.9	4.2	92.34
3	78.0	7.1	90.89
4	78.1	8.2	89.50
5	94.0	7.5	92.02
6	61.2	6.4	89.54
7	74.2	5.4	92.72
Average Peeling Efficiency			91.20

From the results it was clear that there is no significant variation in the efficiency of peeling operation with respect to the diameter of feeding cylinder. For a particular cylindrical guide, peeling efficiency increases if the plantain correctly fits into the feeding cylinder. Peeling efficiency was lowered for curved shaped plantains. From the results, it is understood that proper grading should be done before peeling for enhancing the peeling efficiency.

4.2.3 Material loss

The material loss of the plantain during peeling was calculated using the formula given in 3.4 and the results of the study is presented in Table.4.8,4.9,4.10. The material loss of plantain using 42 mm diameter feeding cylinder varied from 6.31 to 7.32 per cent with a mean value of 6.8 percent. Similarly, the material loss of plantain for 47 and 54 mm diameter feeding cylinder varied from 3.99 to 9.71 percent and 7.39 to 9.63 percent, respectively. Maximum material loss of plantain was observed for 54mm diameter feeding cylinder and minimum for 44 mm diameter feeding cylinder.

Table 4.8 Material loss (44mm diameter feeding cylinder)

No	Weight of the peeled plantain(g) W	Weight of pulp obtained from the peel(g) Z	Material loss(%) (Z/W+Z)×100
1	65.5	4.7	6.69
2	62.3	4.2	6.31
3	68.6	5.1	6.91
4	66.1	5.2	7.29
5	61.5	4.1	6.25
6	58.2	4.3	6.88
7	69.6	5.5	7.32
Average Material Loss			6.80

Table 4.9 Material loss (47mm diameter feeding cylinder)

No	Weight of the peeled plantain(g) W	Weight of the pulp obtained from peel(g) Z	Material loss(%) (Z/W+Z)×100
1	125.5	13.5	9.71
2	137.0	14.8	9.74
3	105.7	4.4	3.99
4	134.4	13.7	9.25
5	112.6	6.9	5.77
6	121.0	12.4	9.29
7	124.8	12.9	9.36
Average Material Loss			8.15

Table 4.10 Material loss (54mm diameter feeding cylinder)

No	Weight of the peeled plantain(g) W	Weight of the pulp obtained from peel(g) Z	Material loss(%) (Z/W+Z)×100
1	168.6	15.2	8.26
2	155.7	12.6	7.48
3	169.7	18.1	9.63
4	170.3	13.6	7.39
5	179.9	18.5	9.32
6	164.7	11.6	6.57
7	146.6	14.2	8.83
Average Material Loss			8.21

From the values, it is revealed that the material loss depends on the shape and size of the plantain. For a particular feeding cylinder, it was found that the percent material loss increases with weight of the plantain. This may be due to the constant size of the circular peeling blade.

Plate 4.1 Plantain after mechanical peeling

4.3 Comparative evaluation of manual and mechanical peeling

Table 4.11 Comparison of manual and mechanical peeling

Sl No	**Total time required for peeling 1kg plantain (s)**	
	Manual	**Mechanical**
1	146	35
2	147.6	35
3	144	35

A comparison of manual and mechanical peeling is presented in table 4.11. From the table it is observed that a skilled labour can peel nearly 25 kg of of plantain in one hour whereas the power operated plantain peeler could peel 105 kg in one hour. The peeling capacity of the developed machine is found to be four times more effective than manual peeling .This machine eliminates the drudgery involved in manual peeling 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

Banana is one of the major and economically important fruit crops in India. It contributes nearly 37 per cent of the total fruit production in India. India is the largest producer of banana in the world followed by China and Philippines. The annual production of banana in India during 2013-14 was 26.5 MT from an area of 7.7 L ha with a productivity of 34 T/ha. Banana is used as 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. Plantains are usually processed into chips and the peel is used in the preparation of pickles. Among the banana varieties *viz., robusta, nendran, dwarf cavendish, poovan etc, nendran* variety is mostly preferred for making chips. Banana wafer is a popular snack food in South India especially in Kerala. Commercial chips manufacturing process involves four unit operations such as peeling, slicing to small wafers, frying and packaging. At present, peeling of plantain is done by traditional methods using stainless steel knives. This conventional method poses danger to operator's finger by inflicting injury. The output capacity of the system is less and the whole process is time consuming and labour intensive. Hence, an attempt was made at Kelappaji College of Agricultural Engineering and Technology, Tavanur to develop a power operated plantain peeler.

Prior to the fabrication of the peeler, important physical and mechanical properties of plantain were studied. The plantains having a moisture content of 80±2 percent were graded according to their size for the determination of properties. The moisture content of plantain was determined as per AOAC (1984) method by placing samples of 5 g in a hot air oven, at 80ºC and dried to constant weight, which took about 24 hours. The peel and pulp were weighed to determine the pulp to peel ratio. The thickness of peel was determined using screw gauge having a least count of 0.001mm. The diameter of the banana with and without peel was recorded using a steel rule. The load required to cut a cross-sectional slice of peel and pulp was found out by texture analyzer.

Power operated plantain peeler consists of 1. Feeding unit 2. Peeling unit 3. Pushing unit 4. Collection unit 5. Power transmission assembly 6. Frame assembly.

The feeding unit consists of 4 cylindrical guides of different diameters placed 90º apart permanently fixed to a flat plate of 266.7×266.7mm. Four MS hollow cylinders having diameters 44, 47, 47, and 55 mm, height 200 mm and thickness 2 mm were used for the fabrication of cylindrical guide.

Peeling unit separates the peel from the pulp. Four high carbon steel blades of width 25 mm were bent to form circular type openings of diameters 25, 32.5, 32.5 and 40 mm for respective cylindrical guides through which plantain passes during the peeling operation. Pushing rod consists of piston rod, screw shaft and pulley. The lowering and lifting of the piston is achieved by screw shaft mechanism. Screw shaft with outer square threads meshed with cast iron pulley with inner threads. It converts the rotary motion of pulley into linear motion of screw shaft. A 1.0 hp single phase reversible electric motor of 1425 rpm was selected as the power source. The speed of the plantain peeler was optimized using gear box. The speed reduction gear was connected with motor to reduce the motor speed in the ratio 5:1 rpm. Belt and pulley were used to transmit power from one shaft to another by means of pulleys and belts respectively. 5 V-grooved pulleys (3 pulleys of 150 mm diameter, 200 mm and 50 mm) made up of cast iron were used for power transmission. The outlet chute was made of SS sheet with 45º inclination towards the horizontal to facilitates easy discharge. A collecting tray of 270 x 270 x 50 mm was made from SS sheet of 1 mm thickness.

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 44, 47,47 and 55 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.

The results of the experiments are summarized as follows,

The average peel thickness of plantain was measured as 2.36 mm. The pulp to peel ratio of *Nendran* variety varies between 1.75 and 1.77 with an average value of 1.76. The maximum and minimum diameters for Nendran banana with peel were 40.3and 23.29 mm, respectively. The corresponding values for without peel were

33.55 and 24.67 mm, respectively. The maximum load required to cut a cross-sectional slice of peel and pulp was 47N and 27 N, respectively.

The overall capacity of the machine for 42 mm diameter feeding cylinder varied from 5.98 to 7.15 kg/h with an average value of 6.62 kg/h. Similarly, the overall capacity of the machine for 47mm and 54mm diameter feeding cylinders varied from 12.44 to 14.09 kg/h and 15.07 to 17.45, respectively. The average overall capacities for 42mm, 47mm and 54mm diameter feeding cylinders were estimated to be 6.62, 13.23 and 16.81 kg/h, respectively. Maximum capacity of 16.81 Kg/h was obtained using 54 mm diameter feeding cylinder and minimum capacity of 6.62 kg/h for 42 mm diameter feeding cylinder. It is understood 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 weight of the plantain ncreases with size and the time taken for peeling operation was constant for all sizes of plantain.

The peeling efficiency of the machine using 42, 47 and 54 mm diameter feeding cylinder are presented in Table 4.5, 4.6 and 4.7. The peeling efficiency of the machine using 42 mm diameter feeding cylinder varied from 95 to 98 percent with an average value of 96.65 percent. Similarly the peeling efficiency for 47 and 54 mm diameter feeding cylinder varied from 90.38 to 94.94 per cent and 89.50 to 92.72 with an average values of 92.93 and 91.20 percent, respectively. From the results it was clear that there is no significant variation in the efficiency of peeling operation with respect to the diameter of feeding cylinder. For a particular cylindrical guide, peeling efficiency increases if the plantain correctly fits into the feeding cylinder. Peeling efficiency was lowered for curved shaped plantains. From the results, it is understood that proper grading should be done before peeling for enhancing the peeling efficiency.

The material loss of plantain using 42 mm diameter feeding cylinder varied from 6.31 to 7.32 per cent with a mean value of 6.8 percent. Similarly, the material loss of plantain for 47 and 54 mm diameter feeding cylinder varied from 3.99 to 9.71 percent and 7.39 to 9.63 percent, respectively. Maximum material loss of plantain was observed for 54mm diameter feeding cylinder and minimum for 44 mm diameter feeding cylinder.

It is observed that the material loss depeds on the shape and size of the plantain. For a particular feeding cylinder, it was found that the percent material loss increases with weight of the plantain. This may be due to the constant size of the circular peeling blade.

A comparison of manual and mechanical peeling was conducted. It is observed that a skilled labour can peel approximately 25 kg of plantain in one hour whereas the power operated plantain peeler could peel 105 kg in one hour. The peeling capacity of the developed machine is found to be four times more effective than manual peeling .This machine eliminates the drudgery involved in manual peeling and saves time. The machine is simple in construction and operation and requires only one person to operate it.

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APPENDICES

APPENDIX I

CALCULATION OF OPERATING COST

Initial cost (C)

Fabrication cost of plantain peeler

including cost of material = Rs.22,000

Average life of machine = 10 years

Working hours per year = 4000

Salvage value = 10 % of initial cost

A) Fixed cost

1. Depreciation $= \frac{C-S}{LH}$

$= \frac{22000-2200}{10\times4000}$

$= 0.495$

2. Interest on investment@ 12% $= \frac{(C+S)\times12}{2\times H\times100}$

$= \frac{(22000+2200)\times12}{2\times4000\times100}$

$= 0.363$

Total fixed cost = 0.858

B) Variable cost

1. Labour wages

Wages of labour = Rs.550 / day of 8 h

2. Cost of electrical energy

Unit cost of electricity = Rs 7 / kwh

Energy consumption of machine = 0.828kwh

Cost of electricity = Rs 5.796/h

3. Repair and Maintenance cost

@ 10% of initial cost p.a. = $\frac{22000 \times 10}{4000 \times 100}$

= 0.55/h

Total variable cost = 75 . 096 / h

Total operating cost = 75.954 / h

APPENDIX II

SPECIFICATIONS OF THE MACHINE

Weight of the machine =80 kg

Dimensions of the feeding cylinder

Sl no.	Inner diameter (mm)	Thickness (mm)	Length (mm)
1	44	2	200
2	47	2	200
3	47	2	200
4	55	2	200

Dimensions of the pushing rod

Sl no.	Diameter (mm)	Length (mm)
1	14	70
2	16	70
3	16	70
4	18	70

Dimensions of blade

Sl.no	Diameter (mm)	Width (mm)
1	25	25
2	33	25
3	33	25
4	40	25

DEVELOPMENT AND PERFORMANCE EVALUATION OF POWER OPERATED PLANTAIN PEELER

By

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ABSTRACT

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IN

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Faculty of Agricultural Engineering and Technology

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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING & TECHNOLOGY

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2017

ABSTRACT

Title of Project work: Development and Performance Evaluation of Power Operated Plantain Peeler

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Banana cultivation is one of the most popular agricultural practices in India. It is a rich source of magnesium, vitamin C, dietary fiber, riboflavin, niacin, iron etc. Many varieties of banana like *robusta, dwarf Cavendish, poovan, nendran* etc are cultivated in India. The green banana which becomes palatable after cooking is popularly referred as plantains. They are usually processed into chips. Among the banana varieties, *nendran* variety is mostly preferred for making chips. At present, peeling of plantain is done manually and no means of mechanical peeling device has been commercialized till now. The conventional method of peeling 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 fabrication of the peeler, important physical and mechanical properties of plantain were studied. Matured plantains, having a moisture content of 80±2 percent were graded according to their size for the determination of engineering properties. The peel and pulp were weighed to determine the pulp to peel ratio. The thickness of peel was determined using screw gauge having a least count of 0.001mm. The diameter of the banana with and without peel was recorded using a steel rule. The load required to cut a cross-sectional slice of peel and pulp was found out by texture analyzer. The average peel thickness of plantain was measured as 2.36 mm. The pulp to peel ratio of *Nendran* variety varies between 1.75 and 1.77 with an average value of 1.76. The maximum and minimum diameters for Nendran banana with peel were 40.3and 23.29 mm, respectively. The corresponding values for without peel were 33.55

and 24.67 mm, respectively. The maximum load required to cut a cross-sectional slice of peel and pulp was 47N and 27 N respectively. Power operated plantain peeler consists of feeding unit, Peeling unit, Pushing unit, Collection unit, Power transmission assembly and frame assembly. 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 44, 47,47 and 55 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 capacity of the peeler was estimated as 6.62, 13.23 and 16.81 kg/h, respectively for small, medium and large size plantains. Similarly, the material loss and peeling efficiency for small, medium and large size plantains were calculated as 6.8, 8.15, 8.21 percent and 96.7, 92.9, 91.2 percent, respectively. The peeling capacity of the developed machine is found to be four times more effective than manual peeling. This machine eliminates the drudgery involved in manual peeling and saves time.