Performance and evaluation of modified rotary banana slicer

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PROJECT REPORT

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TAVANUR- 679 573, MALAPPURAM (Dt)

KERALA, INDIA

2015

DECLARATION

We hereby declare that this project report entitled **''PERFORMANCE AND EVALUATION OF MODIFIED ROTARY BANANA 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, associate ship, fellowship or other similar title of another University or Society.

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Date :

CERTIFICATE

Certified that this project work entitled **"PERFORMANCE AND EVALUATION OF MODIFIED ROTARY BANANA SLICER"** is a record of project work done jointly by Athira A.S.,Cinu Varghese.,and HarithaMohanan under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship or other similar title of another University or Society.

Dr. Sudheer K.P
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Place: Tavanur

Date :

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Athira A.S.

Cinu Varghese

HarithaMohanan

Dedicated to our parents

And

The God Almighty…

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SYMBOLS AND ABBREVIATIONS

%	Percentage
< l	Less than
=	Equal to
±	Plus or minus
≤	Less than or equal to
%D	Percentage damage
A.C	Alternating current
C.E	Coefficient of expansion
cm	Centimeters
C.S	Cross section
C.V	Coefficient of variation
D.C	Direct current
E.C	Effective capacity
et al.,	And others
F&APE	Food & Agricultural Process Engineering
Fig.	Figure
g	Gram
H.P	Horse power
ha	Hectare
hrs	Hours
i.e.	That is
KAU	Kerala Agricultural University
KCAET	Kelappaji College of Agricultural Engineering and Technology
kg	Kilogram
M	Million

mg	Milligram
min	Minute
mm N	Millimeter
O.C	Newton
ppm	Overall capacity
rpm	Parts per million
SS	Revolution per minute
TNAU	Stainless steel
	Tamilnadu agricultural university

Introduction

Chapter 1

INTRODUCTION

Fruits and vegetables are very important food commodities. India has become the largest producer of fruits and the second largest producer of vegetables. Though the production of fruits and vegetables make us believe in our strength for self-sufficiency, a significant qualitative and quantitative loss occurs in the produce from harvest till consumption. For self - sufficiency and also for processing, export and to meet additional requirements, a lot of emphasis need to be given to reduce post - harvest losses, besides increasing production and productivity of horticultural produces.

Banana (*Musa sp.*),adessert fruit for millions, is used in different regions as staple food owing to its rich and easily digestible carbohydrates. At global level, it is largely produced in tropical and subtropical regions of developing countries and is recognised to be an important food crops in terms of gross value. Banana cultivation is distributed among the warmer countries between 30˚ south and 30˚ north of the equator. It is a rich source of vitamins and several minerals such as, calcium, magnesium, potassium, and phosphorus.Due to its abundant year-round availability and nutritional value, is the largest produced and maximum consumed among the fruit cultivated in India.

	Percent		mg.
Moisture	70.0	Phosphorus	36.0
Carbohydrate	27.0	Calcium	17.0
Crude fibre	0.5	Iron	0.9
Protein	1.2	Vitamin C	7.0
Fat	0.3	Calorific value	116.0
Ash	0.9	Ascorbic acid	120.0 ppm
		Riboflavin	0.5 ppm

Table 1.1 Average composition of the banana (per 100 g edible portion)

India ranks first among the banana cultivating countries in the world with an annual production of 23.2 million tonnes from an area of 0.64 million hectares and India's share of banana production is 29% among the ten major banana producing countries of the world. (Indian horticulture data base, 2008).Banana covers 13% of the total area under the total fruit area contributing nearly one third of total fruit production in the country.The highest productivity among fruits with 29780 million tonne and 35.9 million tonnes/ha respectively (NHB,2011).The highest productivity noted was 65.8 million tonne/ha in Tamil Nadu followed by Maharashtra (52.5milliontonne/ha) in the year 2010-2011(NHB,2011).Bananas are highly perishable and bulky which makes their transportation to distant and export market expensive. In India the processed banana product widely manufactured on a commercial scale is chips. Processing of banana into chips is one of the ways to reduce the post - harvest losses of this crop.

STATES/UT'S	AREA(000'ha)	PRODUCTION(000 M)
Andaman Nicobar	1.6	14.9
Andhra Pradesh	80.6	2819.6
Arunachal Pradesh	5.4	13.3
Assam	53.4	805.2
Bihar	31.5	1435.3
Chhattisgarh	11.5	296.3
D & N Haveli	0	1.2
Goa	2.3	25.1
Gujarat	61.9	3779.8
Himachal Pradesh	0.1	0.3
Jharkhand	2.9	58
Karnataka	104.4	2132.3
Kerala	51.3	406.2
Madhyapradesh	33	1459.8
Maharashtra	85	5200
Manipur	4	33.7

Meghalaya	7	82.8
Mizoram	8.7	207.7
Nagaland	6.3	62.7
Orissa	24.7	400.4
Pondicherry	0.5	17.1
Punjab	0.1	5.8
Rajasthan	0	0.8
Sikkim	1.6	3.2
Tamil Nadu	113.7	4980.9
Tripura	7.5	105.6
Uttar Pradesh	30.4	1138.6
West Bengal	41	982.2
Total	770.3	26469.5

Table 1.2 Area and production of banana in India (2012-13)

Banana chips as snack food is very popular in south India, especially in Kerala because of its crispness. Traditional methods of processing bananas in most countries involve making the un-ripened bananas into chips, drying and storing as a famine food. Banana chips making involves four major units operations namely peeling of fruits, cutting of fruits into slices, frying and packaging. Each of these unit operations are done manually especially due to the lack of appropriate mechanical system. This is perhaps one of the main reasons for the banana chip making not emerging as the large scale industry.

Chipping is carried out to reduce the size of the product to suit processing and consumer requirements.However this operation is very difficult and time consuming. At present the chip are made by hand peeling raw banana and slicing the pulp portion in a wooden platform type slicer with mild steel blades and then deep frying in edible oil. The method is unhygienic and does not produce chips of uniform thickness and may cause injury to the operator while slicing. The output of the conventional method with one person peeling and another person slicing has been found to be around 50-70 kg of fried wafers /day. Therefore the operating cost works out to the Rs.0.30/kg of wet slice. Keeping in view, the wide scope and popularity of this banana chips making industries several machineries have been developed for slicing banana. Hence there is a need to develop a new model of banana slicer which can complete with manual slicing both in speed and quality. The new slicer could be efficiently used in both small and large scale industries for slicing bananas withenhanced capacity and slicing efficiency and reduce the drudgery in making chips.

With this point of view, a project was undertaken at Kelappaji College of Agricultural Engineering And Technology, Tavanur to develop a rotary banana slicer with the following objectives:

1. Study of existing models for slicing of banana for the preparation of chips.
2. Development of a rotary banana slicer, in terms of operators comfort,weight of machine, easiness of cleaning, capacity, versatility to use other vegetables etc.
3. Performance and evaluation of the rotary banana slicer in terms of various thickness, capacity, slicing efficiency, coefficient of expansion of the fried chips.

Review of Literature

Chapter 2

REVIEW OF LITERATURE

This chapter deals with the comprehensive review of the research work done by various research workers related to present studies that case the general information and banana if engineering properties viz. Nendran and different slicers used for slicingvegetables and fruits.

2.1 Banana *(Musa paradisiaca*)

2.1.1 History and distribution

Historical reports suggest banana as a native of the Papua, New Guinea. Bananas are a common herbaceous plant of the genus Musa (Arvanitoyannis, Mavromatis *etal*., 2008).Many species of bananas were traded over the last few centuries, and bananas are now cultivated in more than 100 countries around the world (Arvanitoyannis,*etal.*, 2008).Among all the production countries, India, Brazil, Ecuador,Philippines and China are the top five banana producers in the world(FAOSTAT,2012).Major banana producing states in India are Tamil Nadu, Maharashtra, Karnataka, Kerala, Gujarat, Andhra Pradesh, Assam and Madhya Pradesh. Among this Tamil Nadu is the major banana producing state with 125.4 ha cultivating area and a productivity of 65.8 million tonne per hectare (NHB, 2011).

2.1.2 Botanical aspects

Banana plants are mono cotyledonous perennial and important crop in the tropical and sub-tropical world region (Valmayor et al., 2000).Banana fruits grow in clusters hanging from the top of the plant.The fruit is variable in size, colour and firmness, but is usually elongated and curved with soft flesh rich in starch covered with a rint which may be green, yellow, red, purple or brown when ripe.Depending up on cultivar and ripeness, the flesh can vary in taste from starchy to sweet, a texture from firm to mushy. Both the skin and inner part can be eaten raw or cooked.The bananas flavour is due, amongst other chemicals to isoamayl acetate which is one of the main constituents of banana oil.The fruit is usually harvested at its mature but unripe stage ripens within two to 7 days, thus making plantain a highly perishable crop, particularly in the over ripe stage(Robinson,1996).During the ripening process, bananas produce the gas ethylene, which acts as a plant hormone and in directly affect the flavour. Among other things, ethylene stimulates the formation of amylase, an enzyme that breaks down starch into sugar,influencing the taste of bananas. The greener, less ripe bananas contain higher levels of starch and, consequently have a “starchier” taste. On the other hand, yellow bananas taste sweeter due to higher sugar concentrations. Furthermore, ethylene signals the production of pectinase an enzyme which breaks down the pectin between the cells of the banana, causing the banana to soften as it ripens (Ogazi, 1992).

2.2 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,NanaNendran,Thiruvodan,Nedunendran,Chengazhikodan,Kudiravali,Valethan,Keletha n and Myndoli.It is known as plantain in most parts of the world. Nendran fruit is large and it represents the biggest sized edible fruit in India. The fruits are loosely packed in bunch, flesh in firm and starchy. The fruit has fairly good keeping quality and can be used for both culinary purpose and as desert.

Kacharu *et al*., (1994) studied the physical and mechanical properties of the Nendran. The average values of physical and mechanical properties of Nendran shown in Table 2.1

No	**Properties**	
1	Maximum diameter	37.08 mm
2	Maximum length	194.50mm
3	Maximum width	50.00mm
4	Average weight of single fruit	201.43gm
5	Average pulp/peel ratio	2.32
6	Average specific gravity	1.005
7	Maximum load required to cut	28.20N
8	Cutting load per unit width	0.821N/mm

Table 2.1 Physical and mechanical properties of Nendran

2.3 Slicing

Slicing is a cutting process for size reduction of fruits and vegetables; it involves pushing or forcing a thin, sharp knife to shear through the material. The result gives minimum deformation and rupture of the cell wall. Chipping or slicing of banana in to thin wafers of about 1.5 -2.0 mm thick is one of the important unit operations in plantain processing. The quality of chips depends up on 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.

2.4Traditional methods

The most widely practised 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.

2.5Mechanical method

Nandha (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 disc at the bottom of it carries 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.

Balasubramanian *et al.,* (1993) developed and evaluated a motorised cassava chipper. The machine consisting 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 270kg/hr. The chip recovery was assessed at 92% for 1mm chips at 295rpm.The cost of chipping were estimated at Rs.18/t.

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 the 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 223kg peeled raw bananas per hour.

Dayana Paul *et al*., (2007) develop 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 can produce slices at capacity 6 times higher than manual slicing.

Sonawane *et al., (*2011*)* constructed a power operated rotary banana slicer suitable for small scale processing was developed. This banana slicer mainly consists of feeders for round slicing cutter, power transmission mechanism, base support and frame. The slicer has slicing efficiency of about a 93-94% with effective capacity of about 100 kg per hour.

Motor operated rotary banana slicer Model I has developed in Kelappaji College of Agricultural Engineering And Technology, Tavanur.The banana was sliced by horizontal rotary disc fitted with stainless steel blades, which rotates in a vertical axis. The slices falling from the slicer was conveyed to the discharge chute /outlet by gravitational force. A uniform discharge is ensured by the banana slicer without sticking the slices to the discharge chute. The slicer has an effective capacity of 100 -110kg/hr.

An improved banana slicer Model II has developedKelappaji Collegeof Agricultural Engineering And Technology, Tavanur intending to overcome the defect in the first model. The components of the slicer are same with variations in assembling the components and type used for fabricating. The weight of the second model is reduced by 5kg and the performance of the blade was improved. However continuous feeding and cleaning was lacking in this model. The slicer has an effective capacity of 100-110 kg /hr.

Balakrishna Engineering developed a commercial banana slicer. It is simple to operate are easy to clean. The effective capacity is estimated at 80-90 kg/hr. Available blade size ranging from 1.2 -10 mm. It’s versatile and it can be used for slicing beetroot, potato, and lady’s finger. Silent motor of half H.P is used.

Materials and Methods

Chapter 3

MATERIALS AND METHODS

This chapter deals with the methodology adopted for satisfying the objectives for the fabrication procedure of the rotary banana slicer the details of the components and the procedure adopted for evaluation are described in this.

3.1 Study of existing models for banana slicing

Prior to the development of rotary banana slicer with existing model used for slicing banana are studied. Attempts were made to develop 3 models of mechanical slicer for banana. Each model was developed by improving the effectiveness slicing in terms of operator’s comfort, weight of machine, easiness of cleaning, capacity,versatility to use other vegetables etc.The details of the three models developed are given in the following sections.

3.2Development of motorised rotary banana slicer Model-I

A motor operated rotary banana slicer Model-I was developed.The developed banana slicer consists of feed chute, rotary disc with blades,guiding rod, cleaning mechanism, outlet, power transmission unit and main frames to support these components. The mature banana after hand peeling was fed through feed chute at a uniform rate. The banana was sliced by horizontal rotary disc fitted with stainless steel blades, which rotates in a vertical axis. The slices falling from the slicer was conveyed to the discharge chute/outlet by gravitational force. A uniform discharge is ensured by the banana slicer without sticking the slices to the discharge chute.

3.2.1Feed chute

The feed chute was designed to facilitate the continuous feeding of banana in to the rotary disc with four cylindrical feeding hoods forholding the banana vertically. It was made of stainless steel (SS) 304 with cross section oval shape, length of 7cm and breadth of 5cm. The cylindrical hood was supported with two spring holder mechanism made of SS 304 with length and breadth of 20 and 3.5cm. The cross section was curved to hold banana vertically throughout slicing.

3.2.2Rotary disc with blades

The rotary disc was made of SS304 and was fitted with two cutting blades made out of food grade stainless steel. The shape of the blade was straight and plain with length of 9.5cm breadth of 2.5cm and thickness 4mm. The diameter of the rotary disc was 30cm and thickness 5mm. Screws were used to fit the cutting blades to disc. There are two spring supported knobs under the rotating disc to adjust the thickness of sliced banana.

3.2.3Guiding rod

A guiding rod was provided along with rotary disc and was fitted by means of springs at sides of cylinder. Guiding rod moves downward while slicing. Length of the guiding rod was 30cm and made of SS.The main purpose of this guiding rod was to drive banana straightly in to the cylinder. The rod is removable and could be cleaned easily.

3.2.4Housing and main frame

Housing of banana slicer was made of iron with double bearing system. Length and breadth of housing was 10cm and 5.5cm diameter. The main frame was fabricated using iron with length 80cm and weighs 25kg. The slicing section and motor were attached with iron rod. The rotary banana slicer was stationary without tilting arrangement.

3.2.5Cleaning mechanism

Two round pipe rotating brushes were mounted on a spring loaded fixture placed at the bottom on any one side of the rotary disc. The sponge arrangement was provided to keep the cutting blades clean.

3.2.6Power Transmission

The power was transmitted from ½ H.P.AC motor to shaft. The motor was variable speed motor. Adjustment can be for speed of the motor. The banana slicer was tested with different speed of motor. It was found that the thickness varied at different speed. Increase in rpm speed of the motor decreases the thickness of slices.

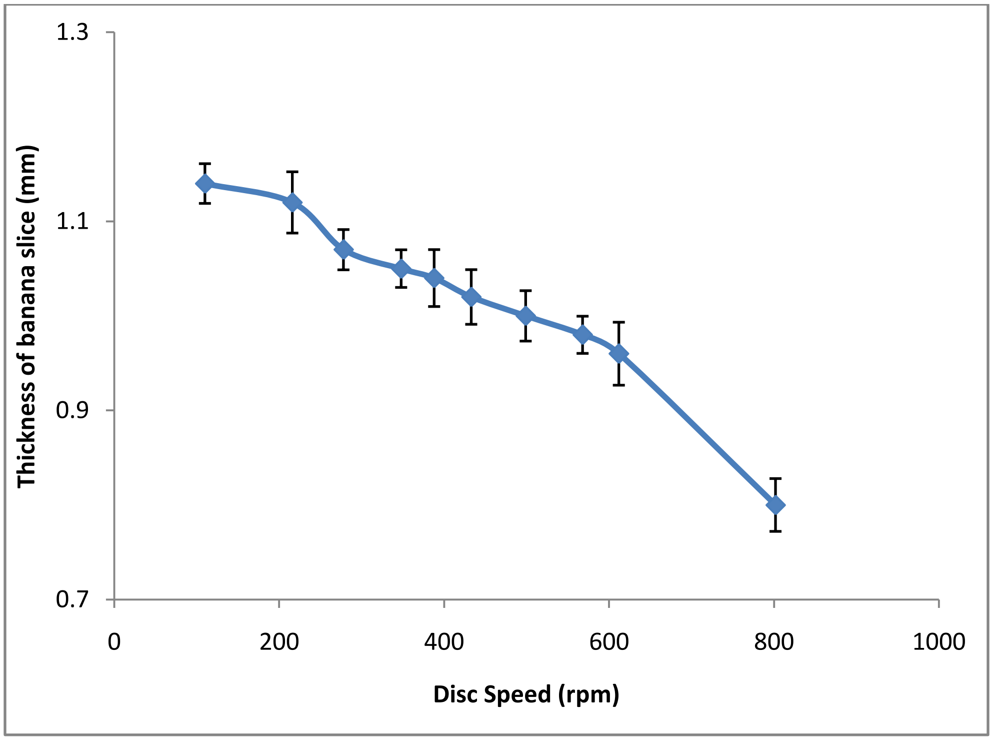
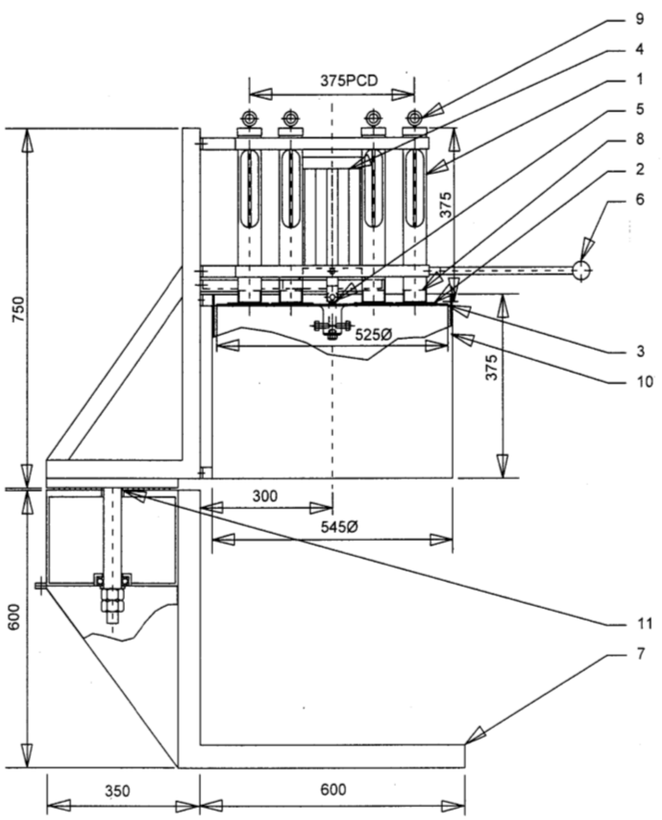


Figure 3.1 Graph showing speed of motor Vs thickness of slices

The banana slicer was tested with different speed of motor. It was found that the thickness varied at different speed. Increase in rpm speed of the motor decreases the thickness of slices. The thickness of banana slices decreased from 1.15 mm to 0.85 mm as the speed increased from 100 to 800 rpm. However the average thickness of 1 mm was maintained between 300 to 600 rpm.



1.SS pipe 50mm
2. SS blade
3. SS base plate for fixing blades
4. Motor
5. Roller
6. Handle for swing aside
7. Frame
8. Counter weight
9. Lever for counter weight
10. Aluminium cover
11. Bearing

Figure 3.2 Front view of the rotary banana slicer Model – I

3.3Motorized rotary banana slicer Model- II

An improved rotary banana slicer Model- II was developed intending to overcome the defects in Model-I. The components of the slicer were same with variations in assembling the components and type used for fabricating.

3.3.1 Feed Chute

The feed chute was designed was same as that of Model I with continuous feeding of banana into the rotary disc with four cylindrical feeding hoods for holding banana vertically. It was made of Stainless steel (SS) 304 with oval shape cross section with length of 7 cm and breadth of 5 cm. The cylindrical hood was supported with two spring holder mechanism made of SS 304 with length and breadth of 20 and 3.5 cm. The cross section was curved to hold the banana vertically.

3.3.2 Rotary Disc with Blades

The construction of rotary disc was similar to Model-I with same measure of length and breadth.The thickness was reduced by 1 mm from previous model and thickness was 4 mm for this rotary disc. The blade thickness was also reduced to 3 mm. The other specifications of bade were unaltered. Under the rotating disc there are two spring supported knobs to adjust the thickness of the sliced banana.

3.3.3 Guiding rod

The shape of guiding rod was remodelled from circular to square and was fitted by means of groove. It moves downwards during slicing operation. The length of guiding rod was 30 cm and made of SS. The side of the guiding rod was measured as 1.5 cm.

3.3.4 Housing and Stand

The material made for housing of slicer was changed to SS for its light weight comparable to iron. Length was same and breadth was shortened to 4.5 cm. The machine was mounted to stand made of galvanized iron with length of 80 cm. The weight of stand was cut down by 5 kg of earlier model and it was 20 kg. Unlike the first model here the slicing section can be moved to and fro with stand. This tilting arrangement will be useful for the processors to place the frying pan directly below the slicer. The cleaning mechanism was similar to that of Model- I.

3.3.5Power Transmission

The power was transmitted from the ½ H.P. DC motor with transformer. The rpm of the shaft was 600.

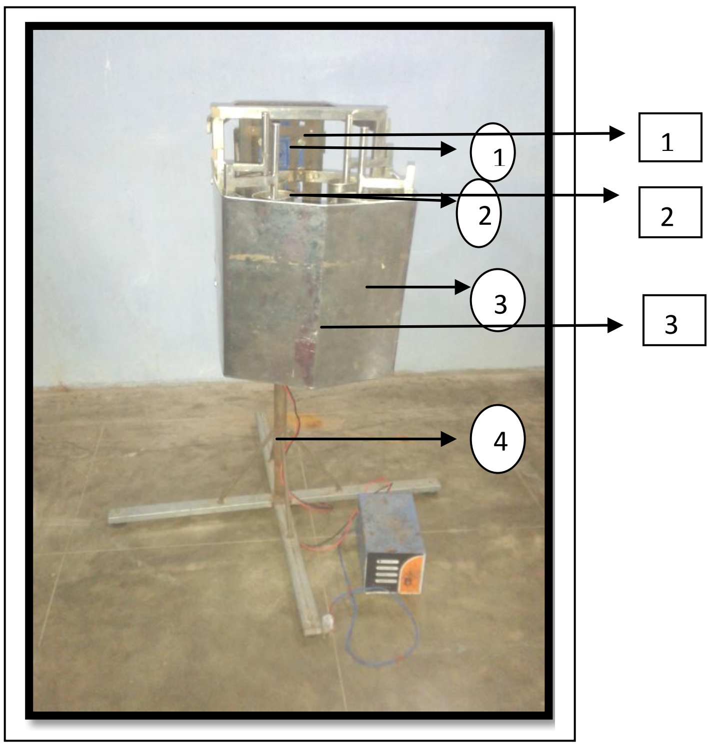


Figure 3.3 Rotary banana slicer Model – I

3.4Motorised rotary banana slicer Model - III

In the third model rotary banana slicer Model III was fabricated in such a way it's suitable for all size and shape of banana and thickness of slice was adjustable according to desired thickness of consumer. The variable speed motor provides an adjustable speed of slicing. Continuous feeding was possible through two stainless steel chutes which have spring loaded curved holding discs to hold the peeled banana straight. An oil coated flexible brush cleans the cutting edge by wiping away the banana sap released on cut surface. A tilting arrangement was provided to stand which helps the sliced banana to fall directly into frying pan.

3.4.1 Feed Chute

The feed chute was fabricated similar to that of Model-II with continuous feeding of banana into the rotary disc. In case of the third model only two cylindrical feeding chutes are provided to hold banana as feeding of four chutes are difficult by a single operator. The balance space over the disc was utilized for a bigger cylindrical chute, which can be utilized for slicing other tubers/ vegetables.

3.4.2 Guiding rod

The shape of guiding rod was remodelled from circular to square and was fitted by means of groove. It moves downwards during slicing operation.

Fig:3.4 Guiding rod

3.4.3 Rotary Disc with Blades

The shape of blades in the rotary disc was changed to semi-circular with diameter 9.5 cm and 3 mm thickness. Semi-circular blades showed better cutting efficiency than straight blades. There was no change in the construction of guiding rod.

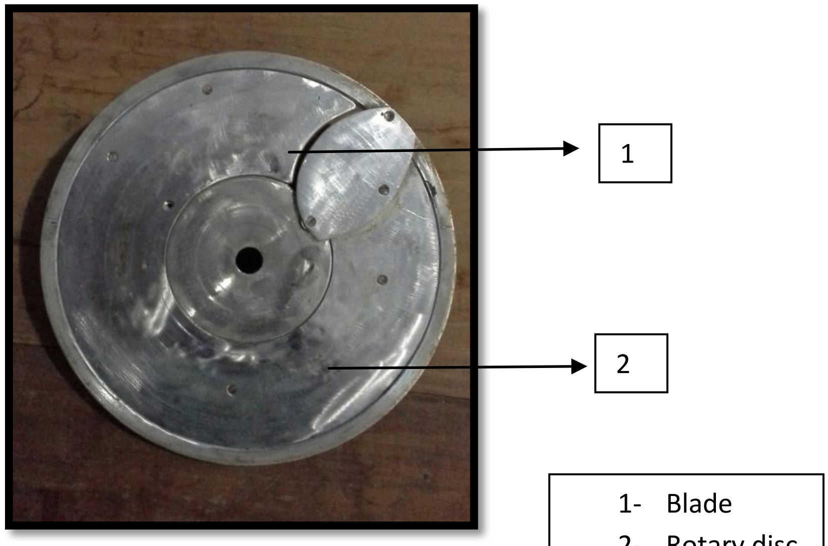


Fig:3.5 Rotary disc with blade

3.4.4Cleaning mechanism

One rectangular shape fixed brush made of fibre was fitted between two cylinders.

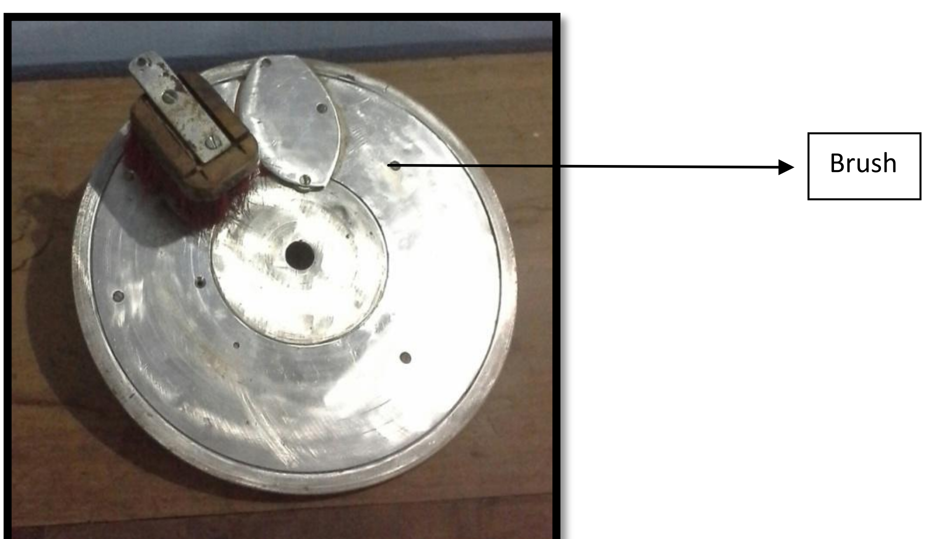


Fig 3.6 Cleaning mechanism

3.4.5Housing and Stand

The housing of slicer was made by thin SS sheet and completely covered by the sheet. The thin sheet was used with intension of reducing the weight and also to cover slicing section and feed hopper completely. The machine mounted to stand was made of galvanized iron with length of 80 cm. The weight was reduced further to 15 kg. The slicing selection can be moved to and fro along with stand. This tilting provision of moving the slicing section makes it possible to slice directly into frying pan.

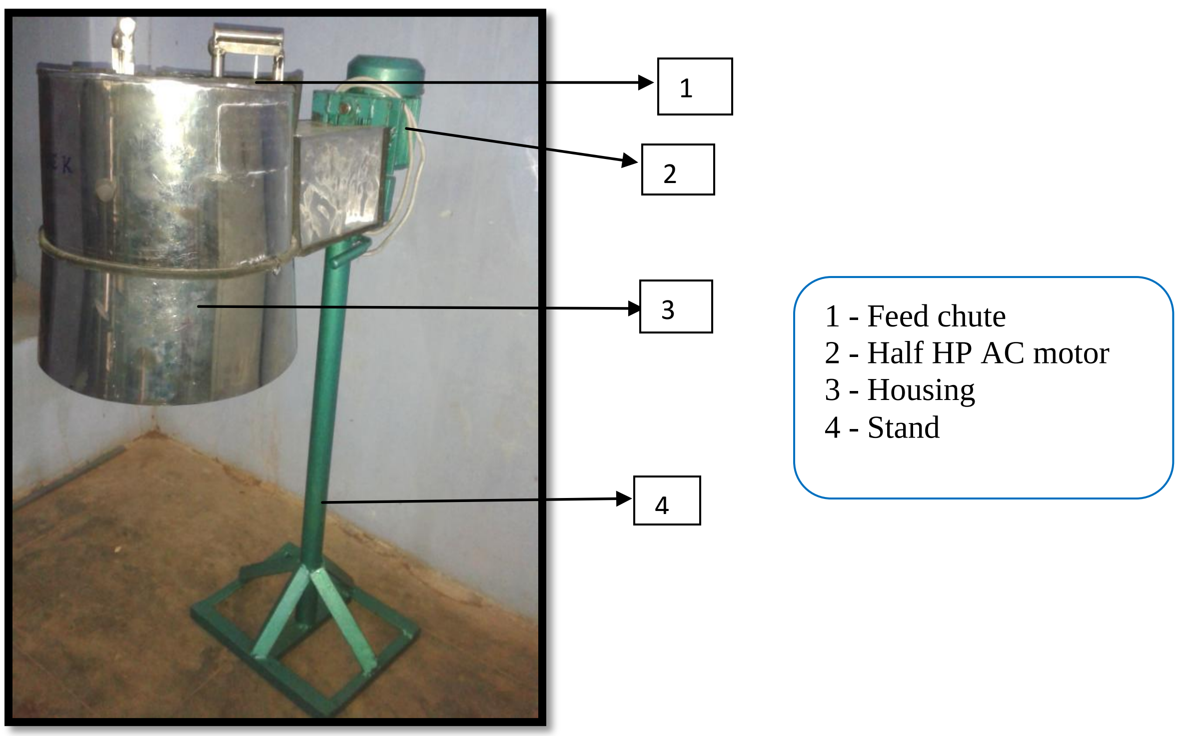
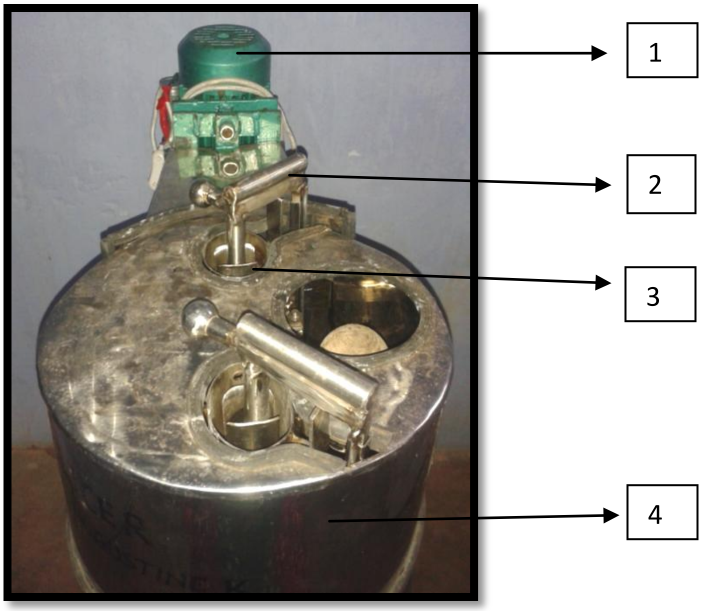
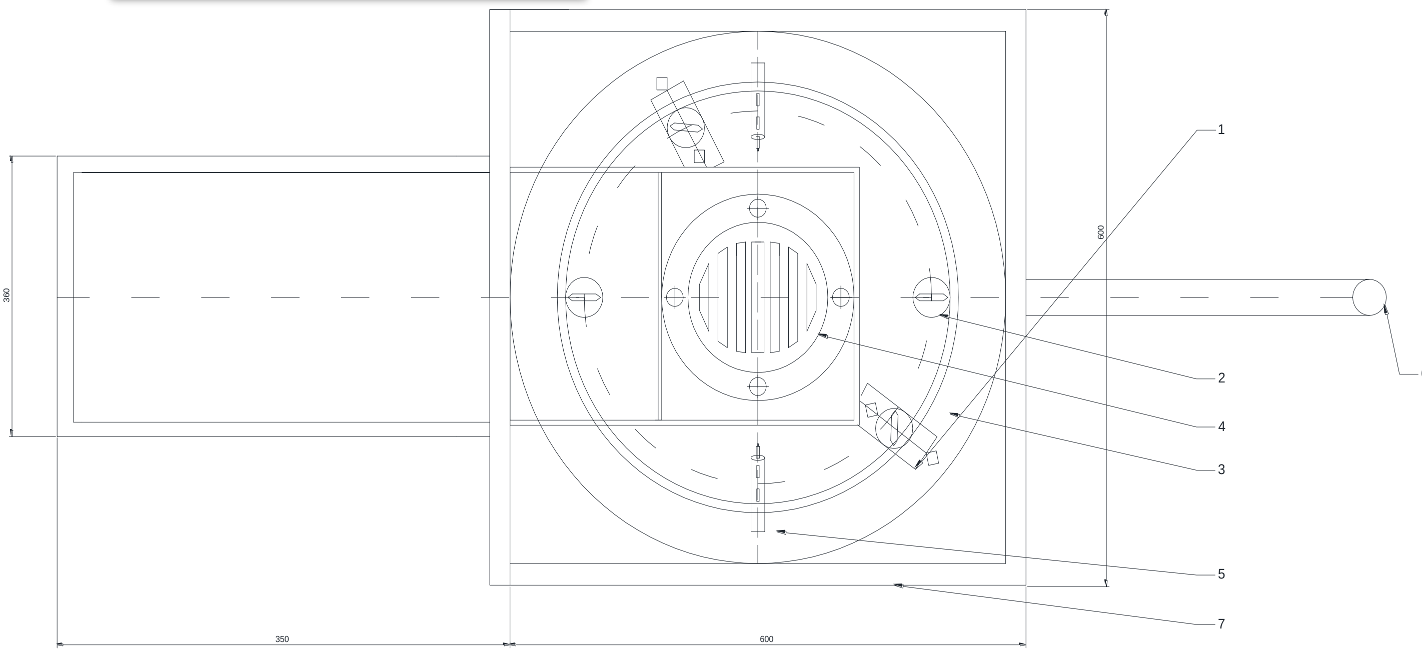


Fig 3.7 Rotary banana slicer Model–III



1- Motor
2- Guiding rod
3- Feed chute
4- frame



1 – Feedchute and guiding rod

2- Blade

3-SS plate

4-motor

5 –Roller

6-Handle

7-Frame

Fig 3.8 Top view of Rotary banana slicer Model –III

3.4.6Power Transmission

The power was transmitted from the ½ H.P. AC motor with 800 rpm. The capacity of the rotary banana slicer Model- III was 90 - 100 kg/h. This reduced capacity is due to the reduced number of feed chutes. Unlike in the Model- I and Model –II, the feed chutes in the third model was limited to two, by taking the continuous feeding comfort of workers. Though this has reduced the capacity by 10 %, the new model provides a better comfort to operator.

In the rotary banana slicer Model III, all the defects of the two older models were rectified. The weight of the machine was reduced from 25 kg to 15 kg, so it was accessible to move anywhere. It was easy to clean and also feed continuously to the feed hopper, since the number of cylinder reduced to two. The thin sheet used for housing provides complete covering to slicing section and helps in maintaining good quality slices. Increase in speed of rpm increased the capacity of slicer.

It is a user-friendly machine capable of slicing banana at desired thickness directly into frying pan. The variable speed motor drive helps to alter the capacity of the slicer. The lateral movement of the slicer unit is possible to and from over the frying pan adding convenience in operation.

3.5 Commercial banana slicer

The commercial banana slicer developed by Balakrishna Engineering is undertaken for the evaluation. It is simple to operate are easy to clean. The effective capacity is estimated at 80-90 kg/hr. Available blade size ranging from 1.2 -10 mm. It’s versatile and it can be used for slicing beetroot, potato and lady’s finger. Silent motor of half H.P is used.

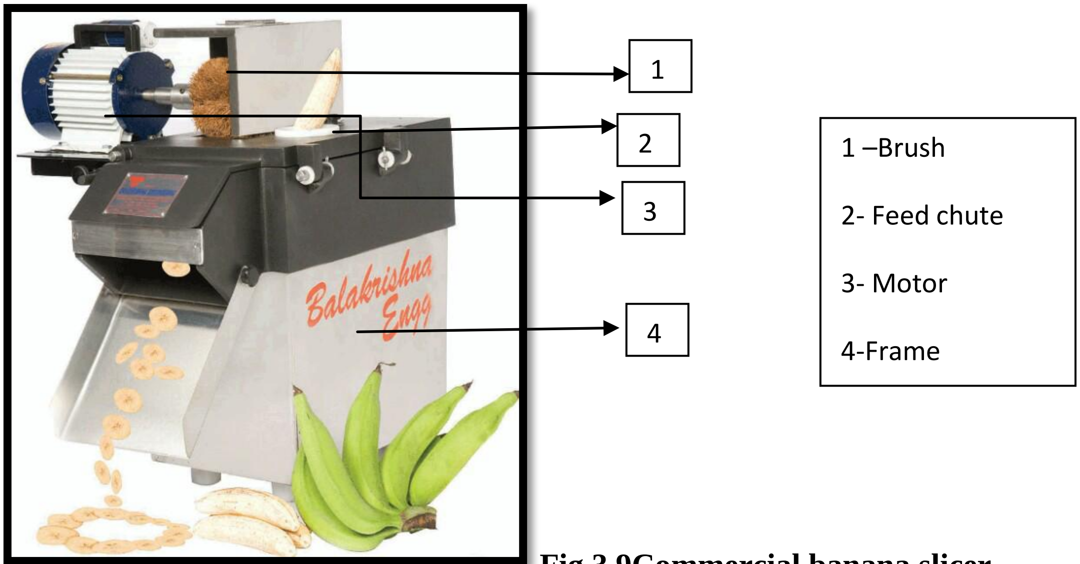


Fig 3.9Commercial banana slicer

3.6 Performance evaluation

Raw green bananas of proper maturity bought from the local market was used for conducting experiment.The bananas were peeled manually using a sharp knife.The machine was then turned ON as the chipping disc cylinder attained a set speed of 800 rpm peeled raw bananas were fed in to the cylinder through the slot and uniformly pressed by means of modified pressing mechanism which is mounted over it. The time taken for chipping this banana was noted an operating capacity, slicing efficiency, percentage damage and coefficient of expansion was then evaluated.

3.6.1 Overall capacity (OC)

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

3.6.2Slicing efficiency

Efficiency of slicer was evaluated by weighing the damaged and round slices separately and using the following expression.

$$\text{Slicing efficiency, } \eta = \frac{\text{Weight of all slices - Weight of damaged slices}}{\text{Weight of all slices}} \times 100$$

3.6.3 Percentage damage (%D)

The percentage damage of the slicer was evaluated using the expression

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

3.6.4 Effective capacity (EC)

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

$$EC = \frac{OC \times \eta}{100}$$

3.6.5 Coefficient of expansion (CE)

The coefficients of expansion of banana chips were determined by measuring the thickness of the slices using the digital vernier caliper. Coefficient of expansion can be found out by the expression

$$\text{Coefficient of expansion (CE)} = \frac{\text{Thickness of the slices after frying}}{\text{Thickness of the slices before frying}}$$

Fig 3.10: Digital vernier caliper

Coefficients of variation of different thickness of slices are determined.

3.8 Comparative evaluation of the rotary banana slicer and commercial banana slicer

Performance of the modified rotary banana slicer Model III was compared with that of commercial banana slicer.

Results and Discussions

Chapter 4

RESULT AND DISCUSSION

This chapter deals with the result of experiments conducted performance of modified rotary banana slicer and commercial banana slicer.

4.1 Performance and Evaluation of Rotary Banana Slicer model –III

The fabricated machine was evaluated for its overall capacity, slicing efficiency, percentage damage, effective capacity, coefficient of expansion and coefficient of variation.

4.1.1 Overall capacity

The average of the overall capacity was found to be 100 kg/hr. The results are shown in the table 4.1 .

Table 4.1: Overall capacity of the modified Rotary Banana Slicer Model-III

Sl. No	Weight of banana(kg)	Time taken for slicing(min)	Overall capacity(kg/hr)
1	10.2	6.00	101.01
2	9.6	5.46	98.60
3	10.1	5.50	100.40
Average			100.00

4.1.2 Slicing Efficiency

The slicing efficiency of the machine was calculated using the formula given in 3.6.2. The slicing efficiency was found to be 95.86%. The results are shown in table 4.2.

Table 4.2: Slicing efficiency of the modified Rotary Banana Slicer Model-III

Sl.No	Weight of all slices(g)	Weight of damaged slices(g)	Slicing Efficiency(%)
1	100	4.14	95.86

4.1.3 Percentage damage

The damage of the machine was calculated using the formula 3.6.3. The percentage damage was found to be 3.4%. The results are shown in table 4.3.

Table 4.3: The percentage damage of the banana slices

Sl.No	Weight of slices(g)	Weight of damaged slices(g)	Percentage damage(%)
1	100	3.4	3.4

4.1.4 Effective capacity

The effective capacity of the machine was calculated using the formula 3.6.4.The effective capacity was found to be 96.6 kg/hr.The results are shown in table 4.4.

Table 4.4: The effective capacity of the Modified Rotary Banana Slicer Model- III

Sl.No	Overall capacity(kg/hr)	Slicing efficiency(%)	Effective capacity(kg/hr)
1	100.1	96.6	96.6

4.1.5 Coefficient of Expansion and Coefficient of Variation

The coefficient of expansion of the Modified Rotary Banana Slicer Model- III was evaluated using the formula 3.6.5.The coefficient of expansion at various thickness are 1.84, 1.27 and 1.14.The coefficient of variation of the banana slices are found to be 14.05, 6.70 and 3.92. The results are shown in table 4.5.

Table 4.5.1The coefficient of expansion of the banana chips at thickness (a)

Sl. No	Thickness of the slices before frying(mm)	Thickness of the slices after frying(mm)	Coefficient of expansion
1	0.82	1.88	2.29
2	0.86	1.56	1.81
3	0.88	1.36	1.54
4	0.77	1.11	1.44
5	0.70	1.41	2.01
6	0.82	1.26	1.53
7	0.87	1.21	1.39
8	0.70	1.62	2.31
9	0.72	1.32	1.83
10	0.61	1.43	2.34
Average			1.84
Coefficient of Variation			14.05

Table 4.5.2 The coefficient of expansion of the banana chips at thickness (b)

Sl. No	Thickness of the slices before frying(mm)	Thickness of the slices after frying(mm)	Coefficient of expansion
1	1.03	1.50	1.45
2	1.00	1.36	1.36
3	1.02	1.26	1.23
4	1.08	1.40	1.29
5	1.05	1.32	1.25
6	1.10	1.16	1.05
7	1.12	1.49	1.33
8	0.96	1.15	1.19
9	0.95	1.15	1.21
10	0.89	1.23	1.38
Average			1.27
Coefficient of Variation			6.70

Table 4.5.3 The coefficient of expansion of the banana chips at thickness (c)

Sl. No	Thickness of the slices before frying(mm)	Thickness of the slices after frying(mm)	Coefficient of expansion
1	2.00	2.09	1.04
2	1.91	2.24	1.17
3	1.97	2.22	1.12
4	1.95	2.35	1.20
5	1.85	2.50	1.35
6	2.01	2.16	1.07
7	2.05	2.11	1.02
8	2.09	2.50	1.19
9	2.12	2.47	1.16
10	2.05	2.22	1.08
Average			1.14
Coefficient of variation			3.92

4.2 Performance and evaluation of Commercial Banana Slicer

The commercial banana slicer developed by Balakrishna Engineering was evaluated for its overall capacity, slicing efficiency, percentage damage, effective capacity, coefficient of expansion and coefficient of variation.

4.2.1 Overall capacity

The overall capacity was found to be 90.00 kg/hr. The results are shown in table 4.8

Table 4.8 The overall capacity of the Commercial Banana Slicer

Sl. No	Weight of banana(kg)	Time taken for slicing (min)	Overall capacity(kg/hr)
1	10.1	7.5	91.10
2	9.8	6.4	90.00
3	10.4	8.1	89.00
Average			90.00

4.2.2 Slicing Efficiency

The slicing efficiency of the machine was calculated using the formula given in 3.6.2.The slicing efficiency was found to be 81.60%. The results are shown in table 4.9.

Table 4.9 The slicing efficiency of the commercial banana slicer

Sl.No	Weight of all slices(g)	Weight of damaged slices(g)	Slicing efficiency %
1	100	18.4	81.60

4.2.3 Percentage Damage

The percentage damage of the machine was calculated using the formula 3.6.3.The percentage damage was found to be 13.60%.The results are shown in table 5.0.

Table 5.0 The percentage damage of the commercial banana slicer

Sl.No	Weight of all slices(kg)	Weight of damaged slices(kg)	Percentage damage %
1	100	13.60	13.60

4.2.4 Effective capacity

The effective capacity was calculated using the formula 3.6.4. The effective capacity was found to be 73.44kg/hr. The results are shown in table 5.1.

Table 5.1 The effective capacity of the commercial banana slicer

Sl. No	Overall capacity	Slicing efficiency %	Effective capacity
1	90.00	81.60	73.44

4.2.5 Coefficient of Expansion and Coefficient of Variation

The coefficient of expansion of the banana chips was evaluated using the formula 3.6.5. The coefficient of expansion was found to be 1.485 and coefficient of variation was found to be 16.55.The results are shown in the table 5.5.

Table 5.5 The coefficient of expansion of banana chips.

Sl.No	Thickness of slices before frying(mm)	Thickness of slices after frying(mm)	Coefficient of expansion
1	0.92	1.13	1.23
2	0.83	1.91	2.30
3	1.46	1.94	1.33

4	1.14	2.27	2.01
5	1.27	1.99	1.57
6	1.01	1.43	1.42
7	1.12	1.62	1.45
8	1.32	1.93	1.46
9	1.09	1.11	1.02
10	0.96	1.02	1.06
Average			1.49
Coefficient of variation			16.55

4.3 Coefficient of expansion vs thickness

The changes in coefficient of expansion with various thickness of slices is shown in fig.The coefficient of expansion decreases with increase in thickness which is expressed using the power equation

$$y = 1.524x^{-0.46} ,$$

$$R^2 = 0.853$$

Where, x is the thickness of slices in mm,y is the expansion ratio and R is the predictability.

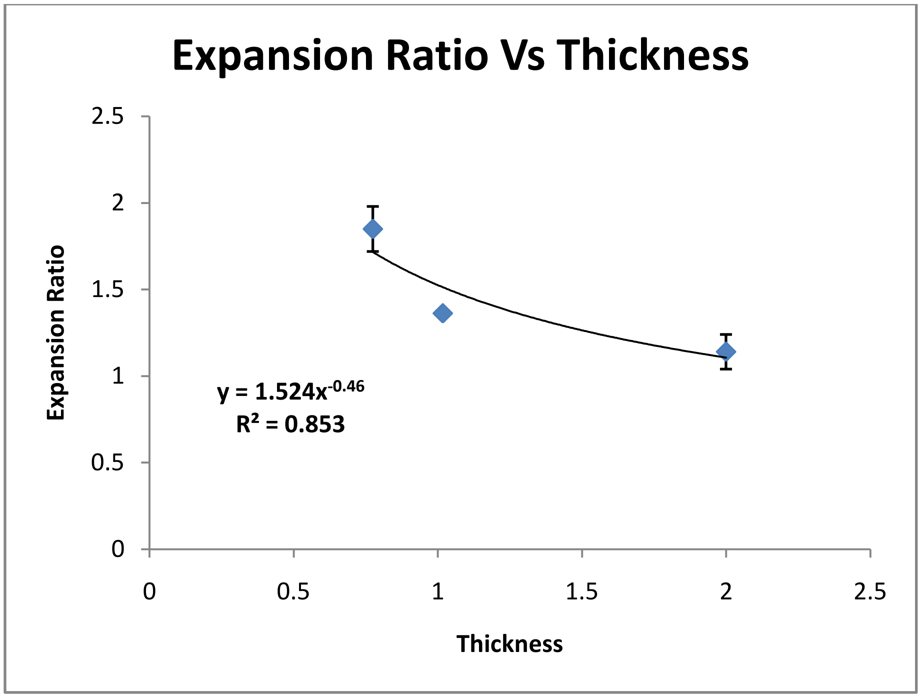


Fig 3.11: Graph showing coefficient of variation VS thickness of slices.

It is due to the fact that the provision for expansion of thin slices is more compared with the thick slices. In the thick slices the outer layer will expand and the inside material remain compact.

4.3 Overall Comparison of all the slicers.

Performance factor	Model-I	Model-2	Final model	Commercial Model
Overall Capacity(OC)	110kg/hr [a]	110kg/hr [a]	100kg/hr[b]	90 kg/hr[c]
Slicing Efficiency(SE)	88.23 %[bc]	89.02%[b]	95.86% [a]	81.60%[d]
Percentage Damage (%D)	6.10%[b]	5.20%[bc]	3.40%[d]	13.60%[a]

Effective Capacity	97.05 kg/hr^{ab}	97.92 kg/hr^{a}	95.86 kg/hr ^{abc}	77.94kg/hr^{d}

Results within 1 row indicated with the same letter are not significantly different ($a < 0.05$)

Summary and Conclusions

Chapter 5

SUMMARY AND CONCLUSION

India is the largestproducerof 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 desserts 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 external as well as internal demand.Nendran which is leading in 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 Kelappaji College of Agricultural Engineering and Technology, Tavanur to modify and develop a rotary banana 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 inflecting injury. Also, the frying quality of the chips depends greatly on the uniformity of the wafers. The existing method does not produce chips of uniform size.

The physical and mechanical properties of green mature plantain like length, diameter, skin thickness, pulp to peel ratio load required to cut across sectional slice of peel and pulp etc were studied prior to fabrication. Attempts were made to develop three models of mechanical slicer for banana. Each model was developed by improving the effectiveness of slicing in terms of operator’s comfort, weight of machine, easiness of cleaning, capacity, versatility to use other vegetables, etc.

In the third model rotary banana slicer Model III was fabricated in such a way it’s suitable for all size and shape of banana and thickness of slice was adjustable according to desired thickness of consumer. The variable speed motor provides an adjustable speed of slicing. Continuous feeding was possible through two stainless steel chutes which have spring loaded curved holding discs to hold the peeled banana straight. An oil coated flexible brush cleans the cutting edge by wiping away the banana sap released on cut surface. A tilting arrangement was provided to stand which helps the sliced banana to fall directly into frying pan.

The power was transmitted from the ½ H.P. AC motor with 800 rpm. The capacity of the rotary banana slicer Model-III was 90 - 100 kg/h.This reduced capacity is due to the reduced number of feed chutes. Unlike in the Model- I and Model –II, the feed chutes in the third model was limited to two, by taking the continuous feeding comfort of workers. Though this has reduced the capacity by 10 %, the new model provides a better comfort to operator.In the rotary banana slicer Model III, all the defects of the two older models were rectified. The weight of the machine was reduced from 25 kg to 15 kg, so it was accessible to move anywhere. It was easy to clean and also feed continuously to the feed hopper, since the number of cylinder reduced to two. The thin sheet used for housing provides complete covering to slicing section and helps in maintaining good quality slices. Increase in speed of rpm increased the capacity of slicer.

It is a user-friendly machine capable of slicing banana at desired thickness directly into frying pan. The variable speed motor drive helps to alter the capacity of the slicer. The lateral movement of the slicer unit is possible to and from over the frying pan adding convenience in operation.It is undoubted fact that the banana chips making industries are evergreen food industry in our society because of its popularity. Hence the model expects high market expansion covering both small and large scale industries. And the ability of this machine in running this industry at a faster and efficient way surely helps this model to be sustainable in the market.

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Abstract

PERFORMANCE AND EVALUATION OF MODIFIED ROTARY BANANA SLICER

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ABSTRACT

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In
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Faculty of Agricultural Engineering and Technology
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ABSTRACT

Banana chips as snack food is very popular in Kerala because of its traditional and ethnic importance. Traditional methods of banana chips making involves four major units operations namely peeling of fruits, cutting of fruits into slices, frying and packaging. Each of these unit operations are done manually especially due to the lack of appropriate mechanical system.Slicing is carried out to reduce the size of the product to suit processing and consumer requirements. However, this operation is very difficult and time consuming.Hence there is a need to develop a new model of banana slicer which can compete with manual slicing both in speed and quality. The new slicer can be efficiently used in both small and large scale industries for slicing bananas with minimum loss of material (3.4%) and quality. It is suitable for all size and shape of banana and thickness of slice is adjustable according to the need of the consumer. The thickness of banana slices decreased from 1.15 mm to 0.85 mm as the speed increased from 100 to 800 rpm. However the average thickness of 1 mm was maintained between 300 to 600 rpm. It is a user-friendly machine capable of slicing banana at desired thickness directly into the frying pan. The variable speed motor drive helps to alter the capacity of the slicer as per the requirement. The lateral movement of the slicer unit is possible to and from over the frying pan adding convenience in operation. Continuous feeding is possible through stainless steel chutes which has spring loaded curved holding plates to hold the peeled banana straightly.This mechanism ensures the slicing of the last segment of peeled banana, which otherwise will be wasted in other commercial models and manual method. Thus the mechanical damage could reduce from 13.6 % in commercial slicers to 3.4% in the present model. An oil coated flexible brush always clean the cutting edge by wiping away the banana sap released through the cut surface. The new slicer could be efficiently used in both small and large scale industries for slicing bananas with enhanced capacity of 100 kg/hr and with a slicing efficiency of 95.86%. The machine is overcoming almost all the technical problems in slicing operation, hence it can be easily used or modified for slicing other kind of vegetables used for chips making and other food industries.