DEVELOPMENT AND PERFORMANCE EVALUATION OF MODIFIED BANANA CHIPPER

By

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PROJECT REPORT

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TAVANUR – 679573, MALAPPURAM.

1997

DECLARATION

I here by declare that this project report entitled **"DEVELOPMENT AND PERFORMANCE EVALUATION OF A MODIFIED BANANA CHIPPER"** is a bonafide record of project work done by me during the course and that this report has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Tavanur

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CERTIFICATE

Certified that this project report entitled **"DEVELOPMENT AND PERFORMANCE EVALUATION OF A MODIFIED BANANA CHIPPER"** is a record of project work done by **Mr. Liju. K** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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LIST OF ABBREVIATIONS USED

Ac	-	Area of the circumscribed circle
Al	-	Aluminium
Ap	-	Projected Area of the circle
Co	-	Company
EC	-	Effective Capacity
Fig	-	Figure
gm	-	Gram
hr	-	Hour
ICAR	-	Indian Council of Agricultural Research
ISA	-	Indian Standard Angles
KAU	-	Kerala Agricultural University
KCAET	-	Kelappaji College of Agricultural Engineering and Technology
Kg	-	Kilogram
Kw	-	Kilowatt
mm	-	Millimetre
MS	-	Mild Steel
OC	-	Overall capacity
PVC	-	polyvinyl chloride
rpm	-	Revolution per minute
Rs	-	Rupees
Sec	-	Second
Tec	-	Technology
TEFC	-	Totally Enclosed Fan cooled
Wt	-	Weight
%	-	Percentage
α	-	Efficiency

Chapter - 1

INTRODUCTION

Food is one of the essential requirements for the existence of human being. This very fact has necessitated its production and for obtaining better quality products, value addition is inevitable. This is more evident from the fact that losses in both quantity and quality occurs in horticultural crops between harvest and consumption. The magnitude of the post harvest losses in fresh fruits and vegetables is estimated to be 5-25% in developed countries and 20-50% in developing countries.

Besides providing essential nutrient vitamins and minerals as human diet, fruits and vegetables also serve for providing colour, flavour and variety to the otherwise monotenous diet. But due to high water content on fresh horticultural crops, they are subjected to dessication, mechanical injury and also susceptible to attack by bacteria and fungi resulting as pathological breakdown. Therefore the thrust should be to process and convert such perishable commodities in to stable product that can be stored for extended periods there by reducing losses and making them available in time of shortage and out of season and at places away from sites of production.

Snack foods especially like Banana chips, potato chips etc. are very popular in South India. Oils, flavour, colour, antioxidants are the major ingredients used by snack food industry. The composition varies depending upon the processes used.

The quality problems faced by such snack foods mainly arises due to moisture ingress, flavour loss, rancidity, discolourisation, browning etc., which can be overcome by use of quality raw materials, correct process parameters and appropriate packaging materials and modes. More over the number of units engaged in the manufacture of snack foods is far less as compared to those in small scale and unorganised sector in which there has been little development and application of the latest technology.

Banana chips is one of the most popular snack food in Kerala and has been gaining more importance in India and abroad especially in Gulf countries. Banana chips making has now grown in to a small scale industry in Kerala.

Banana (*Musa paradisiaca*) cultivation is distributed among the warmer countries between 30° south and 30° north of the equator. It is a large herbaceous tropical plant. In the international fruit trade, Banana is the second largest item, grapes being the first.

Ripe and unripe Banana (Kadali) is a delicate and highly perishable fruit which originated in the Assam - Burma - Indochina region. At present India ranks third in banana production in the world with an estimated 5.79 million tonnes from an area of 0.33 million hectares against the world production of 23 million tonnes. However, the largest area under Banana cultivation is under Africa. Banana is now one of the most important commercial horticultural crop in the world.

Coming to the Indian states, though Kerala has got the largest area under banana cultivation, its productivity is low as can be seen from Table 1.1. From the table, it is evident that maximum productivity in banana cultivation is in Gujarat. The nendran variety in Kerala is the only medium yielder in this state and is grown under under better management on a commercial scale. The production of nendran and other varieties in different districts of Kerala are shown in Table 1.2.

Table 1.1 Area and production of banana in India (1982-83)

States	Area (100 ha)	Production (1000 tonnes)	Yield/ha (in tonnes)
Andra Pradesh	23.20	389.50	16.79
ArunachalPradesh	0.50	1.40	2.80
Assam	25.35	320.18	12.63
Bihar	21.84	436.80	20.00
Gujarat	21.40	536.00	25.05
Karnataka	40.63	1015.75	25.00
Kerala	51.87	393.47	7.58
Maharashtra	45.00	1032.00	22.93
Madyapradesh	12.30	217.00	17.64
Manipur	1.00	16.70	16.70
Missoram	0.80	1.20	1.50
Meghalaya	4.00	50.00	12.50
Orissa	18.10	180.50	9.97
Tripura	3.48	24.00	6.89
Tamilnadu	47.28	1040.33	22.00
Uttarpradesh	0.60	4.30	8.00
West bengal	14.00	120.00	8.57
Andaman	0.80	7.00	8.75
Total	**332.15**	**5786.63**	**245.30**

Table 1.2 Production of Nendran and other varieties in different districts of Kerala (1982-83)

District	Production (Tonnes)			
	Nendran	Others	Nendran	Others
Thiruvananthapuram	808	5249	9623	19997
Kollam	1406	2479	16715	11093
Pathanamthitta	959	1919	12828	8188
Alappuzha	646	1542	9651	4713
Kottayam	1690	320	29085	16355
Idukki	275	2377	3708	9596
Ernamkulam	2130	3340	26851	17083
Trissur	1327	3853	16017	8469
Palakkad	1574	2409	20349	11566
Malappuram	2586	2359	29967	7054
Kozhikkode	1083	2746	14484	10238
Wynad	566	12006	8142	6418
Kannur	1188	2240	14938	8693
Kasaragod	262	1562	3338	6062
Total	**16600**	**36502**	**215696**	**145430**

Banana chips as snack food is very popular in South India, especialy in Kerala because of its crispness. For this, unripe banana (Nendran variety) is generally used. The wafers are made throughout the year, since the salt fried banana wafers have very good demand in both internal and external markets.

Banana chips making involves four major units operations namely peeling of fruit, cutting of fruit in to 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 reason for this (banana chip making) not emerging as 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. In the past this was done manually using stainless steel adjustable wooden platform hand slicer or by stainless steel knives. But these have a lot of drawbacks. This conventional method poses danger to the operator's fingers by inflicting injury especially while slicing the fag or tail end of the fruit. Besides uniformity in the size of chips results in poor end quality of wafers after frying. 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.

In order to eliminate the drudgery involved in chip making and avoid injury to workers, enhance the capacity and to maintain hygiene, an attempt was undertaken at Kelappaji College of Agricultural Engineering and Technology with the following objectives.

1. To develop a mechanical banana chipper.
2. To evaluate the performance of the machine.

3. To modify the developed machine based on the results of the performance evaluation.
4. To compare the performance of the modified chipper with that of the parent machine and manual chipping.

Chapter - II

REVIEW OF LITERATURE

2.1 Agronomical characteristics:

Banana is a large herbaceous tropical plant which requires warm humid and rainy climatic conditions for its growth. Thus it thrives best in Kerala, parts of Tamilnadu, Maharashtra and West Bengal. It also flourishes throughout Bihar, parts of South India and Assam.

Soil conditions are important factor governing the cultivation of crops. For banana, it is essential that the soils should be rich, free working, soft, deep and well drained with uniform crumb structure. The land should be deeply ploughed, harrowed and levelled and pits of half cubic meters should be dug at required distance for planting the crop. Planting should generally be started during the onset of Southwest monsoon in June. The distance of planting varies according to the height and spread of variety and growth conditions.

Cultivated forms of banana is propagated vegetatirely from their suckers. The plant matures its fruit from 12 - 18 months after planting depending upon the variety and dies soon after harvest. Under favourable conditions, the plant starts flowering in 9-12 months after planting and takes 3 - 4 months to mature its fruit. The fruit ripens best if packed at full maturity.

2.2 Food value

Like other horticultural crops, banana too is of great nutritional value, providing proteins, vitamins and tissue building elements. Also due to its low water content, it is a good source of calorie. A large banana supplies more than 100 calories and contains a large amount of easily assimilable sugar, making it a good source of quick energy and an excellent means of recovery from fatigue. The food value of raw banana per 100g edible portion as reported by V.H.Potty et al. is represented in table.

Table 2.1 Average composition of Banana fruit (per100g edible portion)

Moisture	-	70.1%
Protein	-	1.2%
Fat	-	0.3%
Minerals	-	0.8%
Fibre	-	0.4%
Carbohydrates	-	27.2%
Calcium	-	17mg.
Phosphorous	-	36mg.
Iron	-	0.9mg.
Vitamin C	-	7mg.
Calorific value	-	116

Raw banana contains mostly starch which is converted to sugar during ripening. The changes in carbohydrates during ripening is represented in table as reported by Jacob(1952).

Table 2.2 Carbohydrate change during ripening.

Stage	Total carb. (%)	Soluble carb. (%)	Insoluble carb. (%)
Green	25.56	1.3	25.26
Ripe	19.00	17.02	1.98

2.3 Varieties:

There are about 60 varieties grown in India, but only a dozen of these are of commercial importance. Other varieties are grown in small areas and are consumed by growers themselves or are disposed off in local markets. Reported by Aravindakshan et al. (1996) the cultivated forms can be divided in to two main groups, namely;

1. Edible when raw-*Musa paradisiaca var sapientium and Musa nana.*
2. Plantains or cooking bananas - *Musa paradisiaca*

Some important commercial varieties of banana are,

Poovan of South India

Basari dwarf of maharashtra

Harichal or Bombay green

Rasthali of South India

Lalkel or Red banana

Hill bananas

Tella chakkrakeli of South India

Nendrans of South India

Monthan of South India

2.4 Nendrans of South India:

Nendrans are bananas of most tropical seacoast. It is the most important variety grown in Kerala from time immemorial. There are many types of Nendran namely, AttuNendran, NanaNendran, Thiruvodan, NeduNendran, Changazhikodan, Kudiravali, Velethan, Kelethan, Myndoli. It is known as plantain in most part of the world.

Nendran fruit is large, being about 9 - 10 inches long with thick skin representing the biggest sized edible fruit in banana. The fruits are loosely packed bunch, lind is thick, flesh is firm and starchy. The fruit has fairly good keeping quality and can be used for both Culinary purposes and as dessert.

Jacob (1952) reported that a lower moisture content for dual purpose Nendran variety compared to other varieties represented in table 2.3.

Table 2.3 Moisture, Sugar and acid content of dual purpose Nendran and other varieties

	Nendran (%)	Other varieties (%)
Moisture content	64.20	73.75 - 78.16
Reducing sugars	23.00	10.02 - 19.76
Non-reducing sugars	2.52	0.2 - 5.02
Acid	0.41	1.00 - 1.22

Nendran contains greatest amount of sugars and much less acid content compared to other varieties. Many delicious products can be prepared from ripe as well as unripe Nendran. Some of the products, their uses and methods of preparation are described below.

Banana Fig:

It is prepared out of all Nendran varieties. Preparation involved 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 fruit make a delicious sweet meal or they may be made into jam.

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.

Banana flour:

Banana flour also known as banana meal is made from fully mature unripe bananas. The unripe green fruits are dip in scalding water for five minutes to enable easy peeling of green skin. The peeled fruits are then splits into halves and dried. When the moisture is reduced to 15% or less, the dried fruit is ground and run through sieves of 120 mesh to the inch.

Banana chips

Banana chips is a delicious and popular snack food not only in India, but also abroad. There are made by cutting the unripe fruit in to thin wafers and frying in oil. Generally the chip making involves four major unit operations namely peeling of fruit, cutting of fruits into slices, frying the wafers and packaging.

Peeling.

Peeling is the initial unit operation to be carried out for the processing of banana which involves removal of the outer skin of the fruit when raw. This was generally done manually with a stainless steel scoring knife. This operation is to be carried out carefully as there is every chance of loss of flesh parts.

Chipping

In banana chip making, chipping or slicing is one of the most important unit operations. The chips are generally made 1.0 to 1.5mm thick. The size and uniformity of chips determines the quality of the chips. The uniformity of banana chips plays an important role in crispness of the product which is one of the textural characteristics determining the consumer acceptance of the product as reported by Krishnan Kutty et al. in 1981.

Frying

Crispness can be controlled by uniformity in the chips and proper frying . Frying is done by heating coconut oil in frying pan and putting the cut wafers and cooking until required texture is attained. Quality of the wafers depends upon the time, quality of oil used, temperature of oil as well as flame used. Crispness depends upon the quality of frying.

Packaging and storage

The preservation of food stuffs against spoilage, spillage etc. has necessitated proper packaging and storage of food stuffs. Moreover it aids in value addition of the product through extended shelf life or in other ways .It is now increasingly recognised that packaging can be effective marketing tool and can add substantial value to the product through extended shelf life or in another ways. New forms of packaging are gradually introduced in the markets.

Banana wafers can remain unaffected for 2-3 months of proper packaging and storage standards are adopted. These are usually packed in transparent airtight polythene bags. This does not possess much consumer acceptance, texture etc.

2.5 Traditional method of chipping banana.

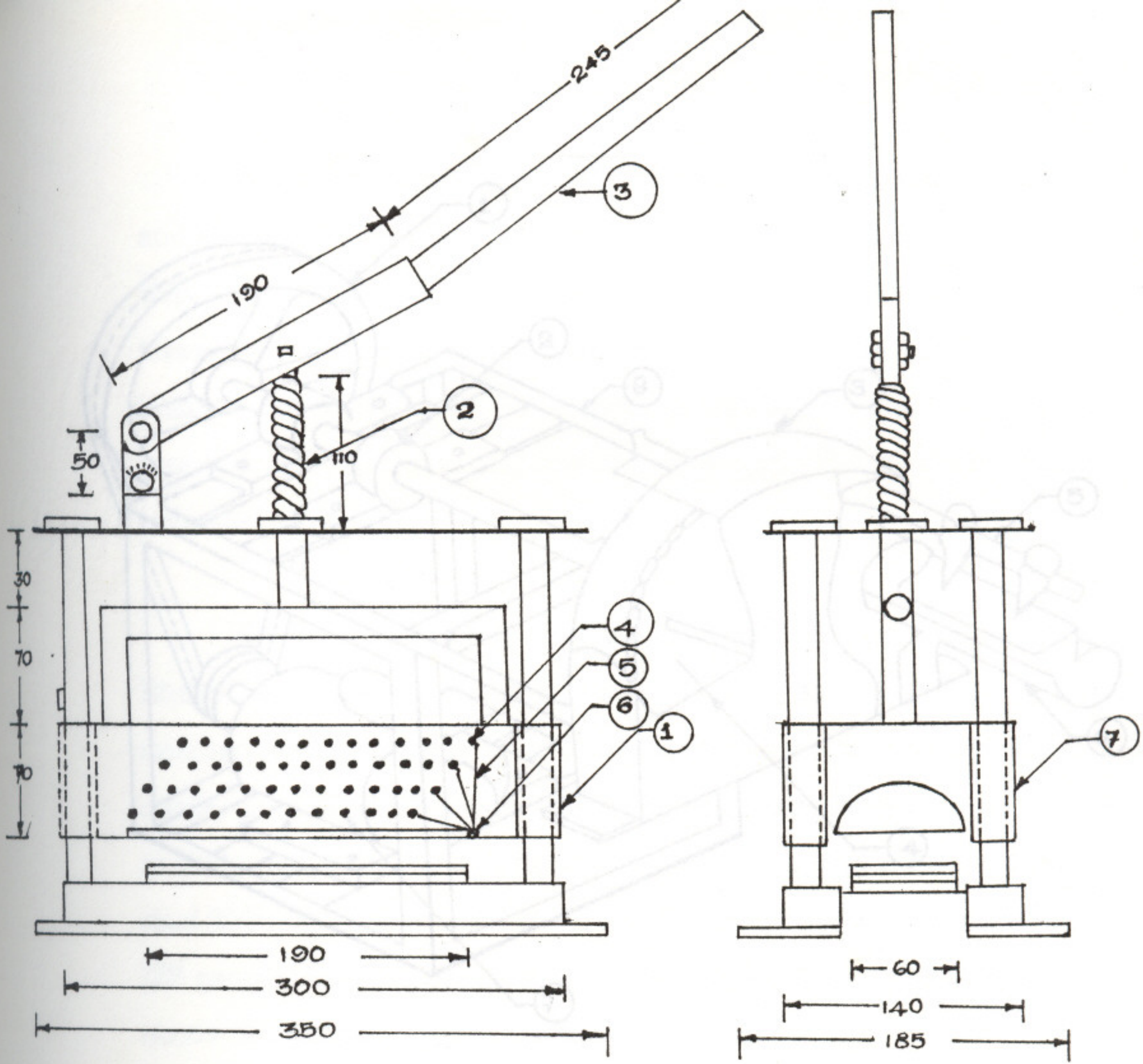
The initial unit operations such as peeling and slicing were done manually using house hold knife. However, few entrepreneurs use platform type manual slicer holding 3-4 bananas at a time in between the fingers and moving across the sharp edge of the slicer.

According to Krishnankutty et al. (1961), the simplest mode of processing is that banana fruits are hand peeled using stainless scouring knife and then steeped in 2% salt solution for 10-15 minutes to maintain the colour by avoiding the browning effect. Slicing is done using stainless steel adjustable wooden platform hand slicer. But these had the draw back of injuring the operator's fingers and also resulted in non-uniformity of chips.

2.6 Works on Mechanical Chipping

Nanda (1981) central tuber crop research institute, developed a hand operated vertical feed cassava chipping machine which consists of two concentric mild steel drums , the annual 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.

The pedal operated chipping machine consists of a feeder assembly with two concentric mild steel cylinders. It has partition walls in annular walls to form feed compartments, a cutting disc with blades which is driven with a driven shaft and pulley. The capacity of the machine is 768 kg/hr with chip thickness of 6.2 mm. The cost of operation/hour is Rs.18.80.



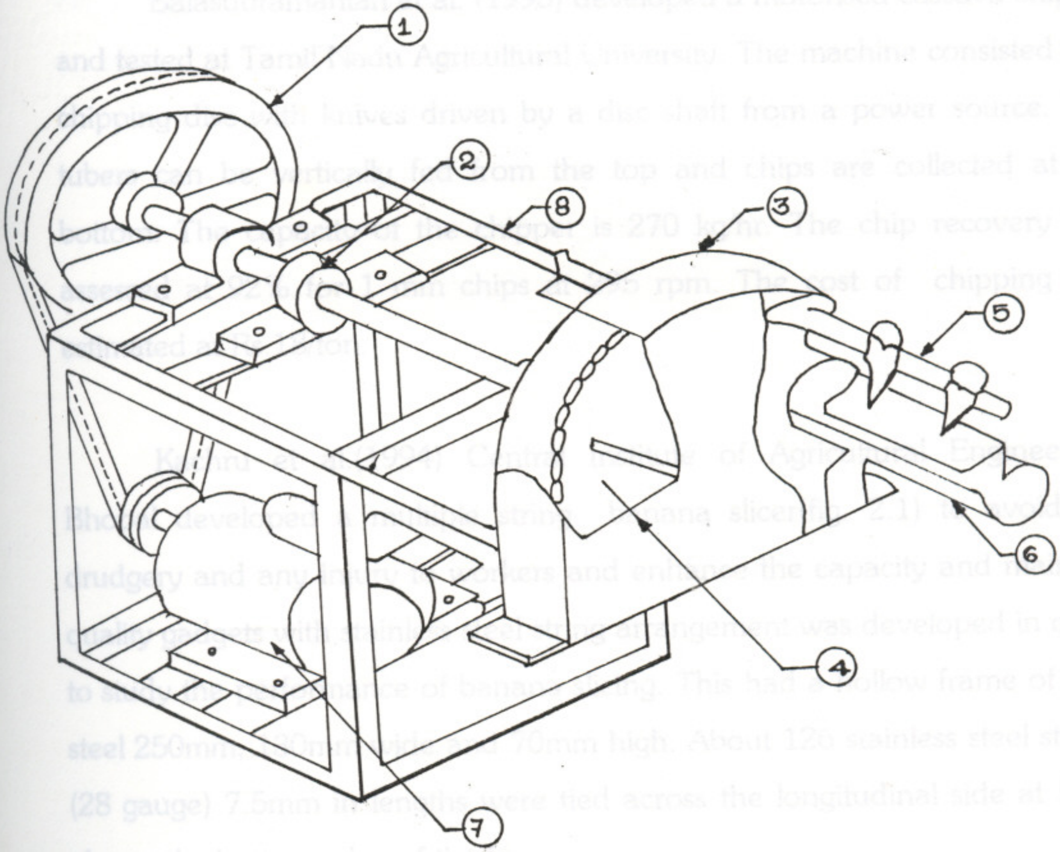
SIDE VIEW

FRONT VIEW

All Dimensions in mm

1. FRAME
2. SPRING SUPPORT
3. LEVER HANDLE
4. SCREWS FOR TIGHTEING WIRES
5. STAINLESS STEEL WIRE
6. HOLES FOR WIRES
7. BUSH AND BAR ARRANGEMENT

Fig. 2.1 MULTIPLE STRING BANANA SLICER



1. V-PULLEY
2. BEARING
3. DISC COVER
4. SLICING DISC
5. SPRING LOADED FRUIT SUPPORT
6. FEEDING TROUGH
7. ELECTRIC MOTOR
8. MAIN FRAME

Fig. 2.2 SCHEMATIC DIAGRAM OF HORIZONTAL TYPE ROTARY SLICER

Balasubramanian et al. (1993) developed a motorised cassava chipper and tested at Tamil Nadu Agricultural University. The machine consisted of a chipping disc with knives driven by a disc shaft from a power source. The tubers can be vertically fed from the top and chips are collected at the bottom. The capacity of the chipper is 270 kg/hr. The chip recovery was assessed at 92% for 1 mm chips at 295 rpm. The cost of chipping was estimated at Rs.18/ton.

Kachru et al.(1994) Central Institute of Agricultural Engineering, Bhopal developed a multiple string banana slicer(fig. 2.1) to avoid the drudgery and any injury to workers and enhance the capacity and maintain quality gadgets with stainless steel string arrangement was developed in order to study the performance of banana slicing. This had a hollow frame of mild steel 250mm, 130mm wide and 70mm high. About 126 stainless steel strings (28 gauge) 7.5mm in lengths were tied across the longitudinal side at 5mm above the bottom edge of the frame.

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

Kachru et al.(1996) developed an electrically operated rotary slicer for raw banana (fig 2.2) and tested at Central Institute of Agricultural Engineering, Bhopal. The horizontal type chipping machine consists of a slicer disc attached with blades at 120^0 apart. A mild steel shaft is used to drive the slicing disc. A stainless steel semicircular feeding chute is used for feeding the peeled banana and chips are directly discharged into the pan by centrifugal action. It has a capacity of 61kg of peeled banana per hour with an efficiency of 90%, which is two times higher than the capacity achieved by conventional method. It produces chips of uniforms thickness with roundness index of 0.85. The machine costs of Rs. 1700 and the cost of operation for producing 1 Kg. of wet chips is Rs. 0.15. Thus the cost of operation per Kg. of wet chips was reduced to 50 % by mechanising the process.

Chapter III

MATERIALS AND METHODS

The Banana chipper developed is a vertical feed type motorised unit. The fabrication procedure of the chipper, test procedure adopted for performance evaluation, details of the components modified are described in this chapter.

3.1 General lay out and details of the machine

The machine consists of the following units.

Frame assembly

Power source.

Chipping disc with blades.

Disc shaft.

Modified feeding cylinder with pressing mechanism

chip outlet.

3.11 Frame Assembly

The main farm assembly was fabricated of ISA 25x25x3 MS section and a motor frame of ISA 35x35x5 MS section. In this frame assembly other subassemblies like bearing mountings, feeding cylinders and outlet were mounted.

3.12 Power Source.

A 3 Phase, 440 V 50 Hertz, 1370 rpm, TEFC motor rated at 0.5 Hp was used as primemover. Motor was mounted inside the frame assembly by nuts and bolts. The drive was transmitted through a V belt pulley with 6 times

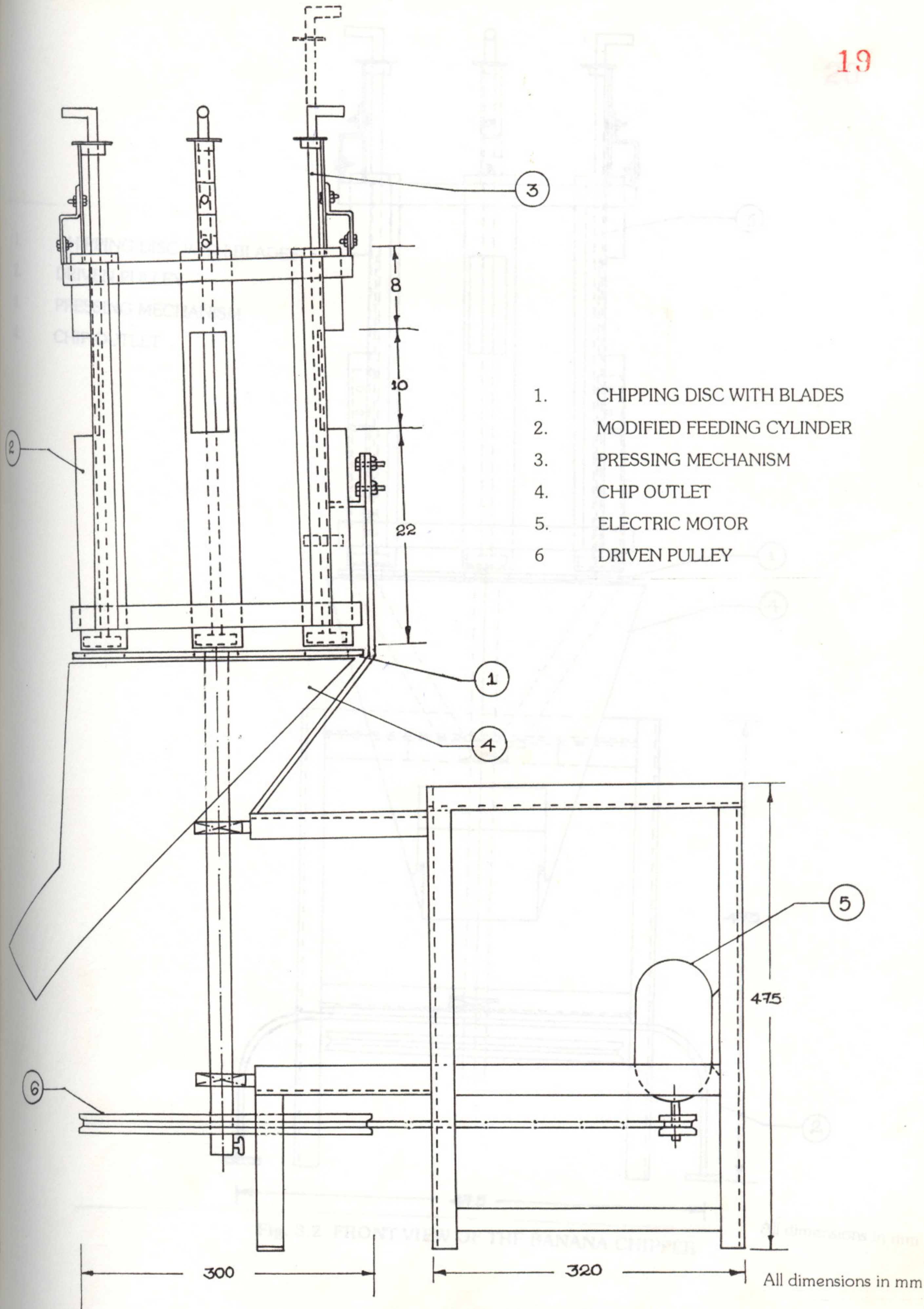


Fig. 3.1 SIDE VIEW OF THE BANANA CHIPPER

1. CHIPPING DISC WITH BLADES
2. DRIVEN PULLEY
3. PRESSING MECHANISM
4. CHIP OUTLET

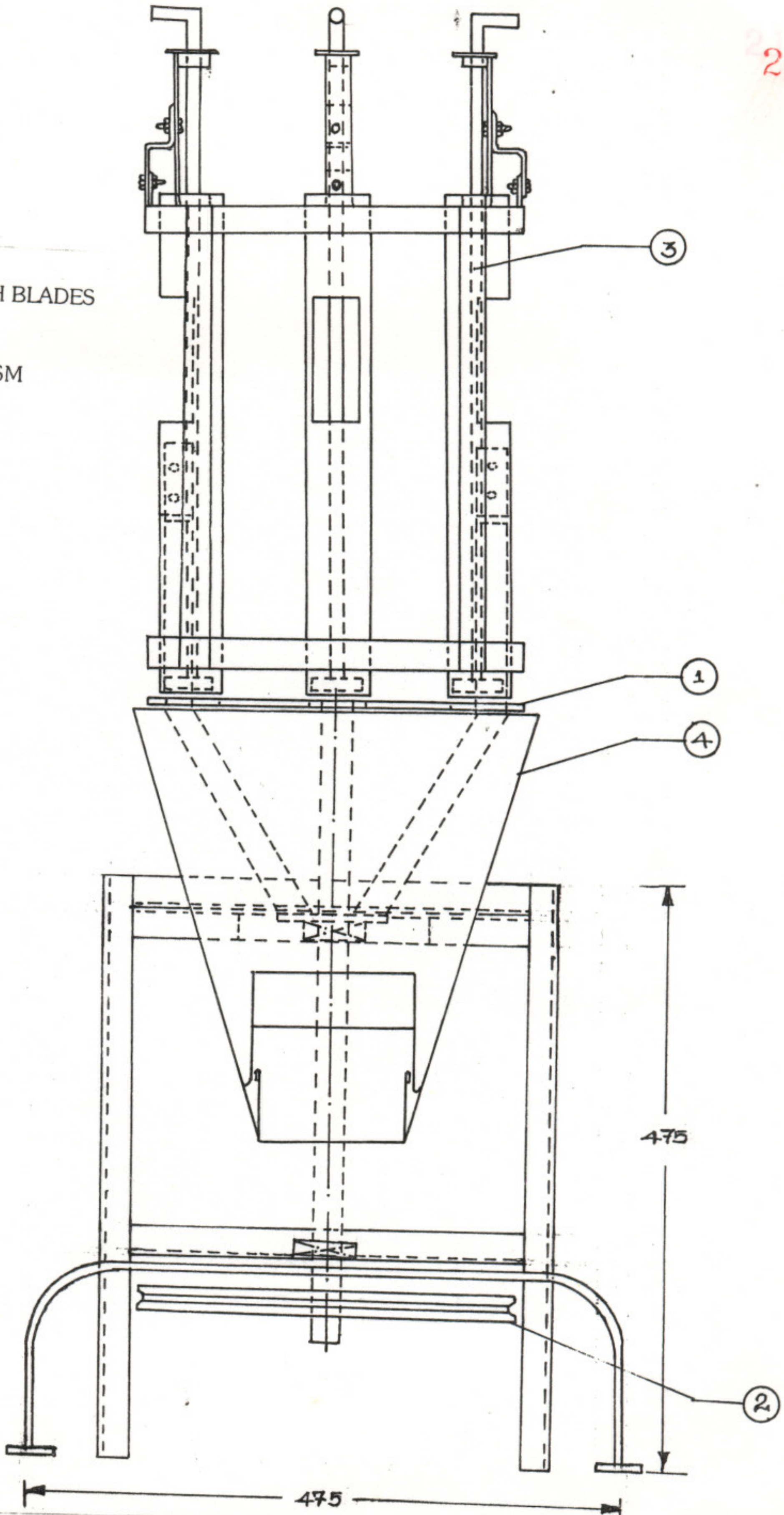


Fig. 3.2 FRONT VIEW OF THE BANANA CHIPPER

All dimensions in mm

speed reduction, so as to obtain 200 rpm at the chipping disc. The motor weight provided stability to the machine.

3.13 Chipping disc and Blades

A chipping disc of 300 mm diameter and 5mm thickness was cut out from MS sheet and was machined properly to make it smooth. Four holes of 42mm diameter were drilled on it at apart as shown on figure 3.3. Blades of different profiles as shown in figure 3.4 with 2.5 ° bevel angle were attached using nuts and bolts along these holes with proper throat clearance to permit easy flow of chips to the outlet. Washers of different thicknesses were used for adjusting the clearance between slot and blade (throat clearance) to vary the thickness of chips.

3.1.4 Disc Shaft

A mild steel shaft of 20 mm diameter and 610 mm length was mounted vertically on two bearing. Top end of the shaft was connected using a sleeve and nut to the chipping disc. At the bottom end, drive was transmitted to the shaft through a V-belt pulley of 600mm diameter.

3.1.5. Modified feeding cylinders with pressing mechanism.

The results of the performance evaluation of the developed banana chipper recommended the modification of the feeding mechanism in order to further improve the quality and quantity of chipping and to reduce the drudgery involved in feeding. Therefore the feeding mechanism was modified. Four P.V.C. Cyclinders of 50 mm diameter and 400 mm length was used to feed the raw bananas for efficient cutting. A slot of size 100 x 40 mm were made at a distance of 220 mm from the bottom end of the pipe, in order to facilitate uniform feeding of raw peeled banana to the slicing disc. All the cylinders were fitted to the main frame by means of clamps and screws.

Modified pressing mechanism as shown in figure 3.5 consists of a mild steel rod of 10.0 mm diameter and 530 mm length which passes through two guides of 11.0 mm diameter and 10.0 mm in length and these guides were welded at 120 mm apart on a mild steel flat of 2.0 mm thickness. The top end of the MS rod is bend which acts as a handle for easy lifting of the rod. There is a stopper which is welded on the rod which stops the movement during its downward travel, So that the opposite end of the rod don't go down beyond a predetermined limit which prevents the rod from touching the rotating disc and damaging the blades.

All the four such pressing mechanisms were fastened to the main frame by means of MS flat using nuts and bolts. Thus the 10.0 mm diameter MS rod can move inside the guide freely. An end plate made of wood of 10.0 mm thickness and 40.0 mm diameter is fixed at the end of the rod in order to have more contact area on the banana and also to avoid the accidental damage to the blades. The clearance between the wooden end plate of the MS rod and the cutting blade was kept as 3.0 mm. Each of the rods were lifted and raw peeled banana was fed through the slots and the handle was then released. The rod with wooden end plate push the banana down through the PVC cylinder to the rotating disc with blades affects the chipping. Then the rod was again lifted to feed another raw peeled banana and the process was repeated for all the four feeding cylinders

3.1.6 Chip outlet

The Sliced raw banana were collected at the outlet. The outlet chute as shown in figure 3.6 was made of 30 gauge Aluminium sheet. To facilitate the easy discharge of chips, the chute was made at 45° inclination to the horizontal.

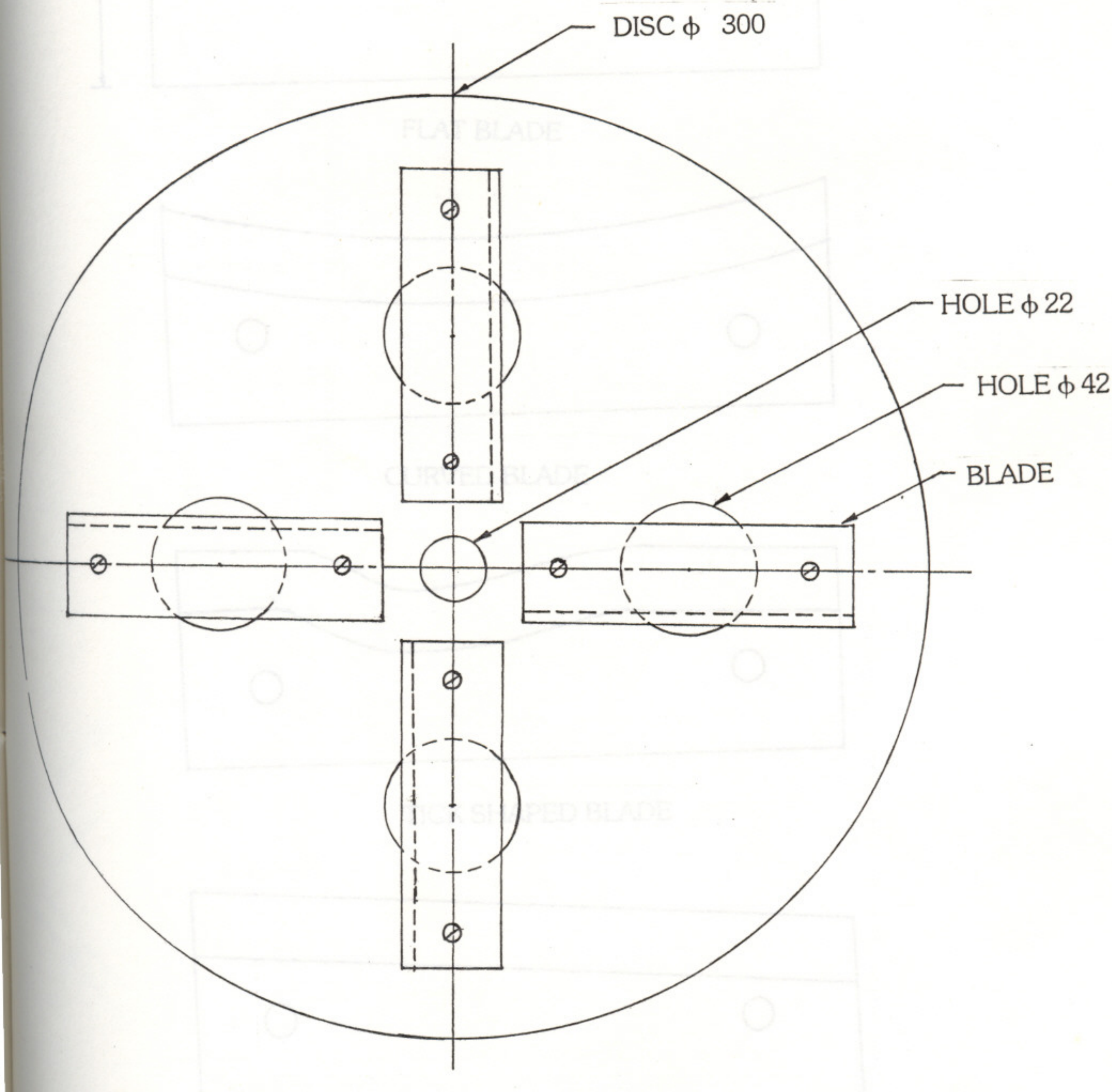
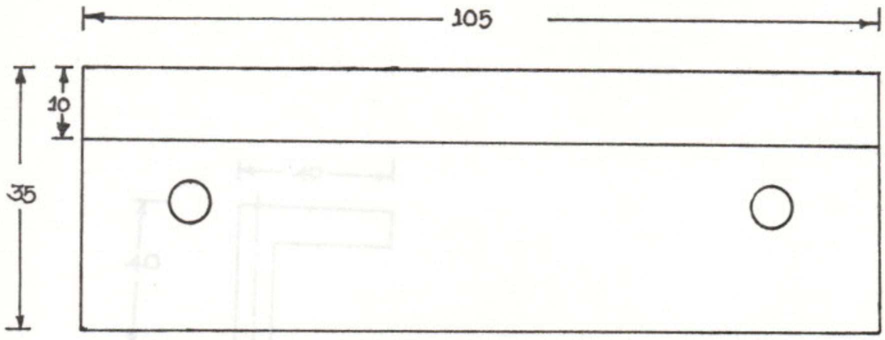
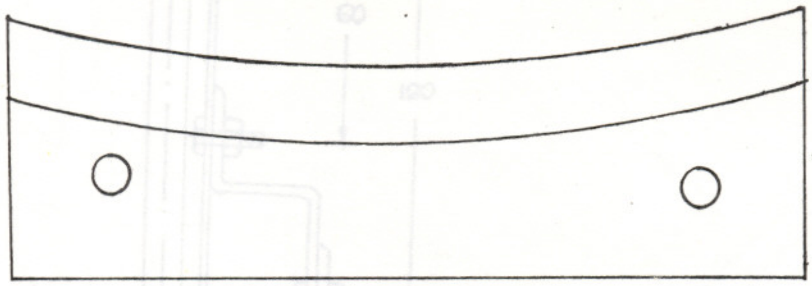


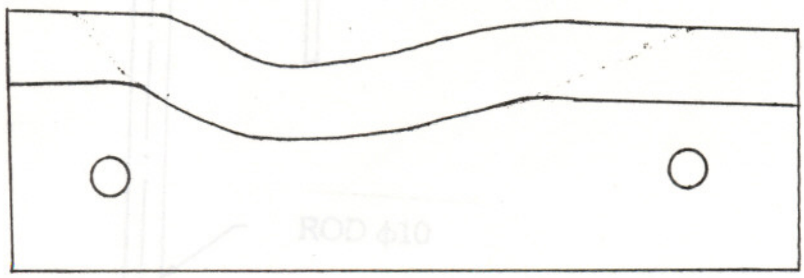
Fig. 3.3 CHIPPING DISC WITH BLADE ATTACHMENT



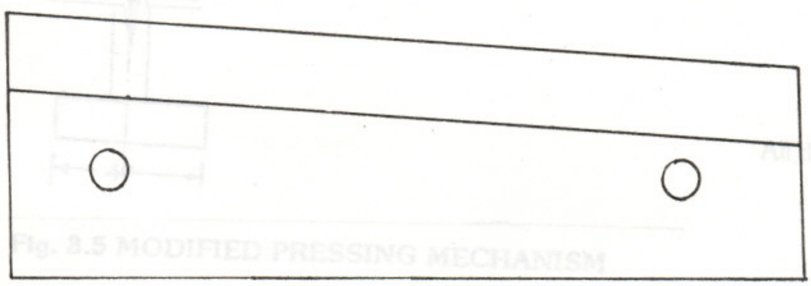
FLAT BLADE



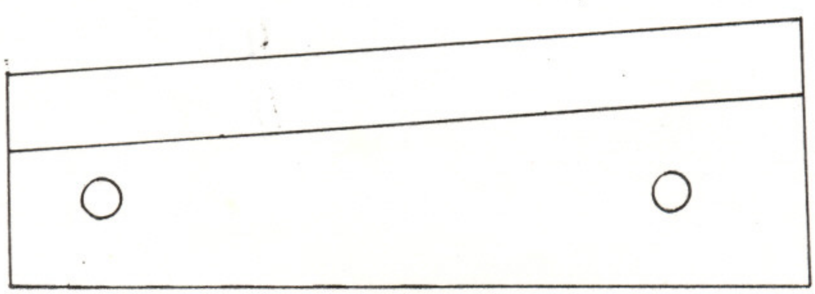
CURVED BLADE



TICK SHAPED BLADE



INCLINED [RIGHT] BLADE



INCLINED [LEFT] BLADE

Fig. 3.4 BLADES OF DIFFERENT PROFILES

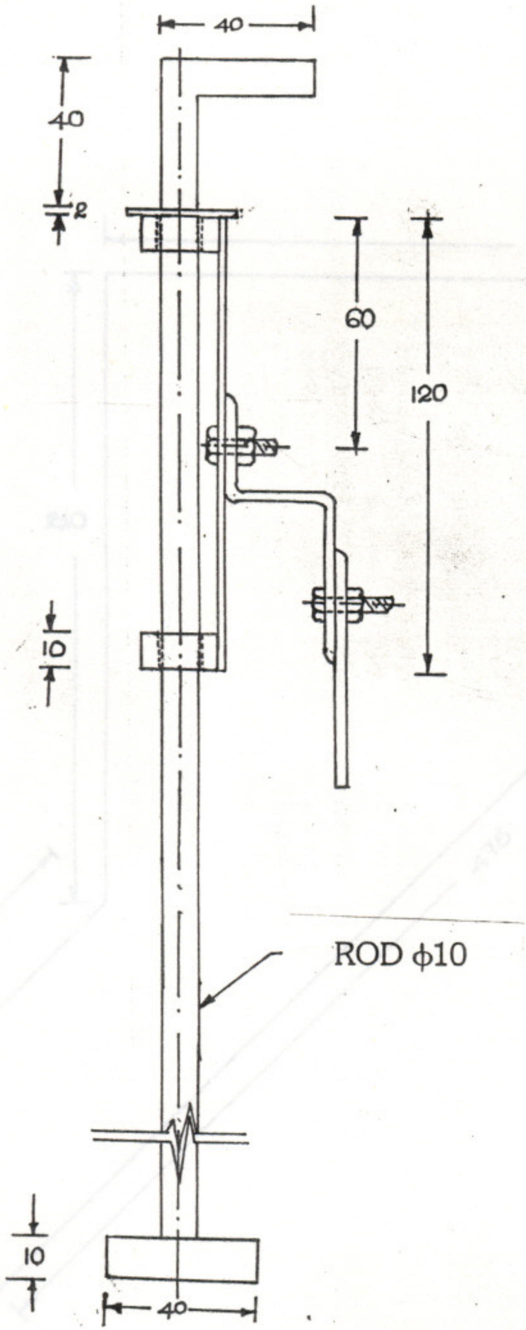
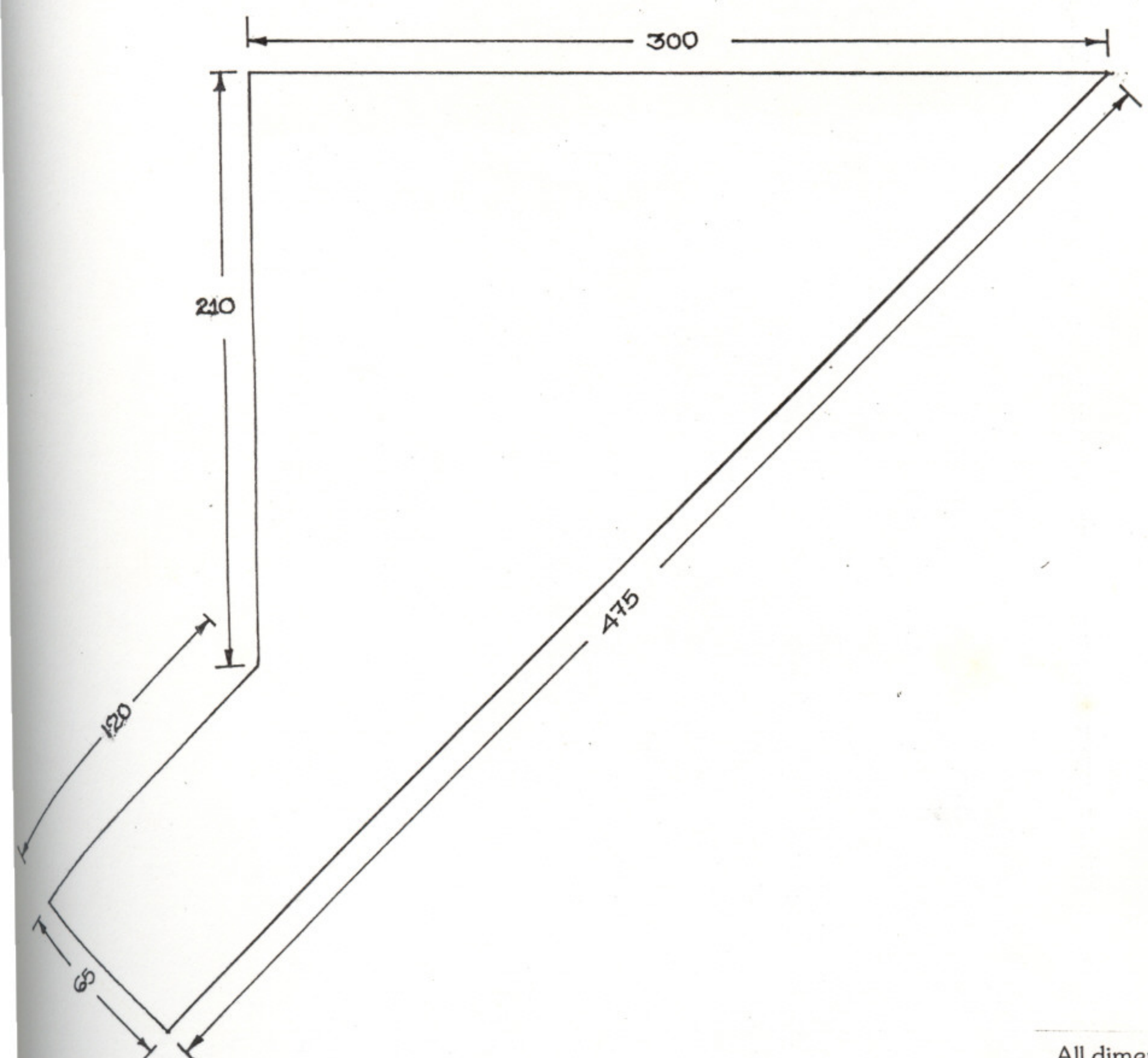


Fig. 3.5 MODIFIED PRESSING MECHANISM



All dimensions in mm

Fig. 3.6 CHIP OUTLET

3.2 Performance Evaluation

Raw green bananas of proper maturity bought from the local market was used for conducting the experiment. The bananas were peeled manually using a sharp knife. The machine was then turned on. As the chipping disc attained a set speed of 200 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 these bananas were noted and the operating capacity, roundness of chips and efficiency of chipper was then evaluated.

3.2.1 Operating Capacity

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

3.2.2. Efficiency of the chipper

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

$$\alpha = \frac{\text{Wt. of all slices-Wt. of damaged slices}}{\text{wt. of all slices}} \text{ X100}$$

3.2.3 Effective Capacity

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

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

3.2.4. Roundness of chips

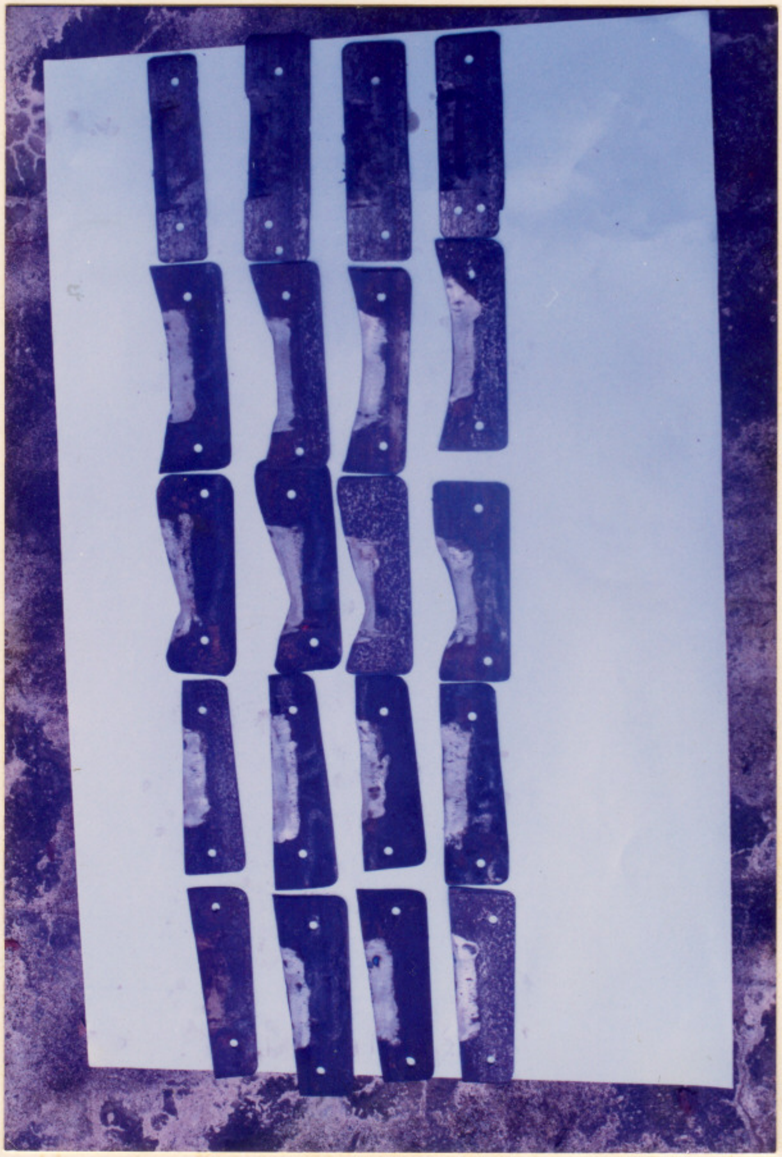
Randomly selected slices from each of the above experiment was used to assess the roundness of the slices. The profiles of these chips were drawn on a graph paper and the projected area (A_P) was calculated. A circumscribing circle was drawn for each of these profiles touching maximum possible edges of the profile. Area of circumscribing circle (A_C) was calculated for each of these profiles. The roundness was then calculated using the expression

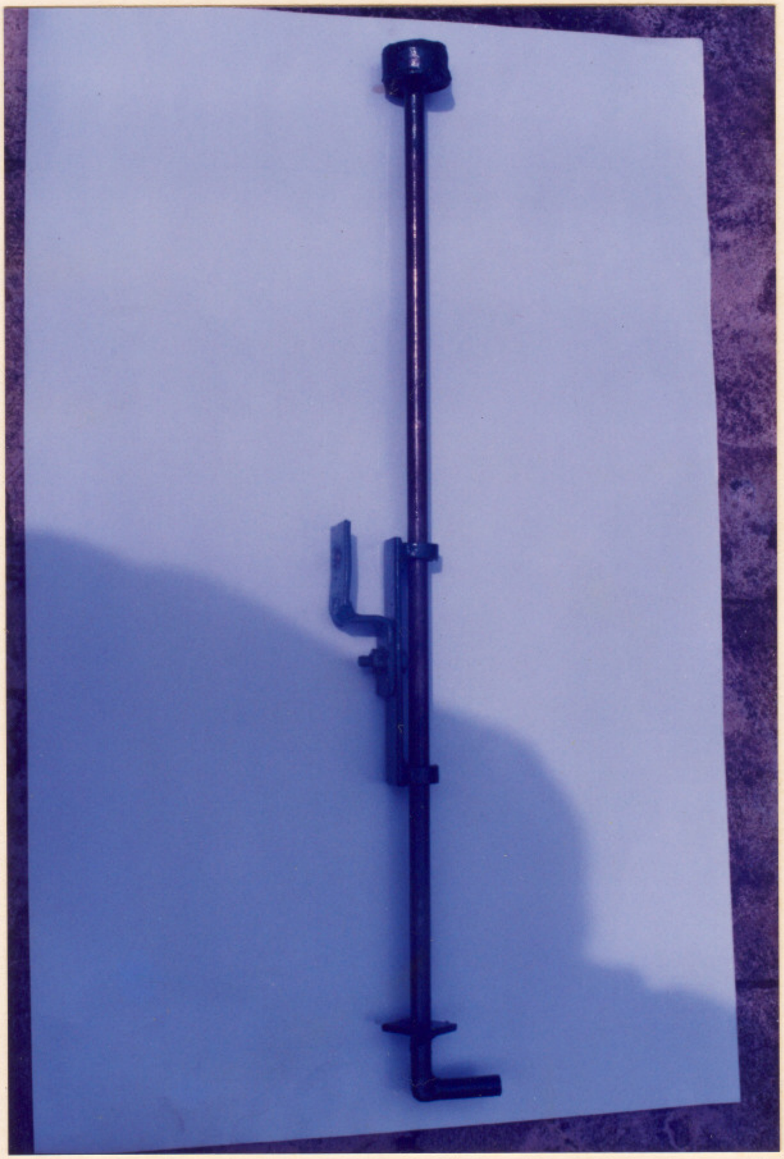
$$\text{Roundness} = A_P / A_C$$

The experiment was repeated for five different blade configurations such as flat, Curved, Tick shaped, Inclined (Right) and Inclined (left) with for different throat clearance (chip thickness) such as 0.5 mm, 1 mm, 1.5 mm and 2.0 mm. Specifications of blades are given in appendix I

3.3 Comparative evaluation of the Modified chipper, Parent machine and Manual chipping

The performance of the fabricated chipper with modified feeding mechanism was evaluated in terms of operating capacity, chipping efficiency and roundness of chips obtained. The performance was then compared with that of the parent chipper and with manual chipping . For manual chipping , peeled raw bananas were sliced using conventional stainless hand slicer by holding three bananas at a time in between the fingers and moving across the sharp edge of the slicer. The time required to chip these bananas were noted. The chipping efficiency and operating capacity were found out adopting the same procedure. The results of comparison are presented in the following chapter.





3.2 Performance Evaluation

Raw green bananas of proper maturity bought from the local market was used for conducting the experiment. The bananas were peeled manually using a sharp knife. The machine was then turned on. As the chipping disc attained a set speed of 200 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 these bananas were noted and the operating capacity, roundness of chips and efficiency of chipper was then evaluated.

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

$EC = OC \times \alpha / 100$

Chapter IV

RESULTS AND DISCUSSION

This chapter deals with the results of experiments conducted to evaluate the performance of the chipper and its comparative performance with manual chipping.

4.1 Test Details

The study was conducted with five different sets of blades of at a disc speed of 200 rpm. The specification of each of these blades are given in Appendix. The throat clearance (Thickness of chips) was varied using washers of different thicknesses. The thickness of washers used were 1.0 mm, 1.5 mm and 2.0 mm

4.2 Performance Evaluation

The modified experimental model was evaluated for its overall capacity, chipping efficiency and roundness of slices with different operating parameters such as throat clearance, blade configuration and at an optimum disc speed of 200 rpm. The results are furnished in the following tables.

Table 4.2 a Overall capacity of chipping machine with different blades and throat clearance

Blade Type	Throat Clearance	Time (Sec)	Wt. of slices (gm)	Overall Capacity (kg/hr)
Flat	0.5	17.00	502.70	106.46
	1.0	6.30	496.80	283.88
	1.5	5.90	621.14	379.00
	2.0	5.80	668.87	415.16
Curved	0.5	21.10	545.82	93.125
	1.0	8.42	585.73	250.43
	1.5	7.54	605.79	289.23
	2.0	7.29	654.83	323.37
Tick shaped	0.5	19.8	490.12	89.11
	1.0	8.43	530.46	226.53
	1.5	7.80	589.80	272.21
	2.0	7.20	624.46	312.23
Inclined(Right)	0.5	19.5	495.23	91.43
	1.0	8.5	540.32	228.84
	1.5	8.12	624.50	276.86
	2.0	7.13	631.08	318.64
Inclined (Left)	0.5	19.6	498.4	91.54
	1.0	8.58	542.82	227.76
	1.5	7.90	612.29	279.34
	2.0	7.28	640.51	316.74

Referring to the test results, the overall capacity of the machine is found to vary from 89.11 kg/hr for the Tick shaped blade with 0.5 mm Throat clearance to 415.16kg/hr for flat blade with 2 mm throat clearance.

Table 4.2 b Chipping efficiency of the machine with different blades and throat clearance

Blade Type	Throat Clearance	Wt. of slices (gm)	Wt. of damaged slices (gm)	Efficiency (%)
Flat	0.5	295.74	14.99	94.93
	1.0	306.40	10.29	96.65
	1.5	388.56	10.90	97.19
	2.0	398.42	9.8	97.54
Curved	0.5	336.46	30.2	91.02
	1.0	380.68	28.00	92.64
	1.5	359.20	23.20	93.54
	2.0	389.56	21.36	94.51
Tick shaped	0.5	310.20	35.46	88.56
	1.0	320.40	33.20	89.51
	1.5	347.60	33.60	90.33
	2.0	354.84	30.8	91.31
Inclined(Right)	0.5	250.81	24.6	90.19
	1.0	285.60	24.8	91.31
	1.5	290.84	23.00	92.05
	2.0	295.78	19.50	93.4

Inclined (Left)	0.5	245.58	24.92	89.85
	1.0	250.65	23.00	90.82
	1.5	254.79	22.63	91.11
	2.0	265.80	18.96	92.86

The Chipping efficiency of the machine varied between 88.56 percent to 97.54 percent for different machine set up as depicted in table 4.1 b. Maximum chipping efficiency of 97.54 is observed with flat blade having a disc blade gap of 2 mm.

Table 4.2 c Effective Capacity of the machine with different blades and throat clearance.

Blade Type	Throat Clearance	OC (kg/hr)	α-in decimals	EC (Kg/hr)
Flat	0.5	106.46	0.9493	101.06
	1.0	283.88	0.9665	274.37
	1.5	379	0.9719	368.35
	2.0	415.46	0.9754	404.94
Curved	0.5	93.125	0.9102	84.76
	1.0	250.43	0.9264	231.99
	1.5	289.23	0.9354	270.54
	2.0	323.37	0.9451	305.61
Tick shaped	0.5	89.11	0.8856	78.91
	1.0	226.53	0.8951	202.76
	1.5	272.21	0.9033	245.88
	2.0	312.23	0.9131	285.09

Inclined(Right)	0.5	91.43	0.9019	82.46
	1.0	228.84	0.9131	208.95
	1.5	276.86	0.9205	254.84
	2.0	318.64	0.9340	297.60
Inclined(Left)	0.5	91.54	0.8985	82.24
	1.0	227.76	0.9082	206.85
	1.5	279.34	0.9111	254.50
	2.0	316.74	0.9286	294.12

The effective capacity of the machine is found to vary between 78.91 kg/hr to 404.94 kg/hr under different set up of the machine . Maximum effective capacity of 404.94 kg/hr is obtained with the flat blade having a disc blade gap of 2 mm and disc speed of 200 rpm.

Table 4.2 d Roundness of chips with different sets of blades

Blade Type	$A_P(cm^2)$	$A_C(cm^2)$	A_P/A_C
Flat	2.5449	2.6980	0.94
Curved	2.3970	2.5776	0.90
Tick shaped	2.2203	2.5230	0.88
Inclined (Right)	2.2482	2.4980	0.90
Inclined (Left)	2.2300	2.4778	0.90

The roundness of chips obtained with different sets of blades and different throat clearance were recorded. The average values of roundness with different sets of blades is presented in the table. The roundness is found to vary between 0.88 to 0.94.

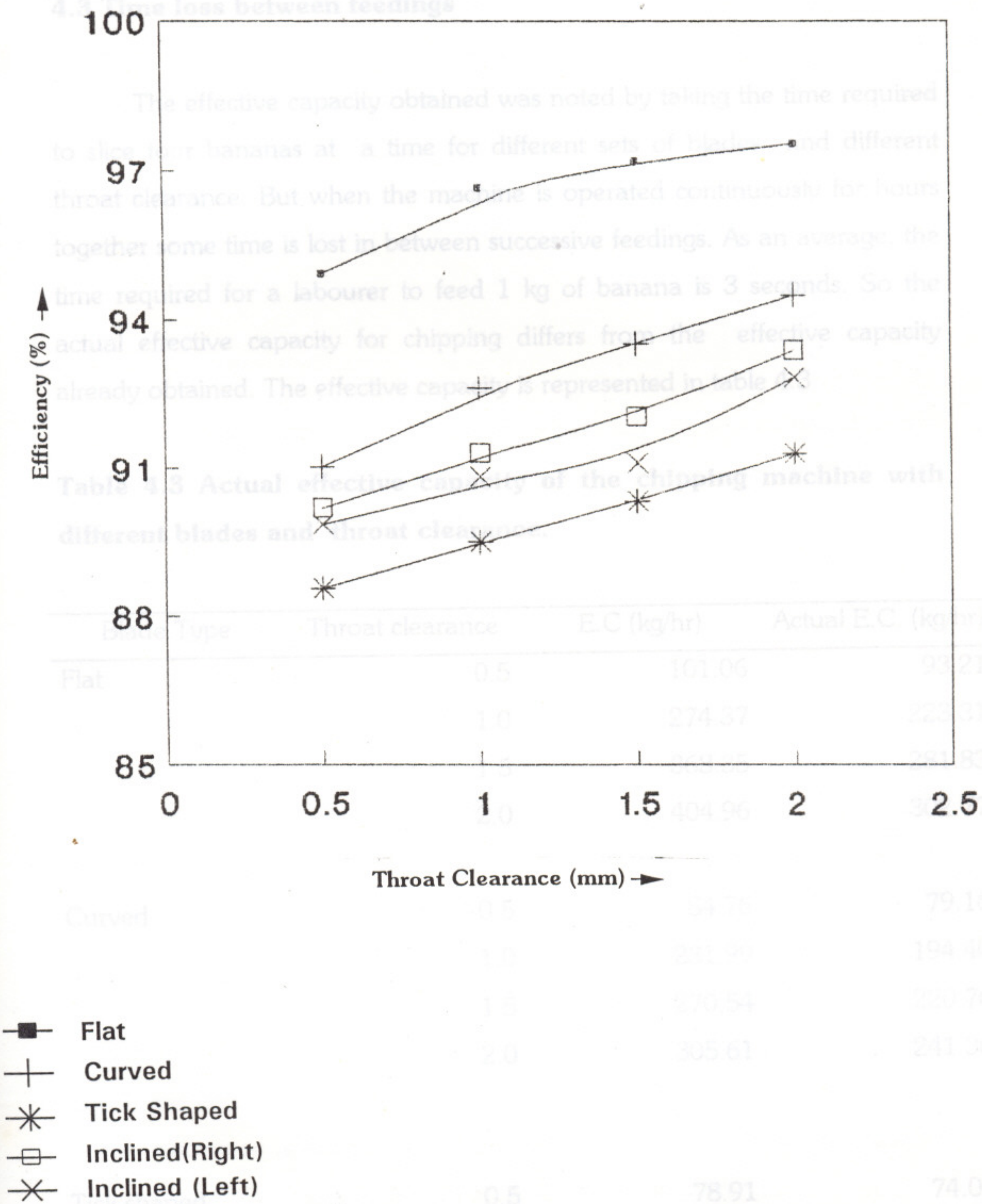


Fig 4.2 Efficiency of the Banana Chipper with different blades and throat clearance

4.3 Time loss between feedings

The effective capacity obtained was noted by taking the time required to slice four bananas at a time for different sets of blades and different throat clearance. But when the machine is operated continuously for hours together some time is lost in between successive feedings. As an average, the time required for a labourer to feed 1 kg of banana is 3 seconds. So the actual effective capacity for chipping differs from the effective capacity already obtained. The effective capacity is represented in table 4.3

Table 4.3 Actual effective capacity of the chipping machine with different blades and throat clearance.

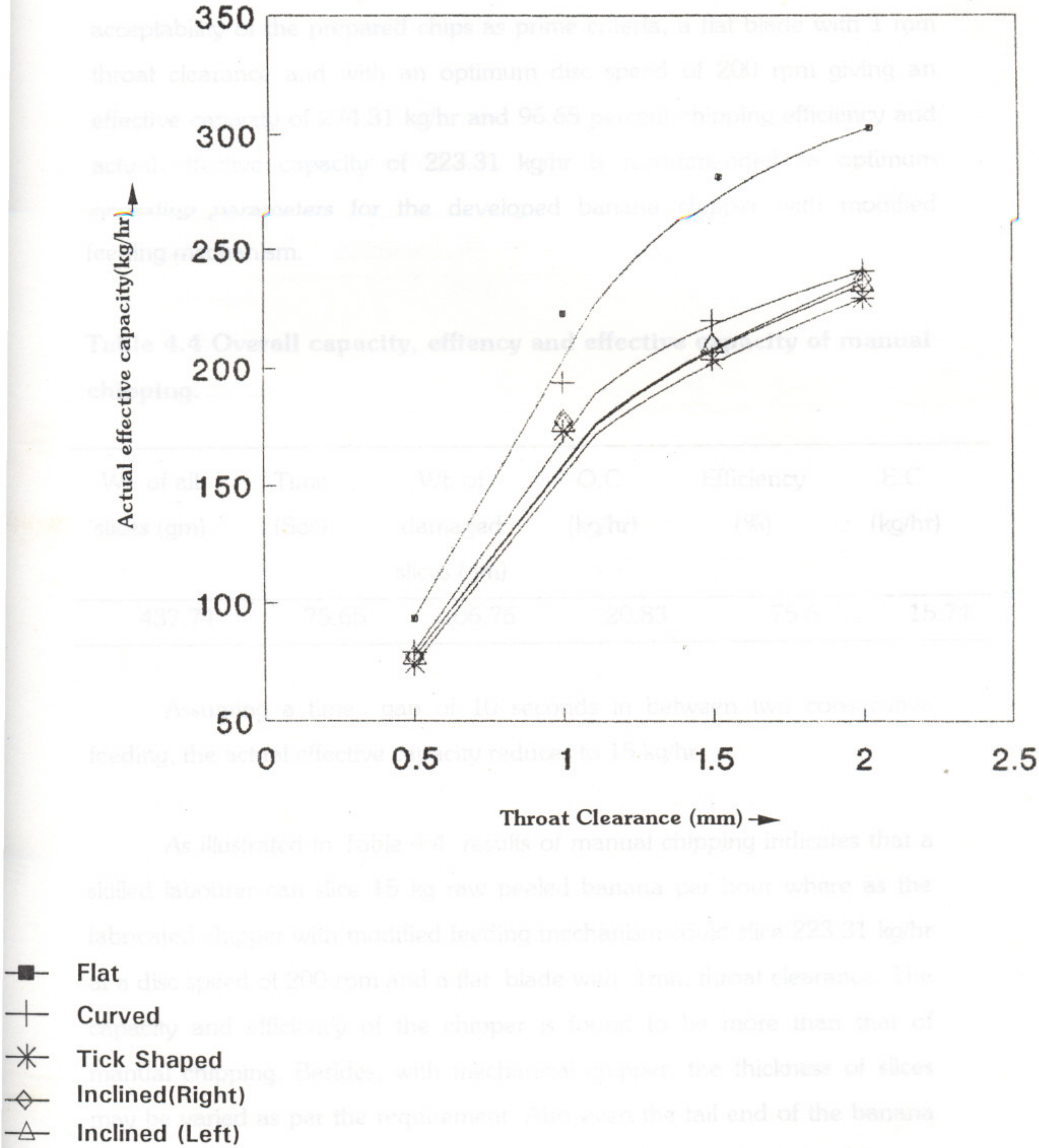
Blade Type	Throat clearance	E.C (kg/hr)	Actual E.C. (kg/hr)
Flat	0.5	101.06	93.21
	1.0	274.37	223.31
	1.5	368.35	281.83
	2.0	404.96	302.77
Curved	0.5	84.76	79.16
	1.0	231.99	194.40
	1.5	270.54	220.76
	2.0	305.61	241.36
Tick shaped	0.5	78.91	74.04
	1.0	202.76	173.45
	1.5	245.88	204.06
	2.0	285.09	204.06

	0.5	82.46	77.15
Inclined (Right)			
	1.0	208.95	177.96
	1.5	254.84	210.20
	2.0	297.60	238.46
Inclined (Left)	0.5	82.64	76.96
	1.0	206.85	176.43
	1.5	254.50	209.96
	2.0	294.12	236.22

Assuming a time gap of 3 sec/kg between successive feedings, the actual effective capacity of the chipper is found to vary between 74.04 kg/hr for Tick shaped blade with 0.5 mm throat clearance to 302.77 kg/hr for flat blade with 2 mm throat clearance for a disc speed of 200 rpm and a maximum actual effective capacity of 302.77 kg/hr is obtained for a flat blade with a throat clearance of 2 mm.

The flat blade has performed well than other blades in terms of capacity and efficiency. This may be due to the increased support which the cutting chips receive while getting cut when compared with other blades. When support area increases when the blades penetrates in to the banana, the chances of chips getting broken or sheared due to vibration and unevenness of cut becomes meagre. For the same blade configuration, the chipping efficiency and effective capacity is found to increase with increase in throat clearance. This may be due to the increase in thickness of chips by which the chips acquires an additional strength so that it do not break or shear. Also more uniform chips can be obtained due to the self weight of the rod while pressing the raw peeled banana inside the cylinder.

A proclaiming market survey on quality aspects of prepared banana chips conducted in the local markets of Trichur and Calicut revealed that chips of optimum sizes of about 1 mm thickness are preferred by the



ig 4.2 Actual effective capacity of the Banana Chipper with different blades and throat clearance

consumers. Therefore taking into account quality leading to consumer acceptability of the prepared chips as prime criteria, a flat blade with 1 mm throat clearance and with an optimum disc speed of 200 rpm giving an effective capacity of 274.31 kg/hr and 96.65 percent chipping efficiency and actual effective capacity of 223.31 kg/hr is recommended as optimum operating parameters for the developed banana chipper with modified feeding mechanism.

Table 4.4 Overall capacity, effiency and effective capacity of manual chipping.

Wt. of all slices (gm)	Time (Sec)	Wt. of damaged slices (gm)	O.C. (kg/hr)	Efficiency (%)	E.C. (kg/hr)
437.74	75.65	106.76	20.83	75.6	15.74

Assuming a time gap of 10 seconds in between two consecutive feeding, the actual effective capacity reduces to 15 kg/hr

As illustrated in Table 4.4, results of manual chipping indicates that a skilled labourer can slice 15 kg raw peeled banana per hour where as the fabricated chipper with modified feeding mechanism could slice 223.31 kg/hr at a disc speed of 200 rpm and a flat blade with 1mm throat clearance. The capacity and efficiency of the chipper is found to be more than that of manual chipping. Besides, with mechanical chipper, the thickness of slices may be varied as per the requirement. Also even the tail end of the banana can be sliced easily which is difficult in manual chipping because this may inflict injury to the operator's finger.

Comparative study of the performance of the modified machine with that of the parent machine revealed that the modified chipper performed better than the parent machine and is shown in table 4.5

Table 4.5 comparative performance of the modified chipper with parent machine and Manual chipping

Machine	Efficiency (%)	E.C. (kg/hr)	Actual E.C. (kg/hr)
Parent Machine	89.67	215.2	134.6
Modified Machine	96.65	274.35	223.31
Manual Chipping	75.6	15.74	15.0

The chipping efficiency, effective capacity and actual effective capacity of the parent machine with flat blade and throat clearance of 1mm are 89.67%, 215.2kg/hr, 134 kg/hr respectively where as the same was found to be 96.65%, 274.35 kg/hr and 223.31 kg/hr respectively for the modified machine at an optimum disc speed of 200 rpm.

Chapter V

SUMMARY AND CONCLUSION

Banana chips making has grown in to a small scale industry in Kerala and the product is acquiring high demand in India as well as abroad. There is a great scope for further development of these industry by modifying the product quality.

The traditional method of chipping raw banana is manual slicing using conventional knife or using stainless steel adjustable wooden platform hand slicer by holding three bananas at a time in between fingers and moving across the sharp edge of the slicer. These methods are cumbersome, labour intensive, time consuming and inflict injury to hand . As per the new technique, a motorised raw banana chipper was developed. The machine essentially consists of a prime mover, feeding cylinders with pressing mechanisms, chipping disc with blades and chip outlet. In operation power from the motor is taken to the disc shaft through a V-belt pulley. The disc shaft connected to a chipping disc attached with blades is rotated. Raw peeled bananas fed through the slots made in the feeding cylinders are cut during the rotation of the disc. The cut chips are then collected at the chute outlet.

This machine was evaluated for its performance using different blades and throat clearance and at a capacity, actual effective capacity of this machine using a flat blade and at a throat clearance and at a disc speed of 200 rpm. The chipping of this machine using a flat blade and at a throat clearance of 1mm which is the optimum product thickness was found to be 89.67%, 215.2kg/hr and 134.6kg/hr respectively. This study recommended *the modification of the feeding mechanism in order to further improve the* quality and quantity of chipping and to reduce the drudgery involved in feeding. Therefore the machine was modified so as to make the feeding easy.

Experimental trials were conducted at Kelappaji College of Agricultural Engineering and Technology, Tavanur to evaluate the performance of the modified banana chipper. The experiments were conducted using five different sets of blades and varying the throat clearance at a disc speed of 200rpm. The different throat clearance yields chips of different thickness. The results indicated that besides being more efficient and higher in capacity, the modified banana chipper has more advantages over parent chipper and manual chipping. It was analysed that a flat blade with 1.0mm throat clearance giving 1.0mm chip thickness performed well in terms of efficiency , capacity and product quality.

From the experimental results, it is obvious that the newly developed machine is technically and economically suitable for small scale industries.

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APPENDIX -I

Specifications of blades used

Blade type	Beved angle	length (mm)	width (mm)	Radious of curvature (mm)	Inclination from horizontal
Flat	2.5°	105	35	-	-
Curved	2.5°	105	35	200	-
Tickshaped	2.5°	105	35	-	-
Inclined(Right)	2.5°	105	35	-	4°
Inclined(Left)	2.5°	105	35	-	4°

APPENDIX -II

specification of 3 Phase induction Motor

Ampere	:1.2
V	: 4.5
Cycles	: 0.37
rpm	: 1370

Made by kirloskar Electric Co. Ltd., Bangalore

APPENDIX -III

Specification of energy mater

Ampere	: 3 x 10
V	: 4 x 400

Cycles : 50 Hz

1 K.W.h : 112.5 revoluation of disc made by General electric Co.

India (Pvt. Ltd) Culcutta

APPENDIX IV

Calculation of operating cost

Initial Cost (c)

fabrication cost of chipping machine including cost of material	= Rs. 2000/-
Initial cost of motor	= Rs. 3500/-
Average life of chipping machine	= 10 years
Average life of motor	= 20 year
working hours per year	= 2400
Salvage value	= 10% of initial cost
for motor	= Rs. 350/-
for machine	= Rs. 200/-

A . Fixed cost

1. Depreciation	= (C-S)/(L x H)
for chipping machine	= (2000-200) / (10 x 2400)
	= Rs. 0.075/hr
for motor	= (3500-350) / 20 x 2400
	= Rs. 0.066/hr

II. Interest on investment at *the rate of 15%*	=(C+S) x 15 / 2 x H x 100
for machine	= (2000+200) 15 / 2 x 2400 x 100
	= Rs. 0.069
for motor	= (3500+350) x 15 / 2 x 2400 x100
	= Rs. 0.12/hr

Total fixed Cost = Rs. 0.075+0.066+0.069+0.12

= Rs. 0.033/hr

Variable cost

(I) Labour wages

Wages of a labourer = Rs. 60.00/ day of 8hr

for 2 labourers = Rs. 15.00/hr

(ii) Cost of electrical energy

unit cost of electricity = Rs. 1/kw-hr

Energy consumption of machine = 0.15 kw-hr

Cost of electricity = Rs. 0.15/hr

(iii) Repair and Maintenance

(a) 10% of initial cost per annum

for machine =2000 x 10 x 1 / 100 x 2400

= Rs. 0.083/hr

for motor = 3500 x 10 x1 / 100 x 2400

= Rs. 0.15/hr

Total variable cost = Rs. 0.15+ 0.15+0.083+0.15

= Rs. 15.383/hr

Total operating cost = Rs. 0.33/h+ 15.383/hr

= Rs. 15.713/hr

DEVELOPMENT AND PERFORMANCE EVALUATION OF MODIFIED BANANA CHIPPER

By

LIJU. K

ABSTRACT OF THE PROJECT REPORT

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE

Bachelor of Technology
in
Agricultural Engineering

FACULTY OF AGRICULTURAL ENGINEERING
KERALA AGRICULTURAL UNIVERSITY

Department of Post Harvest Technology and Agricultural Processing

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR – 679573, MALAPPURAM.

1997

ABSTRACT

In India, chipping of raw peeled banana is carried out manually and no means of mechanical chipping device had been commercialised till the present day. The conventional method of slicing using a plat form type hand slicer has many drawbacks . To overcome the defects of conventional method, a new vertical feed mechanical chipper was developed at kelappaji college of Agricultural Engineering and Technology and the performance was evaluated with four blades and rotated at 200 rpm by a prime mover. The feeding mechanism has a pressing attachment which consists of a M.S. rod with an wooden end plate at disc and which is lifted up. The raw peeled banana is fed through the slots made in the PVC 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 blades.

By suitably adjusting the throat clearance, chips of varying thickness and uniform sizes are collected at the discharge end. The chipping efficiency of machine is 96% with an actual effective capacity of slicing 223 kg peeled raw bananas per hour. The machine can be suitably used to slice raw bananas, carrots, potatoes and commodities of such type. It can be economically and efficiently used by small scale industries.