DEVELOPMENT OF A TENDER COCONUT CUTTING MACHINE

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PROJECT REPORT

Submitted in the partial fulfilment of the requirement for the degree

Bachelor of Technology

in

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Food and Agricultural Process Engineering
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR-679 573, MALAPPURAM
KERALA, INDIA
2014

CERTIFICATE

Certified that this project report entitled **" Development of a Tender Coconut Cutting Machine"** is a record of project work done jointly by Ms. Bhavya Francis, Ms. Meenu.P.B and Mrs. Sinsha.P.V under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship to them.

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ACKNOWLEDGEMENT

We wish to express our sincere thanks to our project guide, **Er. George Mathew,** Associate Professor, Department of Food and Agricultural Process Engineering, KCA.E.T, Tavanur, for his constant encouragement, timely advice and continuous guidance. It is with a deep sense of gratitude that we express our heartfelt thanks to him. With deep sense of gratitude and due respect, we express our heartfelt thanks to **Dr. M Sivaswami**, Dean, K.C.A.E.T, Tavanur, **Dr. Santhi Mary Mathew**, Professor and Head, **Dr. Prince M.V, Dr Sudheer K.P** and other faculty members of Department of Food and Agricultural Engineering, **Dr. Jayan P.R,** Professor and head, and **Er. Sivaji K.P,** Assistant Professor, Department of FPME for their professional guidance and constructive suggestions offered during this study.

We are in short of words to acknowledge the self-less services of **Mr. Manoj, Mr. Mohammed** and other technicians without their help this venture would have been impossible for us. We exploit this opportunity to thank **Library staff, all our batch mates and students of K.C.A.ET** for their sharing and caring which always motivated us throughout the venture.

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

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

Bhavya Francis

Meenu P.B.

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DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT OF A TENDER COCONUT CUTTING MACHINE"** 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 any other university or society.

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DEDICATED TO THE ALMIGHTY GOD AND OUR LOVING PARENTS

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SYMBOLS AND ABBREVIATIONS

%	percentage
/	per
@	at the rate of
&	and
^{0}	degree
Approx .	approximately
cm	centimeter
et al.	and others
g	gram
GI	galvanised iron
hr	hour
K.C.A.E.T	Kelappaji College of Agricultural Engineering and Technology
kg	kilogram
kg/hr	kilogram per hour
kN	kilo Newton
KVK	Krishi Vigyan Kendra
M	million
Mha	million hectare
mg	milli gram
mm	millimeter

MPa	mega pascal
MS	mild steel
MT	million tones
N	newton
PHT and AP	Post Harvest Technology and Agricultural Processing
pp	page
Rs.	rupees
s	seconds
SS	stainless steel
t	tonne
viz	namely

INTRODUCTION

Chapter I

INTRODUCTION

Agricultural mechanization plays a significant role by increasing the production, reducing cost of cultivation and processing. Post harvest mechanization implies the use of agricultural machinery in performing the operations fast and efficient. Mechanization helps in increasing value addition and processing of agricultural commodities. It reduces the drudgery in performing various post harvest operations and minimizes post harvest loss.

Coconut (*Cocos nucifera.* L) is popularly known as "Kalpa Vriksha". It is one of the most useful trees in the world. Tender coconut (7 to 8 months old maturity) is valued both for its sweet water, which is a refreshing drink and the delicious gelatinous meat. The water of tender coconut, technically the liquid endosperm, is the most nutritious wholesome beverage that nature has provided for people of the tropics and is consumed fresh, largely because, once exposed to air and warm temperatures, it rapidly deteriorates. In addition, sterilizing the water using high temperature and short-time pasteurization destroys some of the nutrients and the entire flavor (Jackson, *et al.*2004a). Chemical composition and volume of the coconut water change during maturation. It indicates that quality and quantity of coconut water as well as consumer acceptability of tender nut is more after 7 months of maturity.

Coconut provides many necessities of life including food and shelter. It is mainly cultivated for its nuts; it yields oil, oil cake and fibre. Water from tender coconut is a common refreshing drink and has been used as an excellent isotonic in several tropical countries. It is not only a thirst-quenching liquid, but also a mineral drink, which is beneficial to human health (Poduval *et al*., 1998). It contains traces of proteins, fats, and minerals like Na, K, Ca, Fe, Cu, P, S, Cl, vitamin C, vitamins of the B group like nicotinic acid, pantothenic acid, riboflavin and biotin (Jean *et al.* 2009).

Coconut water contains organic compounds possessing healthy growth promoting properties. It carries nutrients and oxygen to cells, raise the human metabolism, boost human immune system, detoxify and fight viruses, control diabetes and also aids the human body in fighting against viruses that causes flue, herpes and AIDS (Poduval *et al*. 1998).

Area under coconut in India, over a period of five decades had increased from 0.62 Mha (1950-1951) to 1.892 Mha (2002). Similarly, the annual production has increased from 3,281.7million nuts to 12,821.71million nuts and the productivity increased from 5238 to 6776 nuts per ha per year (Rethinam, 2004). In Kerala the annual production is around 6 billion nuts and is likely to go up by 10 percent in the year 2013. The area under cultivation has increased to 390,000 hectares from 367,000 hectares last year.

Santoso *et al*. (1996) described the presence of vitamins, sugar, organic acids, fatty acids, amino acids, fibres and minerals in coconut water. Besides, minor constituents such as free ammonia gas also contributes to the over flavour and mouth feel (Poduval *et al*. 1998). Despite of all these uses, a common problem that many people are facing in a developing country like India is cutting the tender coconut. Present trends and tools used are unsafe, messy and need skill and training.

The extraction of water from the tender coconut is quite difficult task. One must initially cut through the thick fibrous husk to expose a part of the shell. This is done by chopping the husk in bits with a heavy machete heaving at the nut. The exposed shell is then punctured with another heave of the machete. All these require considerable training and skill. It is not at all easy to master this task. The risk of physical injury is too high.

This is evident from the increasing number of tender coconut parlours along the roadside. But almost at all places, the machete is the tool used in chopping the husk and cuttings open the shell. This has led to the owning of such parlours by only those skilled in the task. Though some attempts were made to devise simple hand tools for punching open the nut and then splitting in to two halves, these too did not result in the production of a tool

suitable for easy use by even women. Hence there was a necessity for developing a simple manual operating tender coconut cutter. It was in this context that this study was undertaken with the following objectives,

1. To study the existing methods used for tender coconut cutting.
2. To develop a manually operated tender coconut cutting machine.
3. To evaluate the performance of tender coconut cutting machine.
4. To comparatively evaluate the traditional methods and hand operated machine.

REVIEW OF LITERATURE

Chapter II

REVIEW OF LITERATURE

The coconut is well known for its great versatility as seen in the many uses of its different parts, throughout the tropic and subtropics area. Coconuts are part of the daily diets of many people. Coconuts are different from any other fruits because they contain a large quantity of "water" and when immature they are known as tender-nuts or jelly-nuts and may be harvested for drinking. When mature, they still contain some water and can be used as seed nuts or processed to give oil from the kernel, charcoal from the hard shell and coir from the fibrous husk. The endosperm is initially in its nuclear phase suspended within the coconut water. As development continues, cellular layers of endosperm deposit along the walls of the coconut, becoming the edible coconut "flesh". When dried, the coconut flesh is called copra. The oil and milk derived from it are commonly used in cooking and frying; coconut oil is also widely used in soaps and cosmetics (Anon.,2010). The clear liquid coconut water within is a refreshing drink. The husks and leaves can be used as material to make a variety of products for furnishing and decorating.

Tender coconut water is a wholesome, nutritious drink. It is one of the most preferred drinks of the city folks. The whole coconut is green coloured. To extract the water and meat, it is to be sliced from the top and strained. The water of tender coconut, technically the liquid endosperm, is the most nutritious wholesome beverage that the nature has provided for the people of the tropics to fight the sultry heat. This type is 90 to 95 percent water. The liquid from this coconut is at its purest and most healing. The water of tender coconut, technically the liquid endosperm, is the most nutritious wholesome beverage that the nature has provided for the people of the tropics to fight the sultry heat. It has caloric value of 17.4 per 100gm (Kuberski *et al.,* 1979a). "It is unctuous, sweet, increasing semen, promoting digestion and clearing the urinary path," says Ayurveda on tender coconut water.

2.1Varieties

The common varieties of tender coconut found in Kerala are as follows

1. Green tender coconut
2. Orange tender coconut
3. Yellow tender coconut

2.1.1Green Tender Coconut

This green tender coconut is highly demanded in different industries like as cosmetic, food & beverage, etc. These are preferred by the consumers owing to their following attributes:

- Delicious taste
- Sweet flavour
- Aroma

2.1.2 Orange Tender Coconut

Known for their juicy water which is different from the fluid inside ripened coconuts, this is a rich source of vitamin and nutrients. These are grown using natural fertilizers and avoid using harmful additives that cause harm to the natural growth. Due to their purity, rich taste, high nutritional value and freshness it is preferable (Chattopadhyay *et al*., 1998).

2.1.3 Yellow Tender Coconut

It is rich in taste, they are perfectly healthy to use and eat. Our Coconuts are usually grown with the methodology of organic farming.

2.2Storage

The tender coconut can be stored at room temperature and can stay best for 2 to 3 days. Once opened, drink it full, don't store for long hours as it's best to drink coconut water fresh for optimum benefits. Coconut water might turn sour, if kept for long whereas coconut meat can be kept for 2 days.

2.3. Health Benefits and medicinal properties

The major health benefits and medicinal properties of tender coconut are that it is good for feeding infants suffering from intestinal disturbances, oral rehydration medium, contains organic compounds possessing growth promoting properties (Kuberski *et al*.,1979b). It keeps the body cool, application on the body prevents prickly heat and summer boils and subsides the rashes caused by small pox, chicken pox, measles, etc. It kills intestinal worms, presence of saline and albumen makes it a good drink in cholera cases, checks urinary infections (Satyavati Krishnankutty, 1987). It is an excellent tonic for the old and sick, cures malnourishment, diuretic effective in the treatment of kidney and urethral stones. It can be injected intravenously in emergency case, found as blood plasma substitute because it is sterile, does not produce heat, does not destroy red blood cells and is readily accepted by the body, urinary antiseptic and eliminates poisons in case of mineral poisoning (Campbell *et al*., 2000; Pumer,S, 2001; Reni Lukose, 2013).

2.4 Food value

Table 2.1 Analysis of Mature and Tender Coconut Water

	Mature coconut water	Tender coconut water
Total solids%	5.4	6.5
Reducing sugar%	0.2	4.4
Minerals%	0.5	0.6
Protein%	0.1	0.01
Fat%	0.1	0.01
Acidity mg	60.0	120.0

Ph	5.2	4.5
Potassium (mg)	247.0	290.0
Sodium (mg)	48.0	42.0
Calcium (mg)	40.0	44.0
Magnesium (mg)	15.0	10.0
Iron (mg)	79.0	106.0
Copper (mg)	26.0	26.0

Santoso, *et al*. (1996)

2.4.2 Sugars

Sugars in the forms of glucose and fructose form an important constituent of the tender nut water. The concentration of sugars in the nut water steadily increases from about 1.5 per cent to about 5 - 5.5 per cent in the early months of maturation and then slowly falls reaching about 2 per cent at the stage of the full maturity of the nut. (Santoso *et al*. 1996)

In the early stages of maturity sugars are in the form of glucose and fructose (reducing sugars) and sucrose (non-reducing sugar) appears only in later stages which increases with the maturity while the reducing sugars fall. In the fully mature nut approximately 90 per cent of the total sugars are sucrose (Nadanasabapathy, S *et al*. 1999a).

2.4.3 Minerals

Tender coconut water contains most of the minerals such as potassium, sodium, calcium, phosphorous, iron, copper, sulphur and chlorides. Among the minerals more than half is potassium, the concentration of which is markedly influenced by potash mannuring (Jackson *et al*., 2004b). Tender coconut water being rich in potassium and other minerals plays a major role to increase the urinary output.

2.4.4 Protein

Coconut water contains small amounts of protein. The percentage of arginine, alanine, cystine and serene in the protein of tender coconut water are higher than those in cow's milk.

Since it does not contain any complex protein the danger of producing shock to the patients is minimized (Santoso *et al*., 1996; Pumer,S, 2001).

2.4.5 Vitamins

Tender coconut water contains both ascorbic acid and vitamins of B group. The concentration of ascorbic acid ranges from 2.2 to 3.7mg per ml, which gradually diminishes as the kernel surrounding the water begins to harden ((Nadanasabapathy, S *et al*. 1999b).

2.5 Study of physical properties of tender coconut

Chikkasubbanna, V *et al*. (1990) studied the effects of maturity on the physical and chemical parameter of tender coconut water was conducted to assess the optimum stage for harvesting the tender nuts. Data on nut weight, volume of water, weights of kernel, shell and fibre, TSS, pH, acidity, reducing and non-reducing sugars, N, protein, K and Na were recorded at monthly intervals. The results suggest that for obtaining adequate amounts of nutrients and sugars in the coconut liquid endosperm, the nuts should be harvested between the 7th and 8th month of maturity.

Uphade, B. K. *et al.* (2008) studied on some physico-chemical characteristics of coconut water. The analysis was carried out for the parameters pH, acidity, potassium, sodium, calcium, magnesium, phosphorous, iron, copper and riboflavin in tender coconut water. In present work, pollution due to industrial waste has been studied by taking tender coconut water samples at eight different places. The natural quality of ground water and soil tends to be degraded by human activities and which is ultimately found in plants. The present study is mainly concentrated in the contents of tender coconut water samples near sugar and chemical factory.

2.6 Traditional cutting methods

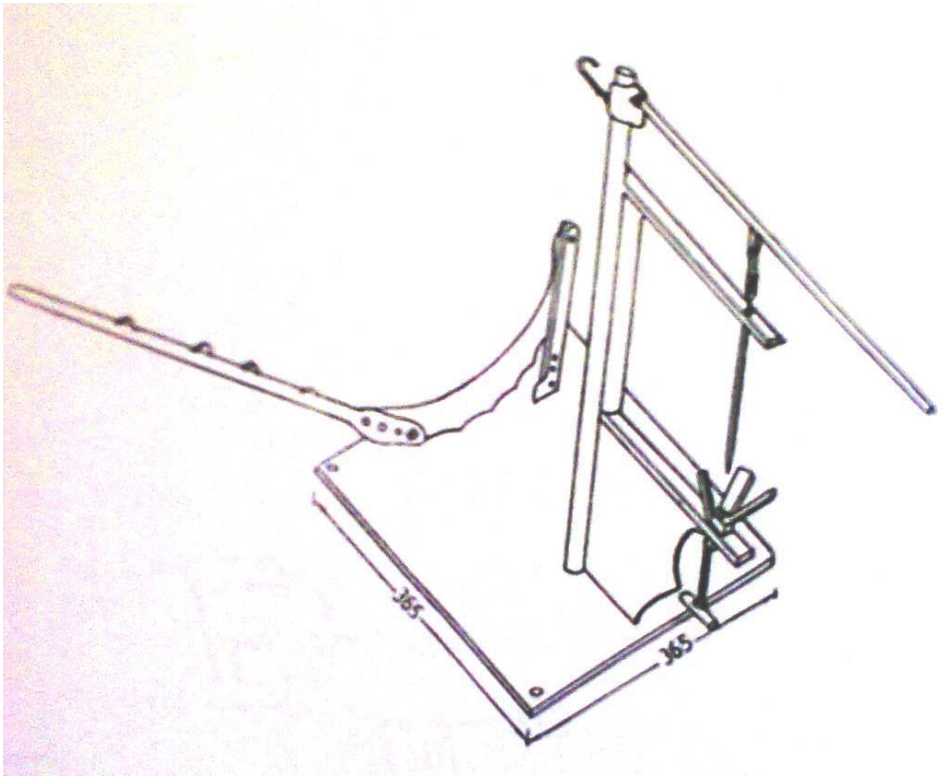
The most widely practiced method of cutting the tender coconut in the country is done manually by large knives to produce thin wafers. A few entrepreneurs use manually operated different type manual cutter.

2.7 Mechanical cutting methods

Carter (1926) has developed a coconut splitter. The invention was mainly to split open, so that kernel can be easily removed from the shell after sun drying.

Rey (1956) developed an apparatus to split open the coconuts. But the apparatus is too bulky.

Shamsudeen K.P and Anitha (1997) developed a tender coconut punch and splitter at the Kellappaji College of Agricultural Engineering and Technology, Tavanur (Fig 2.1). It consisted of a punch assembly and seat assembly. The punch was pivotally attached to a hand-lever, which was hinged along a horizontal pin mounted on a stand. The up and down swinging of the hand-lever made the punch reciprocate up and down in a sleeve. Though it could punch a hole in the tender coconut, movement of the punch through the sleeve was not easy. Further there was also a necessity to enhance the mechanical advantage of the tool.



Isometric view

All dimensions in mm

Figure .2.1.TENDER COCONUT PUNCH AND SPLITTER (Shamsudeen et al. 1997)

Jippu (1998) developed a tender coconut punch, activated by a slider crank mechanism. In this equipment, a tender coconut was placed on a ring stand and as the main hand-lever was lowered, the punch moved downward and punched the husk and shell. Difficulty was experienced in punching more matured tender coconuts due to increased hardness of the shell (Figure 2.2).

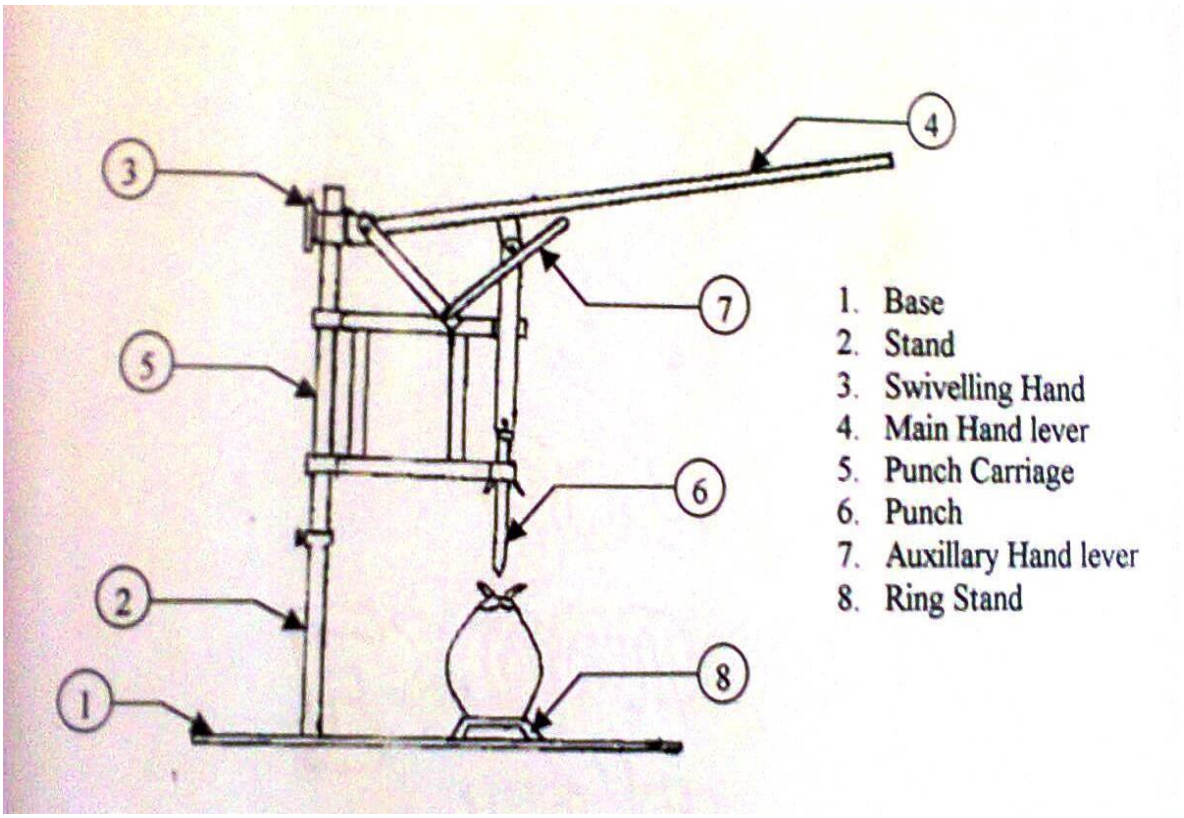
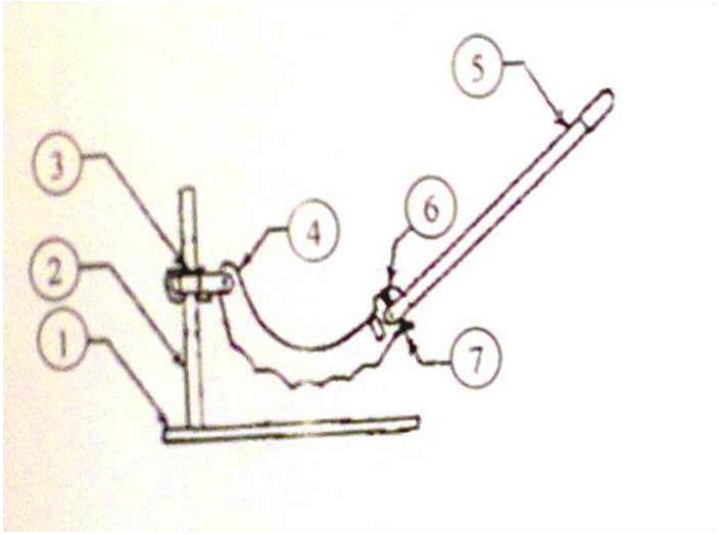


Figure. 2.2 KAU TENDER COCONUT PUNCH (Jippu 1998)

Shamsudeen *et al*. (1999) developed a tender coconut cutter in KAU (Fig 2.3). It comprised mainly a base, a stand, a swivelling head, a blade and a hand – lever. The base was a wooden plank. The stand was mounted on the base. The swivelling head was loosely mounted concentric to the stand and retained at a height of 20cm .The blade was 30 cm long and 5cm wide. Its cutting edge was serrated and tips of serration were at a distance of 4 cm. One end of the blade was attached to swivelling head through a horizontal hinge to enable the blade to be operated in a vertical plane, and the other end was pivotally attached to hand-lever 70cm in length. In operation the coconut was placed on the base such that its longitudinal axis was radial to the stand .Knife was lifted and placed on the coconut. It was then pressed down with a downward thrust splitting the coconut into two halves. This method was much safer than the traditional method, because the blade movement was through a controlled path and at a controlled speed. No special skill was required for operating it and hence an ideal tool for tender coconut parlours owned by men. It was seen that the mechanical advantage was not adequate enough to split open the over-mature nut easily. This made the operation difficult for women when splitting open such nuts. But it was experienced that the mechanical work was not adequate to split open the overripe nuts easily.

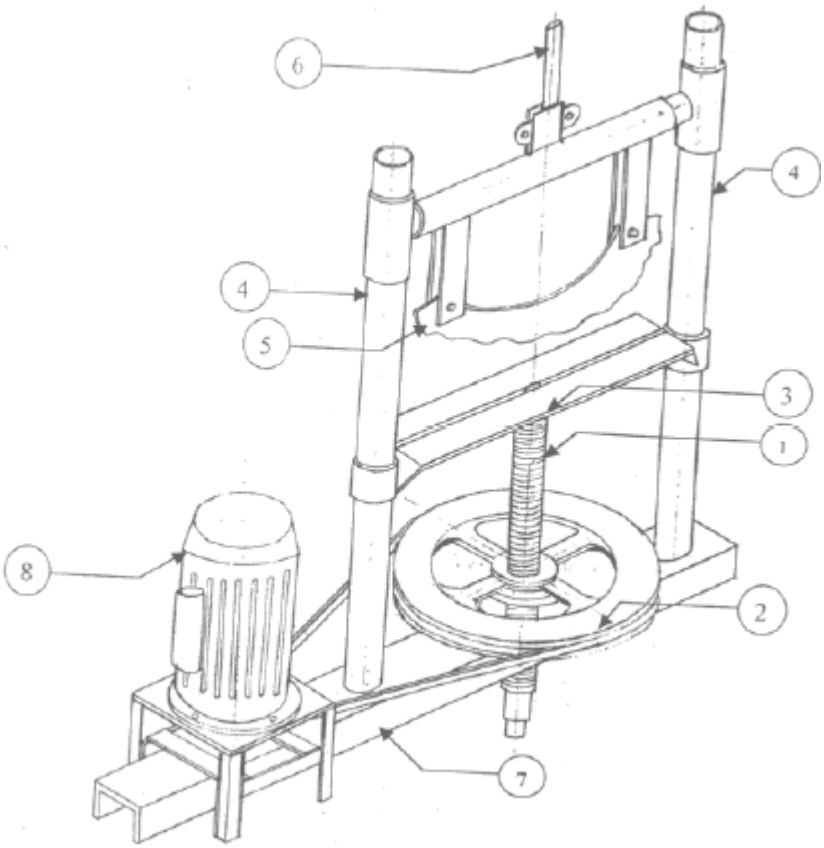


1. Base
2. Stand
3. Swivelling Head
4. Blade
5. Hand lever
6. Upper Stopper
7. Lower stopper

Plate.2.3. KAU-TENDER COCONUT CUTTER (Shamsudeen et al.1999)

Jippu *et al.* (2004) developed a power operated coconut punch-cum-splitter was developed for extracting coconut water and coconut at KCAET. The equipment mainly consists of screw rod, channel section, tapered roller bearing, pulleys, movable tray, and supporting frame, cutting blade, punch and electric motor. The nut of the screw rod was rotated with an electric motor and the drive was transmitted with a belt and pulley system. The tender coconut was placed on the top of the screw rod in natural rest position and was raised to press against either the punch or the blade fixed above the screw rod.

After the desired operation the screw was lowered by reversing the direction of rotation of the motor and thereby that of the pulley-cum main nut. Energy requirement per hour for punching was found to be 3.26W at initial position and 0.98W at raised position. Energy required per hour for splitting was found to be 3.37W at initial position and 1.14W at raised position.



1. Screw rod
2. Pulley-cum-main nut
3. Movable cross- rail
4. End columns
5. Cutter blade
6. Punch
7. Base
8. Electric motor

Figure 2.4. POWER SCREW ASSISTED PUNCH-CUM- SPLITTER (Jippu. et al. 2004)

Venkatramana Upadhya, *et al.* (2005) invented a hand tool for punching the tender coconut. This small tool can drill through a tender coconut within a minute. It was made from a stainless steel tube which was molded with an ergonomically designed plastic handle. The end of the stainless steel is having a cutting profile like a reversed saw tooth with sharp cutting edge along the periphery. In clockwise rotation, it will have smooth cutting edge which will cut the soft tender coconut fibers and not pull the fibers. In anticlockwise rotation, it will cut the hard shell like a sharp saw tooth. The tender coconut opener is having a plastic moulded stem in the middle of the tube for push out the material inside the tube, after opening the Tender Coconut.

Beloin (2008) developed a coconut splitting device that has a lowering means to lower a coconut onto blades and thereby splitting is done. The blade is stationary; the coconut is pushed down in order to split it open.

Satip Rattanapaskorn, *et al.* (2008) developed a semi-automatic cutting machine for young coconuts. The concept is that fruit cutting is accomplished by pneumatic press on a young coconut sitting on a sharp knife in a vertical plane. The machine consists of 5 main parts: 1) machine frame, 2) cutting base, 3) knife set, 4) pneumatic system, and 5) tanks receiving coconut juice and cut fruits. The machine parts contacting edible parts of the fruit are made of food-grade stainless steel. In operation, a young coconut is placed on the cutting base and the pneumatic control is switched on. The coconut is automatically moved to the pressing unit and cut in half by a knife set. The coconut juice flows down to the tank while the cut fruits are separated and moved into the other tank. The machine is found to operate safely without damage to the fruits. The machine capacity is 480 fruits/hr.

A hand-operated tender coconut punch machine has been developed by Kasargod centre to save time and drudgery involved in cutting and preparing the tender nut prior to drinking its water, by using a straw through the punched hole. A coconut cutter (cost Rs 2500, output 20 to 30 nuts/min) has also been developed by Kasargod centre to split open the tender nut into two halves.

Sreekanth (2013) developed a tender coconut cutter-cum-punching machine at KVK, Thelliyoor, near Kozhencherry. The machine's design allows easy and swift cutting and punching of tender coconuts. It takes hardly a minute to make a nut ready to serve. Women find the machine more safe and user-friendly than the conventional machine. The cutter, weighing 15 kg, consists of a 30-cm blade, 50-cm lever, and an iron stand.

Most of the machines described above were commercialized. But power consumption and cost of the machines were being the barriers to adopt. It is possible only by the skilled person and it was not economical for the common people. Based on the above it was felt that there exists a necessity to develop a manually operated tender coconut cutter.

MATERIALS AND METHODS

Chapter III

MATERIALS AND METHODS

This chapter deals with the description of methods used in development of tender coconut cutting machine. The whole work of investigations, development and fabrication, and performance evaluation was done under the following phases.

- Study of the existing traditional methods of cutting
- Study of physical properties of tender coconut which are relevant to the development of the machine.
- Development of the cutting machine.
- Performance evaluation of the machine

3.1 Study of traditional method of cutting

Analysis of the traditional method of cutting was done by investigation among the tender coconut vendors. The study was conducted to analyze time taken, tools used and risk associated or the safety regarding the operation. The merits and demerits of the existing traditional methods were studied in detail. The need and scope for a manually operated machine has also been analyzed.

3.2 Study of physical properties of tender coconut

The following physical properties of the nut which are relevant for the development of the machine were studied:

1. Size

2. Weight

3.2.1 Size

The size of the tender coconut is measured as its length, breadth, girth along major axis and girth along minor axis. The size of the nut is an important parameter which determines the dimensions of the machine components. The measurements were taken by using a measuring scale and a thread twine. The dimensions of a number of nuts were taken and an average value was found.

3.2.2 Weight

To get an average weight of a tender coconut a number of nuts were taken and weighed separately and the average value was found. The whole processes of measuring the weight of the nuts were made by using a digital weighing balance. The average value of the nuts were taken to decide the materials which are to be used for construction.

3.3 Development of the machine

Description of the machine components, fabrication considerations and procedure were narrated in this section. The essential parts of the machine were a cutting unit and a supporting structure. Tender coconut cutter which was developed has a supporting frame, coconut holding unit and a knife guiding mechanism. In order to make it easier, effective and comfort, two kinds of knives and three kinds of holdings are provided.

General layout and details of the model

Tender coconut cutting machine consisted of the following main parts

1 Knife guiding cum cutting unit

2 Holding unit

3 Frame assembly

3.3.1 Knife guiding cum cutting unit

The knife guiding-cum-cutting unit consists of one cylinder, which is freely movable and rotatable on a round shaft and two knives. The knife guiding cylinder is the main and one and only movable part in the machine. The machine makes use of two knives through which the cutting is accomplished. The cylinder unit supports the knife and guides it to move

through the plane of cut. The knife is inserted into the coconut through the slots in the cylinder and then the cylinder is rotated by using handles.

The main components of this unit are

1 Metallic cylinder

2 Knives

3.3.1.1. Cylinder assembly

The cylinder is made up of 3mm thick GI sheet. The diameter of the sheet is determined as slightly greater than the average diameter of the tender coconut. It is taken as 18 cm as the mean diameter of a tender coconut varies from 15-17 cm. The cylinder should enclose the coconut in such a way that the cylinder can rotate over it freely. There are two slots at different distances made on the top of the cylinder so that selection of distance of plane of cut from the apex is possible. GI sheet is selected because of its sufficient hardness and its high resistance to deformation. At the other end of the cylinder two handles are attached. These are made up of hollow steel pipe. The handles have sufficient length to get maximum leverage as well as convenience. The cylinder is mounted on a properly machined round shaft which is then attached to the frame assembly so that easy movement is possible.

3.3.1.2 Knives

3mm thick high carbon steel is used for making the knives. The length of knife is taken as 14 cm and the width as 3 cm. The width is gradually decreasing and pointed at the end. Both sides are precisely sharpened. A round steel pipe is used as handle. One more knife has also been made from blacksmith having length 22 cm.

3.3.2 Holding unit

The holding unit consists of a raised platform made up of angled iron frame. The height of the platform is made in such a way that the coconut placed on it will be eccentric to the cylinder. The seating of the coconut is in between two angled iron pieces so that the depression gives good seating for it. There are three types of holding clamps made so that each can be used according to convenience. The following materials are used to hold the coconut,

3.3.2.1 Metallic arc with projections

The arc is made up of one inch iron flat and it is provided with metallic projections on the inner side for grip.

3.3.2.2 Metallic clamp

This arc has more width and the length is less than the previous one.

3.3.2.3 Flat belt with holding chain

Polyuretene flat belt is used to hold the coconut. At the end metallic rings are attached for proper fixation.

3.3.3 Frame

The frame supports the entire machine components to perform its operation satisfactorily. The frame is rectangular in shape. Holding unit, cutting and supporting unit were mounted on this frame. The whole frame is made up of angled iron.

3.4 Performance evaluation of tender coconut

The performance evaluation was done to find out the capacity of the machine. The experiments were carried out with samples collected from the local market. Tender coconuts varying in size were selected for the experiment. The procedure followed was explained as follows.

1. Place the tender coconut over the seating of the machine.
2. Move the cylinder of the knife guiding cum cutting unit along the shaft to cover the tender coconut partially.
3. Put the holder over the nut to hold the tender coconut firmly.
4. Insert the knife through the slot provided on the surface of the cylinder to pierce the nut.
5. Rotate the cutting unit along with the knife using the handle while holding the coconut firmly by the holder.
6. The tender coconut is cut due to the shearing force exerted during the rotation with the knife.
7. Now the tender coconut is properly cut.
8. Take the knife from the nut and release the holder.
9. Move the cylinder to the original position.
10. Take the coconut put a small opening and serve.

The whole experiment was repeated for five times and the time taken to cut a coconut is noted by using a stopwatch and average value was found. The capacity was found accordingly.

3.5 Comparative evaluation of the traditional method with hand operated machine

The performance of the fabricated machine was compared with those of traditional operation for which tender coconut were cut and open by using conventional stain less steel knives. The time taken is noted for a skilled labor to cut and open a nut by using a stop watch. This is repeated for a number of nuts and the average is found. The same way is used to get the performance of the machine cutting. The risk associated with the cutting in both method were also eva

RESULTS AND DISCUSSION

Chapter IV

RESULTS AND DISCUSSION

This chapter deals with the results of the studies, fabrication work and experiments conducted to evaluate the performance of tender coconut cutting machine.

4.1 Traditional methods of cutting

From the analysis of the traditional cutting method, it is found that the traditional methods are more cumbersome and involves drudgery. The method used heavy machete made up of stainless steel or cast iron as the working tool. The cutting was accomplished by the impact and shear due to the chopping with machete. A skilled person takes a few second to cut the nut. It is found that only skilled persons can do it easily. The risk of operation was very high during chopping with heavy machete. So manually operated machine found more need and scope.

Plate 4.1 Traditional method of cutting using heavy machete

4.2 Study of physical properties of the tender coconut

The physical properties like weight and external dimensions were determined as described in the section 3.2.

4.2.1 Size

The diameter along major axis and diameter along minor axis of tender coconut were measured as explained in the section 3.2.1. The average of the obtained values is tabulated. The average major and minor diameters were found to be 22.3 cm and 15.2 cm respectively.

Table 4.1 Size of tender coconut

Sl.No	Major diameter (cm)	Minor diameter (cm)
1	24	16.5
2	21	15.9
3	23.1	16.8
4	22.6	15.7
5	21.1	15.2
Average	22.3	15.2

Table 4.2 Dimensions of tender coconut

Sl. No.	Properties	Value (cm)
1	Maximum major diameter	24
2	Minimum major diameter	21
3	Maximum minor diameter	16
4	Minimum minor diameter	15

4.2.2 Weight of tender coconut

Weights of whole tender coconuts were taken as described in the section 3.2.2. The obtained values of their weights are shown in the table below. The average weight found was 2.2kg.

Table 4.3 weight of tender coconut

Sl.No	Weight in kg
1	2.190
2	2.165
3	2.380
4	2.345
5	1.930
Average value	2.202

4.3 Development of Tender Coconut Cutting Machine

The machine has been fabricated as per the requirements explained in the chapter 3. The main parts of the fabricated machinery were,

1. Knife guiding cum cutting unit
2. Holding unit
3. Frame assembly

4.3.1 Knife guiding cum cutting unit

This unit consisted of the following parts.

1. Cylinder assembly
2. Cutting tool – knife

Plate.4.2 Cylinder assembly

1. Cylinder Assembly

The cylinder assembly was made as explained in the section 3.3.1.1. The cylinder was made from GI sheet. It is found that it is having strength and hardness enough to prevent deformation during working. The handles fixed to the cylinder provide good leverage on rotation due to its length. The cylinder with 18 cm diameter is found to be suitable because it can enclose because it can enclose nuts with a wide range of diameters. It is observed that the length of the cylinder is sufficient to hold the husk which got rid off the nut and prevent it from falling during operation. The risk of injury was reduced to a great extent due to the enclosing of knife during operation. It is also noted that the movability along the shaft makes the engagement easier. The slots made on the surface of the cylinder were complying with the width and thickness of the knives. The following defects were also noted.

1. The metallic surface of the cylinder assembly got damaged due to the sharpness of the inserted knife.
2. The unit lacks sufficient moment of inertia and hence it was difficult to achieve a smooth rotation.
3. When small sized nuts were being fed the cylinder assembly failed to function.

Plate 4.3 cylinder assembly showing handle

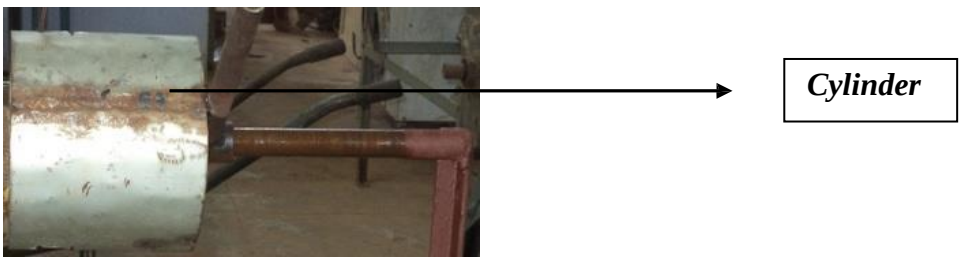


Plate.4.4 Cylinder assembly showing the cylinder mounted on the shaft

2. Knife

The cutting tool in the machine was the knife. As described in the section 3.3.1.2, the knife was developed. Two types of knives were developed.

1. High carbon steel knife

It was found that the knife during insertion reaches only half of the diameter of the nut. i.e., a complete rotation of the cylinder is required to cut the coconut.

Plate.4.5 ***Knife made out of high carbon steel***

2. Cast iron knife

The cast iron knife had length more than the previous one, it could penetrate through the entire nut. i.e., only a half rotation is required to accomplish cutting.

Plate.4.6 ***Knife made out of cast iron***

It is found that the knife made out of high carbon steel performed well during the experiments.

4.3.2. Holding Unit

Performance of holders

The trials made with various holders shown different effectiveness in holding of tender coconut. The results obtained with different materials are explained below.

4.3.2.1 Metallic arc with projections

The arc with radius of curvature 9 cm and length 28 cm is used. It provides satisfactory area of contact that helps in proper holding. The projections on the arc gives more grip between the holder and coconut. This holder is applicable only for tender coconut having a minor diameter in between 16 to 20 cm. Due to the lack of flexibility of the holder, it is difficult to hold coconuts with diameter less than 16 cm.

Plate 4.7 Metallic clamp with projections

4.3.2.2. Metallic arc

The two inch width arc gives more area of contact within less arc length. It is suitable for small, medium and large sized coconuts because of its specific curvature. The round pipe handle attached to the arc shows more comfortability during operation.

Plate 4.8 metallic arc

4.3.2.3. Flat belt

Due to the flexibility of the belt, the holding will not depend on the size of the nuts. The belt is wrapped on the coconut and then it is tightened by means of hook and chain. The coconut gets tightened due to the friction between the nut and belt. This makes the hands free during operation. It eliminates the effort to hold the nut. The whole effort can be given to the rotation of the cylinder only. This method requires precise tightening

Plate 4.9 flat belt with holding chain

4.3.3.Frame assembly.

The frame assembly provided sufficient structural support.it is found that it supports the cylinder assembly and the holding unit properly. Also the height of mounting the cylinder is found very convenient for easy operation.

Plate 4.10 Frame assembly

THE DEVELOPED MACHINE

Plate 4.11 Tender coconut cutting machine

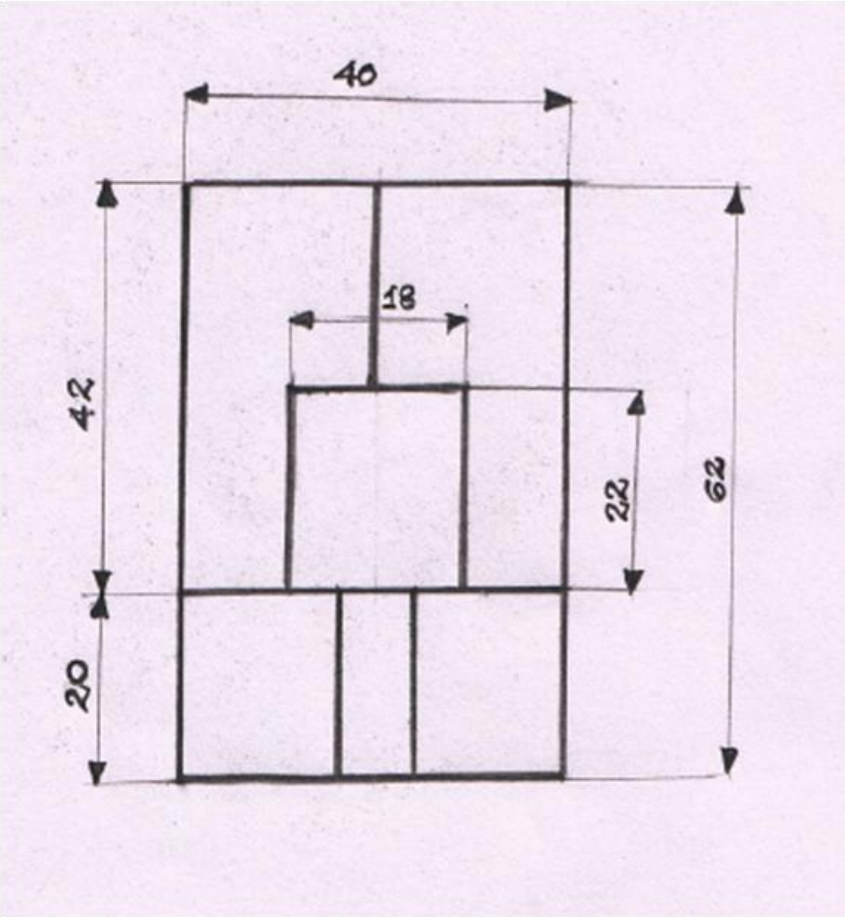


Fig 4.1 Plan of tender coconut cutting machine

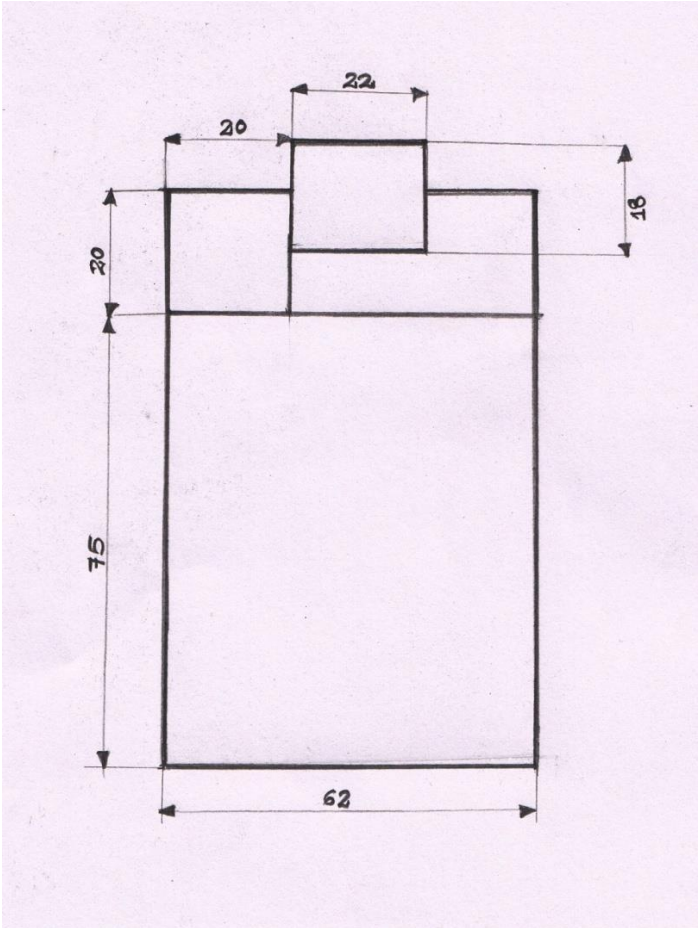


Fig 4.2 Elevation of tender coconut cutting machine

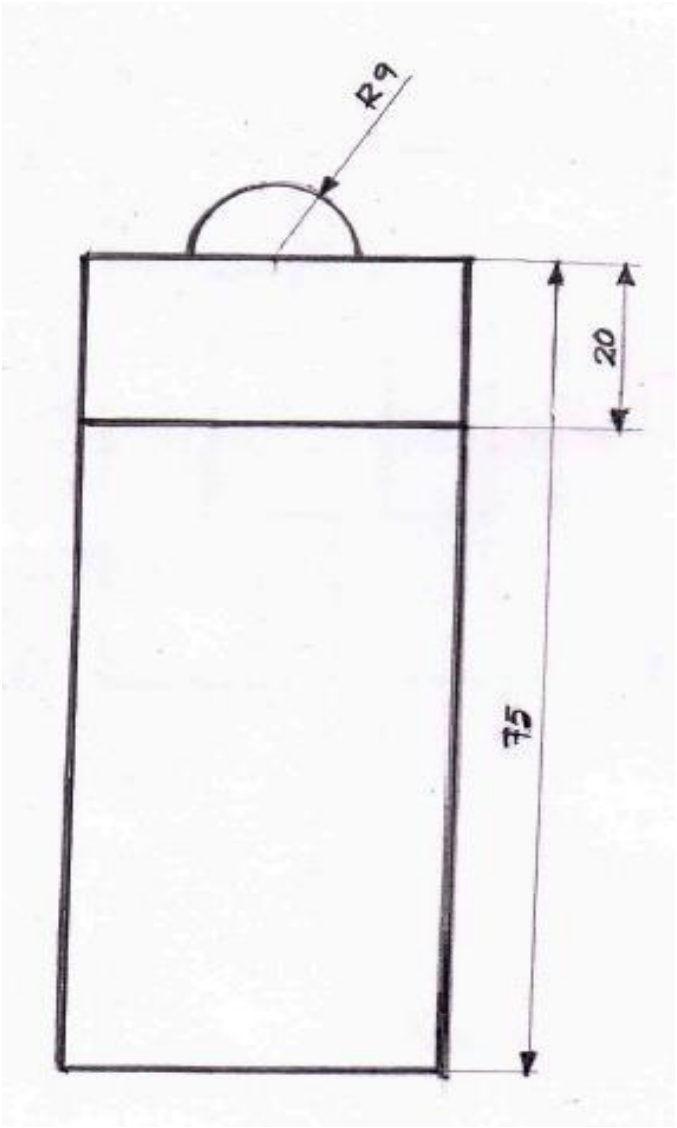


Fig 4.3 Side view of tender coconut cutting machine

4.4 Performance Evaluation of tender coconut cutting machine

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The fabricated machine was evaluated as explained in the section 3.4, for its capacity and performance.

Plate.4.4. Machine during operation

Capacity

The overall capacity was found as explained by the number of tender coconuts in a minute. The average time taken to cut a tender coconut by using this machine was found to be 50 seconds.

Table 4.4 Time required to cut the tender coconut by machine

Sl No	Time taken (second)
1	55
2	49
3	50
4	52
5	47
Average	50.6

Plate4.5.Tender coconut after cutting

Plate 4.6. Coconut after cutting and opening

4.5 Comparative evaluation of the traditional method with hand operated machine

The comparison of the traditional method and machine operation has been done as explained in the section 3.5. The comparison is done with respect to the time taken and the risk associated with the operation. It is found that the conventional method is faster than the machine operated method but huge effort required and high risk is involved. The risk of injury is very much reduced due to the enclosure of knife during operation.

Table.4.5 Comparison of traditional method with hand operated machine.

Sl. No	Time taken in second	
	Using machine	**Traditional method**
1	55	11
2	49	9
3	50	12
4	52	10
5	47	13
Average	50.6	11

Eventhough the efficiency of the machine is low compared to the conventional methods the operation is very smooth and even women can operate it without the fear of any physical injury. The fear of physical injury is preventing the women from the entry into tender coconut business. Thus this fear psychosis is completely eliminated by the machine. The current machine is only a prototype and many improvements are possible and they are listed at the end of chapter 5.

SUMMARY AND CONCLUSIONS

Chapter V

SUMMARY AND CONCLUSIONS

Coconut (*cocos nucifera* L) is valued both for its sweet water, which is a refreshing drink and the delicious gelatinous meat. The water of tender coconut, technically the liquid endosperm, is the most nutritious wholesome beverage that nature has provided for people of the tropics and is consumed fresh, largely because, once exposed to air and warm temperatures, it rapidly deteriorates.

Area under coconut in India, over a period of five decades had increased from 0.62 Mha to 1.892. Similarly, the annual production has increased from 3,281.7million nuts to 12,821.71million nuts. 17% of the coconut production in India is used for tender coconut water. But the tender coconut processing is minimum mainly due to the experience and skill required for cutting the nut by the road side vendors. Another reason is the lack of simple, safe and cheap tools for cutting open the nut.

The hand operated coconut punch–cum-splitter developed by Dept. of FPME, KCAET, though it was safe in operation it had many disadvantages like, It could not be easily used by women, when the nut was hard or mature, It required physical efforts, The tender coconut had to be shifted from punching platform to the cutting platform to the cutting platform for getting the two operations done one after the other.

The power screw assisted punch-cum –splitter for tender coconut developed in KCAET takes less time to operate. But it's not feasible for the common people due to its higher cost. So the manually operated machines are more comfortable than the power operated machines.

In this method, the coconut is placed over the seating .The holder is used for holding the coconut tightly on the stand. The cylinder is then moved along the shaft to cover the end portion the coconut. Then knife is inserted through the convenient slot on the cylinder into the coconut by applying pressure. Then the cylinder is rotated at 360^0 by using handles, so that a plane of cut is made, which is perpendicular to the longitudinal axis of the coconut and the two portions will separate. After the rotation the knife is released. The holder is then loosening to take out the coconut from the machine. The time required for the operation was

noted and operating capacity was evaluated. A skilled labour can done it within a short period of time (less than ten seconds). The cutting capacity of the machine was found as one nut per minute.

The developed cutter takes a few seconds more than the traditional method. But it reduces the effort, so that it can be simply operated even by a woman. It is simple in construction and operation and economically viable. The cost of the machine is about Rs.2500/-. Modifications of the machine can further improve the performance. Some suggestions that may help for the future research works are given below.

1. The cutting unit could be motorized so as to increase the capacity.
2. Another holding mechanism/material will help for the proper holding.
3. By incorporating different types of knives and cylinder assembly, the machine could be used for cutting the different types of fruits and vegetables.
4. The machine can be modified as a multi tool for fruits and vegetables.

APPENDIX

APPENDIX I

CALCULATION OF OPERATING COST

Initial cost (C)

Fabrication cost of tender coconut cutting machine including cost of material (C)

= Rs. 2500

Average life of machine (L) = 8 years

Working hours per year (H) = 1825

Salvage value (S) = 10% of initial cost

A) Fixed cost

1. Depreciation = C- S/LxH
   = 2500-250/ 8x 1825
   = 0. 1541 / hr
2. Interest on investment at 12% = (C +S) x 12 /(2x H 100)
   = (2500+ 250) x 12/ 2x 1825x 100
   = Rs. 0. 0904/ hr
3. Total fixed cost = depreciation+ interest on investment at 12%
   = 0. 1541+ 0.0904
   = 0. 2445/ hr

B) Variable cost

1. *Labour wage*

Wage of one labour = Rs 500 / 8 hr
= Rs 62.5/hr

2. *Repair and maintenance cost*

@ 10% of initial cost per annum = (2500 x 10)/ (1825 x 100)

= 0. 1370/ hr

Total variable cost = 62.637/ hr

Total operating cost = Total fixed cost + total variable cost

= 62.637 + 0.2445

= 62.8815/ hr

The operation cost per nut = 62.8815/71

= 88 paisa/nut (approx.)

Income generation from a small scale tender coconut parlour run by a woman entrepreneur

There are 978 panchayaths, 60 municipalities and five corporations in Kerala. These constitute more than 18,000 wards in the state. Considering one women entrepreneur in one ward, nearly 18,000 women can be gainfully employed in tender coconut parlor business.

Assuming that 150 tender coconuts can be sold by a parlour owner in one day, the cost and profit will be as follows.

1. Procuring coconuts at = Rs 15 per nut
2. Cost of operation of machinery =88 paisa per nut
3. Total cost = Rs 15.88
4. Selling price =Rs 25
5. Profit =Rs 9.15
6. Profit from 150 coconuts =150*9.12
   =Rs 1368
7. Daily rent for sapce =Rs 100
8. Net profit per day =Rs 1368-100
   =Rs 1268.

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DEVELOPMENT OF A TENDER COCONUT CUTTING MACHINE

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PROJECT REPORT

Submitted in the partial fulfilment of the requirement for the degree
Bachelor of Technology
In
Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Food and Agricultural Process Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

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2014

ABSTRACT

Coconut is one of the most useful trees in the world. Tender coconut is valued both for its sweet water, which is a refreshing drink and the delicious gelatinous meat (kernel). But the extraction of water from the tender coconut is a difficult task. But almost at all places, the machete is the tool used in chopping the husk and cut opening the shell. This effort requires considerable training and skill. The risk of physical injury is also too high. Though some attempts were made to devise simple hand tools for cutting the fruit, these too did not result in the production of a tool suitable for easy use by women. To overcome this limitation, a hand operated Tender Coconut Cutting Machine was developed at KCAET Tavanur. The developed tender coconut cutting machine consists of a knife guiding cum cutting unit, holding unit and a stand. In this method the coconut is held tightly by a holder and a knife is inserted via a cylindrical unit. This cylindrical unit is attached with a handle. The cylindrical unit is rotated with the help of the handle. The tender coconut is held firmly with the help of the metallic holder. Thus the tender coconut is held firmly and the cylinder with the cutting tool is rotated. On rotation of the cylinder, the cutting is accomplished. It is found that an unskilled woman labour could operate the machine without any training. The time taken for cutting one tender coconut was less than 12 seconds. It is safe to use and economical. It is found that if a women entrepreneur who purchase this machine for Rs 2500/ can earn about Rs 950 per day easily. Women are not coming forward for starting tender coconut parleys due to the fear of physical injury of their hands while cutting tender coconuts and this problem is effectively solved in this research work.