DEVELOPMENT OF A USER FRIENDLY TOOL FOR PULP/SEED SEPARATION FROM TODDY PALM FRUIT

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT OF A USER FRIENDLY TOOL FOR PULP/SEED SEPARATION FROM TODDY PALM FRUIT"** is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

Place: Tavanur

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CERTIFICATE

Certified that this project report entitled **"DEVELOPMENT OF A USER FRIENDLY TOOL FOR PULP/SEED SEPARATION FROM TODDY PALM FRUIT"** is a record of project work done jointly by Fathima K S (2014-06-008), Keerthana E (2014-06-010), Misha M R (2014-06-011), Shimi W U (2014-06-017) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship to them.

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Fathima K S

Keerthana E

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Shimi W U

DEDICATED TO OUR

PROFESSION OF

FOOD ENGINEERING

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&	And
et al.	and others
cm	Centimeter
^{o}C	Degree Celsius
/	Divided by
=	Equal to
ft.	Feet
FAPE	Food and Agricultural Process Engineering
G	Gram
Hr	Hour
J.	Journal
KCAET	Kelappaji College of Agricultural Engineering & Technology
Kg	Kilogram
M	Meter
MN	Mega Newton

mm	Millimeter
No.	Number
%	Percentage
Rs.	Rupees
S	Second
Sl.	Serial
SS	Stainless Steel
ie.	That is
UTM	Universal Testing Machine

INTRODUCTION

CHAPTER 1

INTRODUCTION

Palmyrah tree belongs to the kingdom Plantae, order Arecales and family Arecaceae. It is the official tree of Tamil Nadu. In Tamil culture it is called karpaha,"nungu" "celestial tree", and is highly respected because all its parts can be used. In ancient times, dried palm leaves were used to write manuscripts. Palakkad District of Kerala State is popularly known as land of Palmyra trees. Many people especially in eastern Palakkad live on earnings by tapping Palmyra toddy, which is sold in outlets controlled by co-op societies. The district authorities are taking action to preserve these trees and maintain Palakkad's identity. There are five main species in *Borassus* family.

- *Borassus aethiopum*
- *Borassus akeassii*
- *Borassus flabellifer*
- *Borassus heineanus*
- *Borassus madagascariensis*

Borassus flabellifer, commonly known as doub palm, palmyra palm, tala palm, toddy palm or wine palm is native to the Indian subcontinent and Southeast Asia, including Nepal, India, Bangladesh, Sri Lanka, Cambodia, Laos, Burma, Thailand, Vietnam, Malaysia, Indonesia and the Philippines.

Nungu fruit has high amount of water content which makes it an ideal fruit in summer season. Besides quenching the thirst it also contains nutrients which contribute to our health. The fruit is used to treat digestive issues and stomach ailments. It also have many ayurvedic benefits. Nungu contains various vitamins and minerals Vit C, Vit A, Vit B, potassium, iron, calcium etc. These are good for liver and spleen disorders. The fruit's ability to make tasty and potent alcohol increases its importance.

Tamil Nadu is pioneer in development of palm products industry in India. Out of estimated 8.59 crores of Palmyra in India, about 5.10 crores of Palmyra are in Tamil Nadu. It is a potential centre for the growth and development of palm products industry to a greater extend so as to attract foreign exchange by way of export of palm products. Preserved Nungu is one of its value-added products promoted for sale. The edible palm products such as neera, palm jaggery, palm sugar, palm candy, preserved nungu, palm fruit jam and palm chocolate varieties are available in market.

Traditionally, the sugar free pulp/seed of the toddy palm fruit is separated by using a hard knife. This manual method is laborious, more time consuming and also unsafe. Only skilled person can do the work without drudgery. To overcome these difficulties and to ensure the maximum utilization of nungu an attempt was undertaken at Kelappaji College of Agricultural Engineering and Technology, Tavanur to develop a gender friendly pulp/seed separating tool. This tool can bring a user friendly safe operation and it can be used in collaboration with tender coconut parlours.

The objectives of this project are

1. To study physical and mechanical properties of palmyrah fruit

2. Development of a mechanical tool for removal of pulp/seed from palmyrah fruit.

3. To evaluate the performance of the developed mechanical tool.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

This chapter deals with the literature pertaining to the design, cultivation, scenario, benefits and processing equipments of palm fruit.

2.1 PALMYRA PALM

Borassus (Palmyra palm) is a genus of five species of fan palms, native to tropical regions of Africa, Asia and New Guinea. These massive palms can grow up to 30 m (98 ft) high and have robust trunks with distinct leaf scars. The leaves are fan-shaped, 2–3 m long and with spines along the petiole margins (no spines in *B. heineanus*). The leaf sheath has a distinct cleft at its base, through which the inflorescences appear; old leaf sheaths are retained on the trunk, but fall away with time. All *Borassus* palms are dioecious, with male and female flowers on separate plants; male flowers are less than 1 cm long and in semi-circular clusters, sandwiched between leathery bracts in pendulous catkins; female flowers are 3–5 cm wide, globe-shaped and solitary, sitting directly on the surface of the inflorescence axis.

Borassus aethiopum is a solitary palm to 25 metres (82 ft) in height and 1 metre (3 ft 3 in) in diameter at the base. In the river bottoms (floodplains) of many East African rivers (the Rufiji in Tanzania and the Tana in Kenya among others) a closely related form can be up to seven feet (2.1 meters) thick at breast height (4 feet (1.2 meters) above ground) and having the same thickness in its upper ventricosity. It also has a height of up to 100 feet (30.5 meters). The fan-shaped leaves are 3 metres (9.8 ft) wide (larger, to 12 feet in the bottomlands form) with petioles 2 metres (6 ft 7 in) long and the margins are armed with spines. In male plants, the small flowers are largely concealed within the scaly catkins; the much larger female flowers reach 2 centimetres (0.79 in) wide and produce yellow to brown fruits.

Each fruit contains 1-3 seeds, each enclosed within a woody endocarp. The floodplains variety is almost certainly the most massive of all palms.

The tree has many uses: the fruit are edible, as are the tender roots produced by the young plant; fibres can be obtained from the leaves; and the wood (which is reputed to be termite-proof) can be used in construction

Fig.2.1 *Borassus aethiopum* plant

Borassus akeassii is a species of Palmyra palm from west and central Africa from Senegal to Congo-Kinshasa.

Borassus heineanus is a species of a large solitary fan palm found only in northern New Guinea, in both Papua New Guinea and Indonesia, where it is threatened by habitat loss. Also known as the New Guinea Palmyra palm, it grows up to 20 m tall with a robust trunk ringed with leaf scars and the old leaves remain attached to the trunk, but eventually fall cleanly. The blueish-green leaves are deeply dissected, up to 3.2 m across and the petioles have very sharp edges, which can give a nasty cut to the unwary.

The male flowers are 1.5 cm long and in semi-circular clusters enclosed within leathery bracts, forming massive catkin-like inflorescences. In contrast, the female flowers are golfball-sized, solitary and rest on the surface of the inflorescence axis. After pollination, they develop into green fleshy fruits, each containing 1-3 seeds. Each seed is contained within a woody endocarp and in some cases, woody flanges inside the endocarp penetrate the seed. *Borassus heineanus* differs from all other *Borassus* species in that it is found in tropical forests, rather than open savannas, resulting in a leaf anatomy resembling forest palms rather than other *Borassus* species.

Borassus madagascariensis is a species in the palm family Arecales endemic to Madagascar. The palm heart and newly germinated seedlings are edible, and an alcoholic drink is produced from the fruit.

Fig.2.2 Palm tree with matured palm fruits

Borassus flabellifer is a robust tree and can reach a height of 30 metres (98 ft). The trunk is grey, robust and ringed with leaf scars. The leaves are fan-shaped and 3 m (9.8 ft) long, with robust black teeth on the petiole margins. *B. flabellifer* is dioecious with male and female flowers on separate plants.

The male flowers are less than 1 cm long and form semi-circular clusters. In contrast, the female flowers are golf ball-sized and solitary

2.2 CULTIVATION AND HARVESTING

Palm can be grown in wide range of soil including waste lands. It is adaptable to semi-arid regions receiving an annual rainfall of less than 750mm. Planting season is October to November. After pollination, these blooms develop into fleshy fruits 15–25 cm wide, each containing 2-4 seeds. Though flowers bloom most of the day, most of them open between 8-11am. Pollination is through insects and wind. Theoretically it takes four months (120-130 days) for the fertilized flowers to develop into mature fruits. But according to local vendors and palm cultivators, the fruit will be harvested two months (60 to 70 days) after flower formation.

Bamboo with side branches was attached with the palm trees for climbing. Sometimes, the climber used a rope for fastening his legs which helped in easy climbing. This method is mainly used for palmyra palm tree and date palms. In this method harvesting was difficult, laborious and time consuming. The climber may use spike shoes for easy climbing. Besides, ladder could be used for climbing dwarf trees. Generally, a climber can easily climb date trees by using the steps which were cut in the previous year. (Hussain, 1990)

2.3 PALM FRUIT

Fig.2.3 Palm fruit in cluster

Palmyra fruit is also known as Nungu or Ice apple. Palm fruit season is May through August and October through December. The fruit weighs around 1-3 kg, measures 4 to 7 inches in diameter. It has a black husk and is borne in clusters.

Fig.2.4 Palm fruit with seeds

The top portion of the fruit must be cut off to reveal the three sweet jelly seed sockets, translucent pale-white, similar to that of the lychee but with a milder flavor and no pit. The jelly part of the fruit is covered with a thin, yellowish-brown skin. The fleshy white body contains watery fluid inside.

The conventional way this fruit is eaten is when the outer casing is still unripe while the seeds are eaten as the fruit. But if the entire fruit is left to ripen, the fibrous outer layer of the palm fruits can also be eaten raw, boiled, or roasted. When this happens, the fruit takes a purple-blackish hue and tastes similar to coconut flesh. The skin is also eaten as part of the fruit similar to how mango skins are often consumed along with the fruit.

In the Indian states of Tamil Nadu, Andhra Pradesh, Telangana and Bihar, the seeds are planted and made to germinate and the fleshy stems (below the surface) are boiled or roasted and eaten. It is very fibrous and nutritious. It is known as Thegalu or Gaygulu or Gengulu. The germinated seed's hard shell is also cut open to take out the crunchy kernel, which tastes like a sweeter water chestnut. It is called Buragunju in Telugu and "thavanai" in Tamil.

The white kernel of the ripe palm fruit after being left for a few months is used as an offering in Lakshmi Puja in various parts of Bengal and is also eaten raw.

2.4 USES AND HEALTH BENEFITS

Nungu provide hydration and a good balance of minerals and sugar for the body. Traditionally, the fruit is used to treat digestive issues and stomach ailments. Jaggery, the sugar made from palmyrah, has Ayurvedic benefits as well. The book, “The Ayurveda Encyclopedia” lists jaggery as a rejuvinative and a tonic. Furthermore, the natural sugar may help digestion and proper elimination. According to a study published in the 2013 edition of the “Pakistan Journal of Pharmaceutical Sciences,” extracts from the root may have antidiabetic potential based on their ability to decrease blood sugar levels and improve glucose tolerance when tested in rats. It also prevents chicken box, keeps your body cool, prevents constipation problem in pregnant women, good for acidity problem. The high potassium content helps eliminate body toxins and good for liver and spleen disorders. Villagers and manufacturers alike have revered the fruit’s ability to make tasty and potent alcohol, but palm fruit has several other culinary purposes.

Nungu pair beautifully with other tropical summer fruits, such as mango, pineapple, papaya, and coconut. Nungus's sweet taste and gelatin texture make the fruit an ideal candidate for a number of sweet dishes like nungu milkshake, payasam etc. Dehydrate the pulp of the fruit to make a leathery preserve. (Koffi *et al*, 2010)

2.5 NUTRIENT CONTENT AND MATURITY

The ripened pulp of the nungu is jelly like tender, flat and round with a light brown skin. It is a rich source of vitamins A, B and C and minerals such as iron, zinc, potassium, calcium, phosphorus, thiamine and riboflavin. The inner portion is a juicy socket and has a mild sweet taste. The fruit generally has three stages of maturity. Low maturity fruits which contain soft seeds with higher amount of water is obtained immediately after harvesting. After one week of harvesting the soft fruit becomes harder and the amount of water decreases.

This medium maturity fruits are ideal for consumption. The fruit becomes over mature, two weeks after harvesting. At this stage the fruit and pulp become harder and there is no free water inside the seed. (Vijayakumari *et al,* 2016)

Table 2.1. Nutrient Content per 100g of Nungu

NUTRIENTS	AMOUNT
Energy	43kcal
Water	87.6g
Protein	0.8g
Fat	0.1g
Carbohydrate	10.9g
Fiber	1g
Calcium	27mg
Phosphorous	30mg
Iron	1mg
Thiamin	0.04mg
Riboflavin	0.02mg
Niacin	0.3mg
Vitamin C	5mg

Table 2.1 shows the nutrient content per 100g of nungu according to the book, "The Encyclopedia of Fruit and Nut".

Fig.2.5 Palm seeds ready to eat

In palmyrah, the development of the fruits after fertilization is generally very rapid. The development of nungu is attained much faster in early phase after fertilization, and there after there is very little change in the size of the fruit after this stage, until the fruits become ripe and drops. Generally, three types of fruits do occur i.e., single seeded, double seeded and triple seeded fruits. The immature fruits are available from April – July and ripened fruits from October –December.

The cut and drained Nungu is receptive to oxidation, consider using it for immediate consumption, else the fruit's flavor begins to change. The fruit's rapid fermentation over the course of a mere three hours is the main reason why villagers prefer Nungu as a fast, inexpensive and easy source of alcohol. If you don't want it to be eaten immediately then, opt for each section to be scooped intact with the tan, stringy skin still encasing the husk. By this means you can preserve them in the refrigerator, only by a day or so. Hence, the fruit should be eaten within a day.

When the fruit become over ripened, the seed will become hardened and rubbery in texture. Eating of over-ripened seeds will lead to stomach ache. The water content in this seed is also very low.

2.6 PHYSICAL PARAMETERS

The study of the physical properties of products is very important in the design of particular equipment and analysis of the behavior of the product during post-harvest operations (Sahay and Singh, 1994). The determination of physical properties of different fruits followed by various research workers were reviewed for the study.

2.6.1 Size

Size, generally refers to characteristics of an object which determines the space requirement within the limit and necessary for satisfactory description of the any solid object. The size of fruits is important in determining their suitability and understands the properties that may affect the design of tool. Researchers have used various techniques to investigate the dimensions of different produce and its experimental results are given below.

Singh and Shukla (1995) conducted the experiment on physical properties of potato viz., length, breadth and thickness to develop a potato peeler. Vernier calipers were used for measuring these properties.

Jha *et al*. (2006) studied the physical and mechanical properties of mango fruit to determine the maturity. In order to measure the fruit length, width and thickness digital vernier calipers (least count 2 mm) were used.

Shamsudin *et al*. (2009) conducted the experiments on physical properties of pineapple fruit. Digital vernier calipers were used for determining the fruit length and diameter for both with and without peel.

2.6.2 Mass

Azad (1989) investigated the physical properties of jackfruits harvested from late and early season. The mass of the whole fruit was recorded by electronic balance.

Study revealed that, harvesting from the early season produced the fruits of biggest size (8.67 kg). The smallest jackfruit of 4.57 kg was observed in late season

2.7 MECHANICAL PROPERTIES

2.7.1 Cutting force

The cutting strength is one of the most important tests in the mechanical properties. The test used to determine the materials strength and resistance of tissue to loading cutting force during cutting. Some researches carried out work on requirement of cutting force to cut the fruits which helps in the particular equipment. The determination of cutting strength of different produce followed by various research workers were reviewed for the study.

Ohwovoriole *et al*. (1988) determine the cutting strength to identify the necessary cutting force of unpeeled and peeled cassava tuber. During this test, cutting tool (1.5 mm thick piece of sheet metal with sharpened edge at 300 angle) was placed between the plungers of the universal testing machine. The machine subjects the samples to compression at the speed of 20 mm/min and the resulting data were used to design a cassava peeler.

Shamsudin *et al*. (2009) conducted the experiments on firmness of pineapple fruit at three different locations. The fruit firmness was measured using a cylindrical die of 6 mm in diameter with the Instron Universal Testing Machine (UTM). The result revealed that, force decreased with the stage of maturity from 74.79-42.93 N (top position), 62.56-37.20 N (middle position) and 57.14-36.04 N (bottom position) due to cause of ripening process and storage period.

Ocon *et al*. (1995) analysed the suitability of instrumental techniques for the measurement of the texture of pecan nuts (Carya illinoensis). The following methods were applied to pecan halves from four cultivars (Western, Barton, Wichita and Mahan): 50% compression, texture profile analysis (TPA), puncture and bending.

The measurements were carried out in a Texture Analyser TA.XT2 on nuts from each cultivar. Sensory hardness was assessed by means of ranking tests. The results showed that 50% compression and puncture provide the best reproducibility, variation and correlation with sensory data.

2.8 PERFORMANCE EVALUATION OF PEELER AND SLICER MACHINES

Agrawal (1987) evaluated the performance of a ginger peeler machine. The peeling efficiency and the ginger meat loss were determined by the following formula

$$\text{Percentage loss} = \frac{(\text{Weight of seeds loss during seperation})}{(\text{Total weight of the seeds})} \times 100 \qquad \ldots 2.1$$

2.9 MATERIAL SELECTION

Minimizing the chance of food contamination by designing a piece of equipment for ease of cleaning should be the goal of all processing equipment design engineers. If the proper grade of stainless steel is used in food processing, corrosion will not be encountered.

Coady *et al*. (2000) investigated the good manufacturing and material selection in the design and fabrication of food processing equipment. The two most common grades of stainless steel used in processing equipment are 1) Type 304, most common and versatile stainless steel with excellent forming and outstanding welding characteristics. It is readily brake/roll formed into a variety of parts for equipment and post weld annealing is not required to restore the excellent performance of this grade. 2) Type 316: ¬ better resistance to corrosion and more expensive compared to type 304. Stainless steels are also identified by their surface finishes. Common surface finishes found in food processing equipment are 1) 2B, ewhich is smooth and dull finish.

Jullien *et al*. (2002) research work was carried to identify the surface characteristics relevant to the hygienic status of stainless steel for the food industry.

It was investigated by number of residual adhering Bacillus cereus spores after a complete run of soiling and cleaning in place procedure. The 14 materials tested (304, 316 and 430 grades; pickling (2B), bright annealed (2R) and electropolished finishes) were shown to be highly hygienic with slight differences in adhering spores. However, tested materials were grouped into different classes according to their hygienic status.

2.10 TRADITIONAL CUTTING METHOD OF PALM FRUIT

First of all, the fruit is cut with a knife, then the hard shells are separated from the fruit by plucking with fingers. Afterwards, the outer cover of the seed is separated by pulling with fingers. Moreover, the fruit is being sold in the road sides by common people and in parlours.

Fig.2.6 Road side nungu parlour

2.11 CUTTING METHODS

A sharp sickle was used traditionally for the cutting of both Nungu and tender coconuts and to open it. The tool used is shown in Figure 2.10. (Patil *et al*, 2014)

Fig.2.7 Cutting blade

Keramithra is a widely used tool for dehusking coconut. The tool consisted of two blades one is fixed to the upright column and the other was movable. The movable blade was attached to the handle. As force is applied on the handle the jaw rotates which helps in dehusking. While dehusking the coconut was impaled onto the blades in closed position, and then handle was lifted up to dehusk. Such a repetition or two to three times dehusked the coconut completely. (Jippu, Jobby, 1998)

Fig.2.8 Keramithra

Mango cutter is used for cutting the raw mango. It consisted of sharp blade with handle. The tool is operated by one hand and the mango to be cut with the other hand. (Patil and Chendake, 2017)

Fig.2.9 Raw mango cutter

Sugarcane bud chipper is used for removing the bud from the node of the whole sugarcane set. A simple hand operated cutter was used for this purpose. (Patil and Chendake, 2017)

Fig.2.10 Sugarcane Bud Chipping Tool

Ganesan and Gothandapani (1995) designed a tripod-like device for coconut dehusking. The configuration of the blade was selected to suit various sizes of the coconut. The curvature and sharpness at the edge of the blade was found to be critical for smooth penetration of the blades into the husk.

The force required for dehusking depends on the size and shape of the nut. The designed device enables easy separation of husk from the nut.

Anitha John and Shamsudeen K P (1997) developed a tender coconut punch and splitter at KCAET, Tavanur. The machine consist a stainless steel punch operated by a slider crank mechanism. The coconut was kept fixed with its pedicle end upward and the punch was forced into it using a lever attached to it. After extracting the water the coconut was splitted into two halves. This was done using a knife and lever mechanism. The knife was designed to concentrate the applied force at a single point and this force cuts the coconut.

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.

Coady *et al*. (2000) investigated the good manufacturing and material selection in the design and fabrication of food processing equipment. The two most common grades of stainless steel used in processing equipment are 1) Type 304: ¬ most common and versatile stainless steel with excellent forming and outstanding welding characteristics. It is readily brake/roll formed into a variety of parts for equipment and post weld annealing is not required to restore the excellent performance of this grade. 2) Type 316: ¬ better resistance to corrosion and more expensive compared to type 304. Stainless steels are also identified by their surface finishes. Common surface finishes found in food processing equipment are 1) #2B: which is smooth and dull finish. 2) #4, which is general purpose polished finish. Both the finishes are considered smooth. Smoothness is important because crevices provide places for bacterial growth.

Jullien *et al*. (2002) research work was carried to identify the surface characteristics relevant to the hygienic status of stainless steel for the food industry.

It was investigated by number of residual adhering Bacillus cereus spores after a complete run of soiling and cleaning in place procedure. The 14 materials tested (304, 316 and 430 grades; pickling (2B), bright annealed (2R) and electropolished finishes) were shown to be highly hygienic with slight differences in adhering spores. However, tested materials were grouped into different classes according to their hygienic status.

Thompson and Harrell (2003) invented a pumpkin cutting apparatus. It includes a tubular shaft, cutter tool and plunger shaft which extends through the tubular shaft and cutter tool. The cutter tool was designed in such a way that could cut a pumpkin and retaining the cut portion. When elongated plunger shaft pushed down the cutter, pumpkin was subjected to cut inside the cutter portion. Once a cutting is complete, the plunger shaft brings the cutter tool in its original position to eject the cut portion from the cutter.

Jippu *et al*. (2004) developed a coconut punch-cum-splitter 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.

Best and Kennedy (2005) described a food slicing apparatus. It consists of handle, roller and rigid blade; these are made of same/different materials. Roller and blade are rotatably mounted to the handle. Grip portion and yoke are the supporting members of handle and made of plastic and stainless steel materials respectively. One side of blade includes a cutting surface, which is a decline at an angle relative to a plane of the top surface of blade to cut the food and another side of blade was connected with rein forcing rib, which serves the reinforce blade. Therefore blade can easily slice foods of varying hardness.

Jellesen *et al*. (2006) reported the literature on metal release in the food industry. Stainless steel was the most widely used metallic material in the food industry. Examples of food products with a corrosive effect and cases concerning processes, storing equipment as well as cleaning and sanitising procedures were reviewed.

Pattenden (2011) patented a tool to pierce and split a coconut to facilitate removal of the water and meat from the nut. It consists of body frame, produce required size to accommodate small to bigger dimensions of coconuts and constrictor cup, a shaft which has releasably engaged tap and splitter assembly. The body has a hub aperture to receive the shaft, which push both the cutting and splitting tool through the body of coconut.

Bhavya Francis, Meenu P B, and Sinsha P V (2014) developed a tender coconut cutting machine at KCAET, Tavanur. The main components of the machine were a slotted cylinder and knives. The tender coconut was placed horizontally on a holding unit. The cylinder having diameter slightly greater than the coconut was placed across the fixed coconut. Knives were inserted through the slots provided in the cylinder and the cylinder was rotated using two handles attached to it. When the cylinder rotates, the knife will make a circular cut on the top of the coconut.

Agrawal *et al*. (2014) reported that AISI 304 stainless steel (SS) was used in applications like automotive, oil, gas and the food industry due to its excellent combination of corrosion resistance and mechanical properties.

Fulmali and Bhoyar (2015) developed a young coconut fruit cutting machine. The application of screw jack for the development of this machine reduces the cost of fabrication. Design parameters for a cutting machine consist of the size of young fresh coconut and the maximum compressive force used for cutting the coconut in half by a sharp knife. The young coconut is hold in position on the top face of screw jack. The drill tool is fixed on the top of the frame. Next the screw jack is lifted up with the help of handle.

It will move the jack in upward direction. Due to the lifting force of screw jack the hole will get drilled in the young coconut and water will be ready to use. After this if we change the dill with blade and repeat the same procedure we will get two halves of young coconut.

Mownesh and Ashok (2015) designed punch cum splitter for tender coconut. The tool operated by pneumatic system. The tender coconut is placed on the holder ring, once actuated the air compressor supplies the compressed air to the pneumatic cylinder.The Pneumatic cylinder containing a punching bit makes a hole in a downward direction and move back. After consuming water it is placed on other side of the frame for slicing operation.

Stephen and Samuel (2015) developed a two - blade dehusking machine. In this two-blade model, one blade would be inserted inside the husk of the coconut and the other blade would help in the process of peeling. A 1.5 hp motor is coupled through a belt to a long cylindrical metal rod. Two sharp blades are fixed at the tip of the rod. The blades are three - quarter of an inch long and placed one inch apart. The rotating motion of the blades would dehusk the coconuts easily.

Vinay *et al*. (2016) proposed a coconut breaker extractor grater machine which can break a de-husked coconut into two pieces, collect coconut water and grate the coconut pieces into desiccated coconut. The main highlight of the proposed project is that there is no contact between the tool and hands of the user both in breaking and grating of the coconut. For the proposed machine, it is required to introduce a de-husked coconut and fix it on the arms of the machine. The main merits of the proposed machine are it is feasible in terms of economy, time and effort, enhanced safety of the user by eliminating injuries caused primarily due to improper handling of the grater tool.

The three processes involved are breaking the coconut into two halves, grating the coconut half and extracting the coconut water has been integrated in a single machine. The breaking operation is accomplished without any power supply. In breaking, coconut is placed in between the breaking tool supported by the clamp The hanged weight is then allowed to hit on the breaking tool under effect of gravity thus splitting the coconut into two pieces.

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

The fabrication procedure of the palm fruit seperator, the details of the components and the procedures adopted for evaluation are described in this chapter. A conceptual design was conceived and then the tool was fabricated in the work shop of KCAET, Tavanur

Before the fabrication, important physical and mechanical properties of palm fruit were studied. The physical parameters, texture and force required to cut the fruit were evaluated.

The *Borassus flabellifer* fruits were procured from local market and street vendors. Fruits of different maturity and sizes were selected and analysed.

3.1 PHYSICAL PARAMETERS

The physical properties of palmyra fruit have greater influence in the design and development of a seed separator. The parameters such as shape, size, weight of the fruits were evaluated.

3.1.1 Shape

The shape of the palmyra fruit varies with region and variety. Generally the shape of the fruit is spherical and the shape of the seed is almost ellipsoidal. The shape of 25 palm fruits were subjected to visual observation.

3.1.2 Size

The size of the palm fruit is usually expressed by its length and diameter. The maximum length and diameter of randomly selected nungu and seed were measured with a vernier caliper of least count 0.01mm. The procedure was repeated for 25 different samples. The mean diameter, length, spacing and thickness of husk were calculated.

3.1.3 Weight

The weight of fruit of 25 samples selected at random were measured, separately by using a weighing machine.

3.2 MECHANICAL PROPERTIES

Mechanical properties may be defined as those which affect the behavior of the agricultural material under the applied force. The mechanical properties such as hardness, compressive strength, impact and shear resistance and rheological properties affect the various operations of agricultural processing. Data on these properties are useful for application in designing equipment for food processing.

3.2.1 Cutting force of Fruit

The force required to compress the fruit from the top using a circular blade and the force required to penetrate from the side using a sharp iron rod were measured using Universal Testing Machine.

A Universal Testing Machine also known as Universal Tester, Materials Testing Machine or Materials test frame, is used to test the tensile strength and compressive strength of materials. An earlier name for a tensile testing machine is a tensometer. The “universal” part of the name reflects that it can perform many standard tensile and compression test on materials, components and structures.

Common components of UTM include, Load Frame, Usually consisting of two strong supports for the machine. Some small machines have a single support. The load cell which is a force transducer or other means of measuring the load is required. Periodic calibration is usually required by governing regulations or quality systems. A movable cross head is controlled to move up or down. Usually this is at a constant speed, sometimes called a constant rate of extension machine.

Some machines can program the cross head speed or conduct cyclical testing, testing at constant force, testing at constant deformation, etc.

Extensometers are used to measure extension or deformation sometimes. Output devices are the means of providing the test results. Some older machines have dial or digital displays and chart recorders. Many newer machines have a computer interface for analysis and printing.

The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control systems and its associated software record the load and extension or compression of the specimen. Machines range from very small table top systems to ones with over 53 MN capacity.

Fig.3.1 Universal Testing Machine

3.2.2 Cutting force of Seeds

Texture of seeds was checked using Texture Analyser (Stable Micro Systems) with a P/5 cylindrical probe at test speed of 8mm per second. Analysis was done for three different maturity seeds with and without skin. The experiment was conducted at Food engineering laboratory, KCAET, Tavanur.

A Texture Analyser moves in either an up or down direction to compress or stretch a sample. The characteristics of the force response are as a result of the sample's mechanical properties, which correlate to specific sensory texture attributes. A texture analyzer applies this principle by performing the procedure automatically and indicating the results visually on a digital numerical display, or screen.

We use Texture Analysers to imitate or create controlled stresses within the sample just as we do when we consume or use a product. The science of texture measurement (texture analysis) falls across the scientific fields of rheology (the science of material flow) and materials science. The travelling arm is fitted with a load cell and records the force response of the sample to the deformation that is imposed on it. Force, Distance and Time data is collected and usually presented as a curve on a graph which, when analysed, indicates the texture of the sample. The mainly used texture analyser is of Stable Micro Systems. T

The probes and fixtures are attached to a Texture Analyser to allow a particular action or test to be performed. They are in everyday operation worldwide, testing a wide range of products, materials and properties in Research and Quality Laboratories, as well as being integrated into many production lines. Only the finest quality materials and the best quality finishes are used in the manufacture of our probes and attachments; food quality or better Stainless Steels (polished and mirror finish), aerospace quality aluminium alloys (micro finished and hard anodised) and ICI or GE engineering plastics. Cylindrical probe is one of the types of probes used generally for fruits and vegetables in Stable Micro Systems.

Fig.3.2 Texture analyser (Stable Micro Systems)

Fig.3.3 P/5 Probe

3.3 DEVELOPMENT OF BLADES

The fruit was initially tested with existing husking mechanisms. Nungu was cut open using Keramithra tool developed for coconut de-husking. The method was easy to separate the first seed. But separation of the consecutive seeds became difficult and separation depends on fruit maturity.

Plate 3.1 palm fruit open using Keramithra tool

The Nungu was fed into Power operated coconut husking machine developed by KAU.

A triangular blade of side 7cm each was developed as first tool. Force was applied from top using hydraulic press. Due to the gradual force the seed/pulp was crushed and the water came out. Considering the limitations of the first tool a curved blade was developed.

Plate 3.2 Triangular cutting blade

Plate 3.3 Curved blade

A tool having two circular discs with six L-shaped flat blades welded on each was fabricated. Force was applied while placing the Nungu in between the discs at correct position.

Finally a U-shaped SS blade was developed for the separation of seed , one at a time.

3.4 DEVELOPMENT OF FIRST MODEL

From the beginning of the project we developed a simple manually operating tool (Plate 3.5). General layout and details of the tool is given below,

The tool consists of the following units:

1. Frame Assembly
2. Base
3. Holding Unit
4. ‘U’ Shaped Blade

The frame was made into rectangular shape and it can be movable in back and forth direction. The holding unit with a sharp rod was attached to the rectangular base made of galvanized plane sheet.

'U' shaped blade was welded on horizontal shaft and the shaft connected to the frame using two hollow cylinders at each end.

After cutting the top portion, the fruit inverted placed in the holding unit such that the sharp rod pass through the middle of the fruit. The blade was inserted into the fruit and the husk was removed by pulling the frame forward. Repeat the same for other seeds.

Plate 3.4 Model 1

3.5 DEVELOPMENT OF FINAL TOOL

To overcome the failure of first developed tool a new seed separating tool was developed and fabricated in workshop of KCAET, Tavanur. General layout and details of the tool is given below,

The tool consist of following units

1. Base
2. Cutting knife
3. Holding platforms
4. 'U' shaped blade

3.5.1 Base

A rectangular base made of AISI Type 302 SS on which other parts are mounted.

3.5.2 Cutting Knife

A SS (AISI Type 302) knife of length 20 cm and width 9 cm was fitted in a frame work as shown in the figure. This knife can be moved up and down to cut the top and bottom portion of the fruit.

Plate 3.5 Cutting Knife

3.5.3 Holding Platforms

The tool consists of two holding platforms. A ‘M’ shaped holding unit for holding the fruit while cutting the top and bottom portions and other, a rectangular platform for placing the fruit while removing the seeds.

3.5.4 ‘U’ Shaped Blade

A ‘U’ shaped blade made of SS (AISI Type 302) is used to remove the seeds. Cutting edge has been sharpened by using a file. The blade has a length of 120 mm and height of 60 mm.The two arms of the blade is inserted into the sides of the seed from top of the fruit. Then the blade is pulled out and husk is removed from the seed. Repeat this procedure for remaining seeds.

Plate 3.6. U Shaped Blade

Auto CAD drawing of the developed tool is give in Plate 3.7.

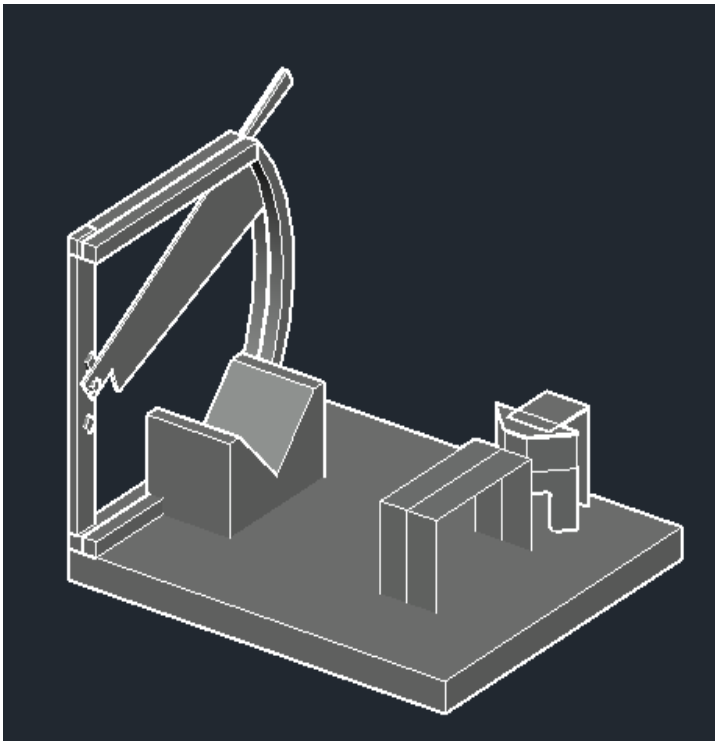

Plate 3.7 Auto CAD drawing of developed tool

3.6 OPERATIONAL PROCEDURE

The nungu was bought from road side vendors. Then it is removed from the bunch and the crown is removed from individual fruits.

1. Place the fruit horizontally on 'M' shaped holding unit
2. Adjust the length and bring the knife down. The bottom portion is cut upto 5cm thickness.
3. Repeat the same procedure to cut the top portion upto 2.5 cm.
4. Place the fruit vertically on the rectangular platform .
5. Insert the 'U' shaped blade into the fruit on the sides of the seed.
6. Pull out the husk along with the blade.
7. Repeat the same for other seeds.
8. Clean the tool after operation.

3.7 PERFORMANCE EVALUATION

Evaluation of the final tool is made using the following equations.

3.7.1 Capacity of the tool

The capacity of the tool, which is the number of kg of nungu seeds separated in one hour was calculated by noting the weight of seeds removed and the time taken for the same. It was then expressed in kg/hr.

$$\text{Capacity (kg/hr)} = \frac{\text{total weight of the separated seeds}}{\text{Time taken for separation}} \quad \ldots 3.1$$

3.7.2 Material Loss

Material loss for each sample of palm fruit was calculated based on following formula.

$$\text{Material Loss (\%)} = \frac{weight\ of\ the\ \ seed\ loss\ during\ seperation}{total\ weight\ of\ the\ seeds} \times 100 \quad \ldots 3.2$$

3.7.3 Percentage Damage

$$\text{Damaged seeds (\%)} = \frac{Number\ of\ seeds\ damaged}{Total\ number\ of\ seeds} \times 100 \qquad ...3.3$$

RESULT S AND DISCUSSIONS

CHAPTER 4
RESULTS AND DISCUSSION

This chapter deals with the results of experiments conducted to evaluate the performance of user friendly cutting tool for separation of palm fruit seeds and its comparative performance with manual cutting method.

4.1 TEST RESULTS

The first developed triangular blade was subjected to testing using a hydraulic press. But since the symmetry of the seeds were not uniform in all fruits, the seeds were damaged. Then the blade was changed to a curve by taking in account the curved shape of the seed. Using this blade the damage can be reduced but not upto the expectation. Finally a 'U' shaped blade was developed by considering the width of the seed and length of the fruit. This blade can easily remove the husk without any drudgery and damage.

Next we developed a tool by incorporating the new blade. In this tool, the fruit was placed in inverted position without removing bottom portion. 'U' shaped blade was forced into the fruit. Since the bottom part of the fruit was much harder compared to other parts, large amount of force was required to penetrate into the fruit and to remove the husk. By applying this force some of the seeds were broken and water was lost. In some cases the remaining seeds were crushed and pushed out.

Plate 4.1 Fruit cut with model 1

To overcome this limitation a second model was developed with a knife attached to it to cut the top and bottom portion of the fruit. The performance evaluation of this newly developed tool was done. The Plate 4.3 shows the developed User friendly tool for palm fruit seed separator.

Plate 4.2 User Friendly Palm Fruit Seed Seperator

4.2 PHYSICAL PARAMETERS OF FRUIT

Palm fruits of different maturity were purchased and physical parameters were measured. The details of the sample are shown in Table 4.1.

Table 4.1 Specifications of palm fruit

Sample	Diameter (mm)	Average Spacing B/W Seeds (mm)	Thickness Of Outer Husk (mm)	Seed		
				Thickness (mm)	Width (mm)	Length (mm)
Fruit-1	110	60	18.8	30	45	65
Fruit-2	90	60	10	25	50	55
Fruit-3	100	70	15	21	45	68
Fruit-4	105	70	20	32	40	62
Fruit-5	90	75	15	20	55	60

4.3 CUTTING FORCE FOR FRUITS

Force required to compress from the top using circular blade was found to be 300kgf and the force required to penetrate from the side using a sharp iron rod was 10kgf.

4.4 CUTTING FORCE FOR SEEDS

Table 4.2. Textural Analysis of Nungu Seeds

SL NO	SAMPLE	FORCE(gm)	
		WITH OUTER SKIN	WITHOUT OUTER SKIN
1	Low Maturity	445.825	160.951
2		228.177	89.211
3		427.89	36.68
4	Medium Maturity	350.25	178.654
5		414.815	240.095
6		506.919	132.949
7	High Maturity	3225.606	1129.315
8		3721.88	1815.813
9		3068.242	2247.985

4.5 PERFORMANCE EVALUATION OF TOOL

4.5.1 Capacity of the Tool

Table 4.3 Capacity of the tool

Sl. No	Weight of the seeds obtained (g)	Time taken for separation (sec)	Capcity (kg/hr)
1	119	44	9.7
2	83.4	33	9.05
3	102.5	37	9.9
4	100.4	35	10.6
5	99.6	43	8.2
6	72.7	39	6.6
7	102.9	32	11.4
8	62	30	7.4
9	50.7	29	6.2
10	141.5	46	11.03
Average			9.008

Time taken depends on the maturity of the fruit. For fruits with high maturity time taken for cutting is also high. The average capacity of the tool was found to be 9.008 kg/hr. Approximately seeds of 95 fruits can be separated in one hour.

4.5.2 Material Loss

Table 4.4 Calculated material loss

Sl. No	Weight of nungu after dehusking (g)	Weight of nungu as waste (g)	Material loss (%)
1	119	0	0
2	83.4	3	3.4
3	102.5	0	0
4	100.4	4	3.8
5	99.6	5	4.7
6	72.7	0	0
7	102.9	4	3.7
8	62	0	0
9	50.7	2	3.7
10	141.5	7	4.7
Average			2.4

From Table 4.4 it is concluded that the loss obtained from the tool while separation is very less. This can be further reduced if proper care is taken during cutting top and bottom of the fruit.

4.5.3 Percentage Damage

Table 4.5 Percentage Damage of Nungu

Total Number of seeds	31
Number of damaged seeds	5
Percentage damage (%)	16.13%

Plate 4.3. Cutting bottom side

Plate 4.4. Cutting top side

Plate 4.5. inserting Blade into Fruit

Plate 4.6. Seed Seperation

Plate 4.7. Seperated Seeds

SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

India is blessed with a variety of fruits and vegetables whose production during 2010 - 11 was 74.87 and 146.55 MT, respectively. Though India is the largest producer of fruits and vegetables after China, it processes only less than 2.5% of the huge production as compared to 70 - 83% in advanced countries. Palm fruit is a rich source of vitamins, minerals and offers numerous health benefits. However, it is an under exploited fruit.

The traditional method is laborious and difficult for common people. It uses a knife for separation. This knife may cause drudgery to the person operating it. Due to these disadvantages of separation, the consumption of nungu is very less. Considering its nutritive value and water content, it has many uses in the field of health. Hence a user friendly hand operated tool for nungu separation is necessary.

Before the fabrication, the physical and mechanical properties of mature palm fruit like length, diameter, skin thickness, load required to penetrate peel and pulp etc were studied. Based on these properties, two models were developed for seed separation of palm fruit.

In the first model the fruit was placed inverted on the platform. Before placing in tool, the top portion was removed inorder to identify the position of fruit. Since the fruit was placed inverted and the cutting blade had to penetrate through the bottom (bottom portion of nungu is very hard), we have to apply large force. This resulted in loss of water and crushing of seeds.

In the second model a cutting mechanism to remove the top and bottom portion was included in the tool. By removing the bottom portion it was easy to separate the seed from fruit. It is developed to be more easier and gender friendly and prevents drudgery compared to the traditional method.

The traditional method has a capacity of 100 fruits/hr and the developed tool has a capacity of 95 fruits/hr. The loss of water and fruit in developed tool is less and it is safe compared to traditional method. Even though the capacity of new tool is slightly lesser than the traditional method, compared to its other advantages it is more useful.

Modifications of the machine can further improve the performance. If possible, both the cutting blade can be made into one. Thus we can reduce the time taken for separation.

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CHAPTER 5

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APPENDICES

APPENDIX I

COST ESTIMATION

Initial Cost (C)

Fabrication cost of tool including material cost = Rs.800

Average life of tool = 10 Years

Working hours per year = 1440

Salvage Value = 10 % of initial cost

A) Fixed cost

1. Depreciation = (C-S)/LH

= (800-80)/(10×1440)

= 0.05

Total Fixed cost = 0.05

B) Variable cost

1. Labour Wage

Wages of Labour = Rs.500/day of 8 hr

2. Repair and maintenance cost

@10% of initial cost p.a. = (800×10)/(1440×100)

= 0.05556/hr

Total variable cost = 62.556/hr

Total operating cost = 62.6056/hr

DEVELOPMENT OF A USER FRIENDLY TOOL FOR PULP/SEED SEPARATION FROM TODDY PALM FRUIT

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ABSTRACT

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ABSTRACT

Nungu is one of the seasonal fruit produced in the Asian countries. The major problem related with the processing of Palm fruit is seed separation. Manual separation of seeds using traditional tool is time consuming, labour intensive, cause drudgery and only a skilled person can separate the seed. Therefore a simple hand operated tool which is easy to operate, portable, gender friendly and economical was fabricated. The equipment consists of a knife and a U-shaped cutting blade. The knife removes top and bottom portion which makes further seed separation easy. Then U-shaped blade inserted along the sides of the seed and pulled out the husk. The designed tool has a capacity of about 95 fruits/h and material loss of 2.4 percentage.