

"Design and Development of Tender Coconut Opening Mechanism"

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Abstract— The Coconut palm belongs to family Palmae and belongs to the Species Cocos Nucifera and is commonly known as Tender coconut. The tender version of the coconut is mainly used as a refreshment drink. In conventional method five to six chops are required to remove the Exocarp to get tender coconut water. While opening the Endocarp some percentage of the tender coconut water spills out. Two to three chops are required to open the endosperm. It requires more human effort, time consuming and ergonomically not recommended. Continuous operation is very difficult. The force acting on the left hand of the tender to open and to split each tender coconut has an average of 315 N & 152 N respectively during conventional method. The time taken to open and split the tender coconut and the effort required to do the same was minimized approximately to 85% by the use of mechanical facilitator as compared to conventional method. The mechanical facilitator makes the work safer and cleaner thus providing opportunity for women entrepreneurs. Using mechanical facilitator torque required to split into two halves is approximately 54.56 N-M. Hence mechanical facilitator was developed to reduce human effort by using cordless drilling machine, piercing tool and hinged chopper with handle.

Key words: Tender coconut, Cordless Drilling machine, Piercing tool, Chopper

I. INTRODUCTION

Historically, in the medieval period the coconut was known as Nux indica, the Indian nut, during the same period it was also referred as Nargil tree, "the tree of life". Western literature mentioned the Malayalam name "Tenga" for the coconut palm which related to Tamil 'Tennai' and believed to have been introduced from Shri Lanka. Its geographical dispersion around the world was aided by waves of sea, travellers migrating and trading between homeland countries and even to more distant islands, from Asia to American coasts. Botanically, the coconut palm is a monocotyledon and belongs to the order Arecaceae, family Palmae and the Specie is known as Cocos nucifera Linn.

India ranks:

Third on world coconut map and in recent times became the largest producer of coconut with the production of 16.9 billion nuts from acreage under plantation of about 1.89 million hectares [1]. Even though India is among the largest producer of coconut with a distinction of having the highest productivity of 7779 nuts per hectare as against 3630 nuts per hectare in Indonesia and 3859 nuts per hectare in Philippines, the per capita annual availability of coconut estimated to have been 10 nuts only which is quite low compared to 222 of Philippines, 145 of Sri Lanka and 55 nuts of Indonesia [2][1].

II. TENDER COCONUT

The tender version of the coconut mainly used as a soft drink. The water of a tender coconut is liquid endosperm. It's refreshingly sweet (mild) with aerated feel when cut fresh. Depending on the size a tender coconut could contain the liquid in the range of 300 to 1000ml.

Coconut fruit:

The most important and economically valuable produce of coconut palm is its fruit popularly known as 'nut'. It is made up of an outer exocarp, a thick fibrous fruit coat known as husk; underneath lies the hard protective endocarp or shell. Lining the shell is a white albuminous endosperm or 'coconut meat' and the inner cavity is filled with a clear sweet refreshing liquid called 'coconut water' [3].

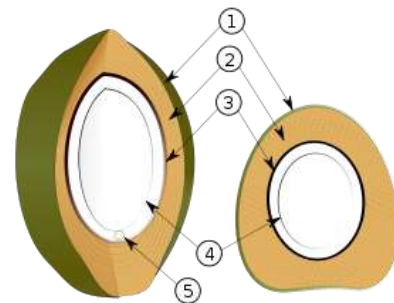


Figure 2.1 Coconut(1)Exocarp/Epicarp (2) Mesocarp (3)Endocarp (4)Endosperm (5) Embryo

Coconut Water:

Coconut water is the liquid endosperm inside young coconuts. As the coconut matures this liquid largely becomes absorbed into the flesh found in mature coconuts. Coconut water has long been a popular drink in the tropics. It is naturally fat-free and low in food energy (16.7 calories or 70 kJ per 100 g) [3]. Due to its sterility, pH, mineral, and sugar content, coconut water had been successfully used as liquid in intravenous therapy in emergency situations.

Coconut water can be found in regular cans or tetra packs, and is also marketed as a sports drink because of its high potassium and mineral content which helps the body recovers from rigorous exercise.

Tender Coconut Harvesting:

The tender coconuts are disposed off by the farmers immediately after harvesting, without giving any kind of dressing or grading. It has been observed that tender coconuts are manually sorted out at the time of retail sale, where the husk of the tender coconut is chopped off with a sharp sickle shape knife to make an opening of about 1 inch diameter to facilitate directly drinking of water. Dehusking of tender coconut is very difficult due to high moisture content of the husk and delicate nature of immature shell. The discarded nuts are cut into halves before being disposed off by natural degradation.

Tender coconuts are sent to market within a day or two after harvesting as there is no practice of storage of Tender Coconuts for longer period. The tender coconuts are kept in shed on the farm till they are lifted by the wholesaler and/or retailer. The wholesalers and retailers store the tender coconuts only for a few days or weeks, since, the interval between the harvesting and consumption does not exceed more than 10 to 15 days, even at the distant places of consumption. Moreover, prolonged storage makes the tender coconut water insipid and hence is disposed off for consumption at the earliest possible. Tender coconuts have great demand in most of the towns and cities all over the country. Kolkata, Mumbai, Chennai, Bangalore and Delhi are the major consumer markets for tender coconuts.

III. PROBLEM DEFINITION

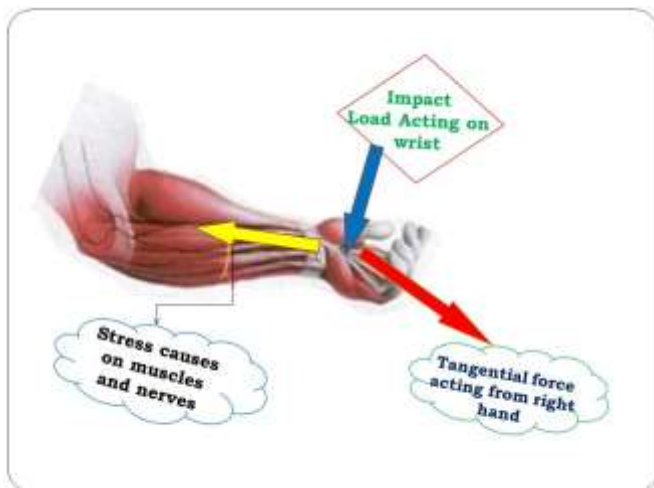


Figure 3.1 Forces acting on left hand with manual Tender coconut opening method

• **Manual method of chopping to open the Tender coconut Force acting on the left hand**

- a) Considering weight of the Tender coconut 1.75Kg, 17.16N (weight may vary according to size)
- b) Chopper weight 1.2Kg, 11.72N
- c) Approximate Force applied to slice to open Tender coconut 4Kg 39.24 N
- d) Approximate force acting on the left hand to slice tender coconut = a +b + c
 = 17.16 + 11.72 + 39.24
 = 68.12 N per slice

- To open tender coconut the number of slices varies from 3 to 7,
- e) Average number of slice is 5 per Tender coconut
- f) The total approximate force acting on the left hand to open Tender coconut= e X d
 = 5 X 68.12
 =340.6 N / Tender coconut

• **Manual method of chopping to split the Tender coconut in to two halves**

- a) Chopper weight 1.2Kg, 11.72N
 Approximate Force applied to split the tender coconut in to two halves 4.5 Kg/ single shot, 44.145 N
- b) Approximate shots required to split in to two halves is 2 to 3
- c) Tender coconut self-weight (may vary according to size) 1.5 kg, 14.75 N
 Total force acting on left to slit in to halves is = a + c X b + d
 = 11.72 + (2.5X44.145) + 14.75
 = 136.79 N / Tender coconut

The following major points observed as follows

- It requires more human effort, time consuming and ergonomically not recommended
- Five to six chops are required to remove Exocarp in order to get tender coconut water
- While opening Endocarp some percentage of the tender coconut water spills out
- Two to three chops is required to open the endosperm
- Lot of garbage is generated

A. Development of Tender Coconut Mechanical Facilitator

Material selection

The following operations to be carried out in the mechanical facilitator

- 1) Tender coconut Cap opening
- 2) Tender coconut Piercing and
- 3) Tender coconut splitting in to two halves

For above operations Stainless steels are widely used, in food and beverage manufacturing and processing industries for manufacture, bulk storage and transportation, preparation and presentation applications [4].

The tender coconut water opening and splitting in to two halves is based on the sliding movement and hinge mechanism method. The mechanical facilitator mainly consist of storage unit, coconut holder before drilling, column, spring arm, sliding slot, expansion spring, cordless drilling machine with holding assembly, tender coconut holder come height adjuster and splitting chopper as shown in figure 4.1. Storage unit: volume of 530 X 380 X 510 mm with table height of 780 mm. Coconut Holder before and during drilling: diameter 124mm, column: 40*40*870mm, sliding slot: 10*275mm, cordless drilling machine capacity: GSR 7.2-2 upto 500rpm, expansion spring coefficient: 1265.35 N/M, splitting chopper: stainless steel & length 500*8*50mm, tender coconut height adjusting screw rod: 25*125mm. Piercing tool: hollow pipe stainless steel length 125mm, 12 diameter taper angle 9°



Figure 3.1 Tender Coconut Mechanical Facilitator with parts name

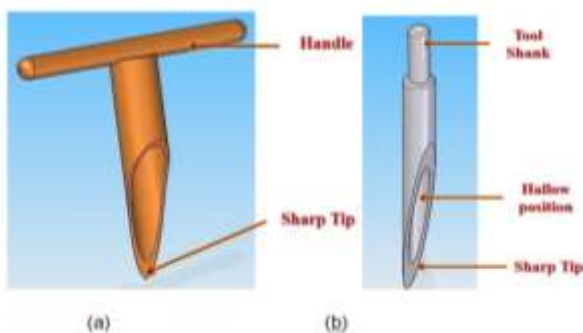


Figure 3.2 (a) Tender Coconut cap opener (b) Piercing tool

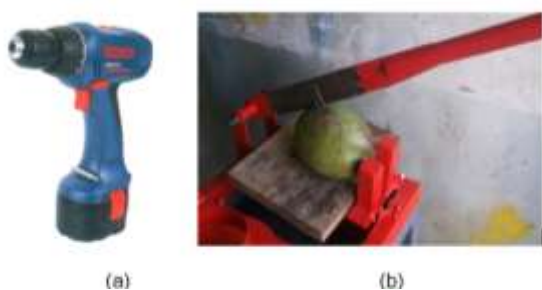


Figure 3.3 (a) GSR 7.2-2 Professional Cordless drilling machine (b) Tender Coconut Mechanical Facilitator for splitting

B Operation:

Tender coconut is placed inside the tender coconut holder before drilling. Using tender coconut cap opener, cap is opened and tender coconut is placed inside the holder - cum - height adjuster. Height is adjusted by rotating the lever and screw rod. Cordless drilling machine is held freely by expansion spring, holder assembly will be sliding inside the slot with the slotted pins. Drilling machine is brought in downward direction and the piercing tool pierces the Exocarpe to open the tender coconut. The soft spongy material comes out

inside the piercing tool thus creating a hole of 10mm diameter. The coconut water can either be extracted using straw or drinking directly through the opening. Tender coconut is split into two halves by slicing with the help of the chopper by applying the force and ready to extract the Endosperm.

C. Calculation of Torque induced in chopper while splitting the tender coconut into two halves

While operation the force applied and angle of force varies with respect to size, shape and maturity of the Tender coconut. The average force will be considered after taking several trials [5]. The load applied to split the Tender coconut into two halves is 5 Kg to 8 Kg. Considering average load, the torque required to split the Tender coconut is 6.5 Kg. The angle of load applied to split the Tender coconut into halves is 70.0 to 85.0°. Considering average angle of load applied to split the Tender coconut as 77.50°

Length of the chopper with handle, $r = 1068\text{mm}$

$$\begin{aligned} \text{Torque required to split into halves } T &= r \times F = r F \sin(\theta), \\ &= 1.068 \times 6.5 \times 9.81 \sin(77.5) \\ T &= 66.84 \text{ N-M} \end{aligned}$$

Table: Trials recorded for Torque requirement while splitting the tender coconut into two halves under different weights of Tender coconut

Trial No.	Tender Coconut weight in Kg	Approximate load applied on the chopper to split in Kg	Torque required to split into halves in N-M T
1	1.75	4	40.92
2	2.00	5	51.15
3	2.00	6	61.38
4	1.5	4	40.92
5	2.3	6	61.38
6	2.5	7	71.61
Avg	2.08	5.3	54.56

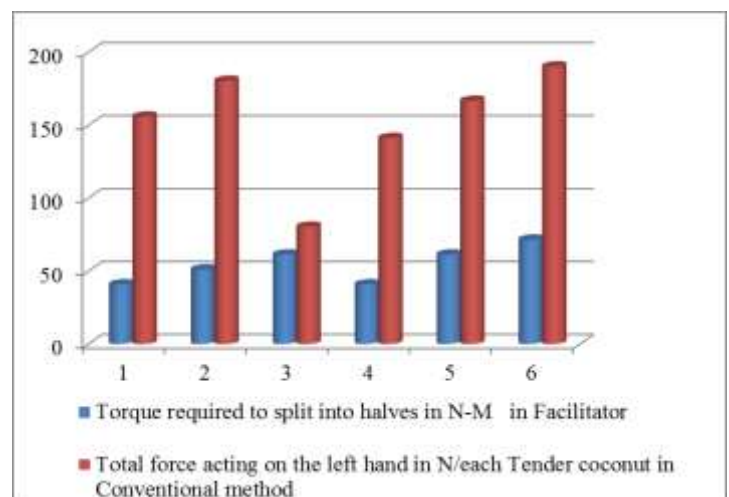


Figure 3.4: Compression of Tender Coconut splitting using Mechanical Facilitator and conventional method

IV. Results and Conclusion

The following were inferred during the project carried out,

- 1) The force acting on the left hand of the vender to open and to split each tender coconut has an average of 340.6 N & 136.79 N / Tender coconut respectively during conventional method
- 2) Average tender coconuts opened in one day during conventional method is around 100 to 125, which causes fatigue and makes the vendor exhausted
- 3) From the above, thus during conventional method, continuous force which acts on the left hand makes the opening of the tender coconut much more difficult. This can be eliminated by the use of mechanical facilitator
- 4) Overall, the time taken to open and spilt the tender coconut and the human effort required to do the same was minimized approximately to 85% by the use of mechanical facilitator as compared to conventional method
- 5) The mechanical facilitator makes the work safer and cleaner thus providing opportunity for women entrepreneurs
- 6) The mechanical facilitator minimizes waste, avoids spillage of tender coconut water and requires less maintenance making it possible for continuous usage

V. Future scope

- Further elimination of the human effort during splitting the tender coconut into two halves can be obtained by introducing Hydraulic attachment for splitting assembly

- Introduction of Solar Panels for charging cordless drilling machines
- Reducing of the weight and the size of the facilitator by using other low cost alloys thus overall reduction in cost of the facilitator during mass production
- Extraction and collection of tender coconut water facility along with the assembly

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