

Introducing a Mechanical Method for Peeling the Palmyrah Fruits in Oder to Promote The Palmyrah Juice Based Products

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ABSTRACT

Palmyrah (Borrssus flabellifer L.) a multipurpose perennial crop is a food which helps waste land development. It is a base tree for the livelihood and ecological security in north and east of Sri Lanka. It has been recorded that the average annual income from palmyrah of Sri Lanka is about 150 million rupees in 2012. Labour scarcity and low level of techniques over several years has caused lot of problems for palmyrah juice production. Although, the juice extraction from peeled palmyrah fruits is properly mechanized, the peeling of fruits is not yet mechanized. Therefore, to increase the annual palmyrah juice production, an efficient way of peeling off the fruits would be helpful. The aim of this study was to introduce an efficient mechanical method to peel off the palmyrah fruit with less labour and time consumption. The major components of this machine were the interchangeable sets of peeling blades and hooks, adjustable fruit holder, operating handle, peel collector and frame. Durable and readily available materials were used to fabricate the prototype in order to facilitate the repairs and maintenance easy at rurally and to keep the production cost at an affordable range. After series of trials and modifications, final prototype machine was fabricated and the performances of it were evaluated compared to manual peeling. Theoretical capacities of the machine and manual peeling were 72 and 59 fruits per hour respectively. Actual capacities of the machine and manual peeling were recorded as 65 and 51 fruits per hour respectively. Efficiencies of machine and manual method were 90% and 86% respectively. There was a significant difference ($p < 0.05$) between performance of peeling machine and manual method. Based on the above facts and figures newly designed Palmyrah Peeler can be recommended as appropriate machinery for Sri Lankan Palmyrah farmers.

Keywords: Palmyrah juice extraction, Palmyrah peeler, Peeling

In villages of Jaffna district, fruit pulp is consumed by people after roasting the fruits. The mature fruit is usually tossed over low burning fire or embers to cook them mildly and the skin is peeled off manually to expose the juicy fruit (Kokulathasan, 1988).

Methodology

Existing palmyrah peeling process was deeply studied to design the palmyrah peeling machine. According to the people who are involving in palmyrah based production, several drawbacks of the existing method were identified and they were highly considered at the designing process of the new machine.

A preliminary study was taken to find out the maximum required force and the easiest way of removing peels. The required force to remove 1 cm width peel was measured using a spring balance. The average force of five replicates was taken as the required force for the machine. This procedure was repeated for three maturity stages of palmyrah fruits to get the maximum required force. In addition to this test, the spring balance was used to determine the least required force to remove the peel in different directions as along the main axis of the fruit and perpendicular to the main axis in order to find the easiest way of peeling off., from randomly selected palmyrah fruits. Fifty fruits from different areas were used to take the maximum values of height, diameter and the thickness of the peel in order to determine the optimum dimensions for the machine. Diameter and height of the fruit was measured using a measuring tape and the thickness of the peel was measured using a vernier caliper.

Considering the cost of production of the machine and the economic situation of palmyrah producers, it was decided to use the manual power to operate the machine. Caring out the village level repairs and maintenance was considered at the designing and manufacturing process. In addition to that, safety and ergonomics factors, efficiency, post-harvest quality, affordability and durability were highly considered. As both male and female are engaged in palmyrah based-production, ergonomics factors such as length of operating handles, directions of force application, force required for adjustments and operation were considered.

All the designing, fabricating and performance evaluation work was carried out at the Engineering workshop, Faculty of Agriculture, Rajarata University of Sri Lanka. In addition, the available facilities of the workshop for a machine manufacturing were also considered at the designing process.

Although, the machine has lot of parts, it can be divided into five main components based on functions as interchangeable sets of peeling blades and hooks, adjustable fruit holder, operating handle, peel collector and the frame. Figure 01 shows the main components and their arrangement. Figure 02 shows some of the major dimensions of the machine.

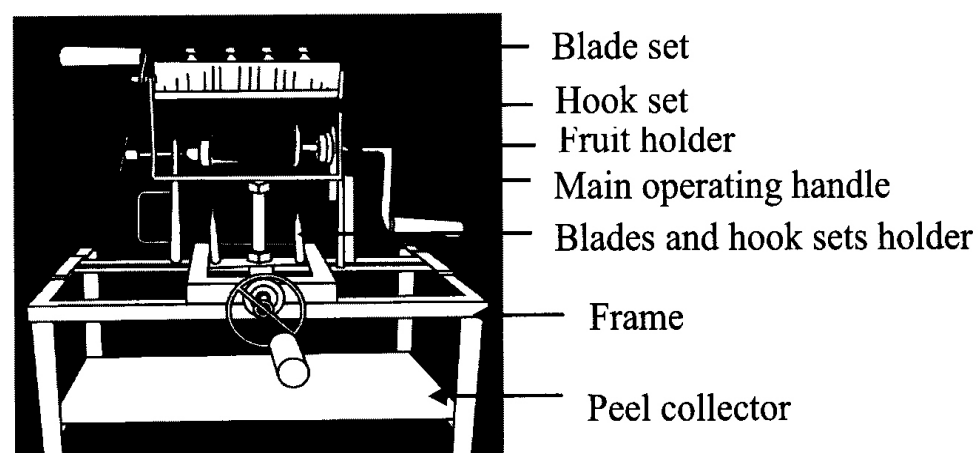


Figure 1 : Manually operated palmyrah peeler

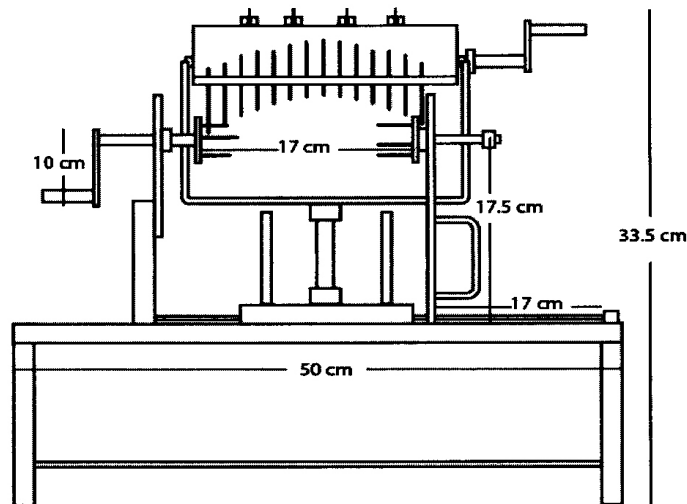


Figure. 2 : Major dimensions of the palmyrah peeler

Set of sharp stainless steel blades and a set of hooks were constructed as interchangeable in order to cut the pericarp of palmyrah fruits into parts and detach the cut pericarp from the palmyrah fruit. A rotating handle was used to change the blade set and hook set as required. Blades and hook sets were attached to a piece of flat iron bar to provide required strength while peeling. The most salient feature of this set is adjustability to overcome inconvenience of different sizes and shapes of palmyrah fruits.

The operating handle was fabricated using 8 mm iron rod with a wooden cover to provide high friction in between handle and hand. It was connected to the fruit holder with bearings to facilitate the rotating action smoothly. Shape of the handle could easily provide the required torque to operate the palmyrah peeler.

The fruit holder is consisting of two circles which were made with sheet metal. Each metal circles consist of three stainless steel pins to hold the fruit easily and avoid the separation of the fruits when processing. One metal circle was permanently fastened to the operating handle, so that it can be rotated by rotating the handle. The fruit holder was consisting of two parts as fixed part and adjustable part. The peel collector was designed to collect the separated peels.

The frame is the base of the machine which connected all the parts together. This was constructed using 1" L iron bar. Sheet metal of 4 cm x 4 cm squares were fastened to the bottom of legs in order to keep on a flat surface without any misalignment while operating.

These fabricated parts were fixed using permanent and non – permanent fastening methods. Non-permanent fastening methods were used in peeling blades and hooks set, at the places where blades and hooks were attached. Therefore, hooks and blades can be easily replaced when it wears away. Since non-permanent fastening methods have been used wherever possible, the machine can be disassembled easily when repairing and cleaning. Permanent fastening methods such as welding were used in the frame, part of the fruit holder and at the place where peeling blades and hook set attached to the frame.

After fabricating the machine, several trails with palmyrah fruits at different maturity stages were carried out to identify the practical problems. According to the identified problems, the machine was redesigned. After each and every modification the machine was tested again with palmyrah fruits to identify other associated problems. After reaching to a satisfactory level, the performances of the machine were compared with the manual peeling method.

Experimental procedure and performance evaluation

A bulk of palmyrah fruits from Anuradhapura area was collected and categorized into three categories according to the perimeter of the fruits such as small (perimeter < 10 inches), medium (perimeter in between 10 – 15 inches) and large (perimeter > 15 inches). They were peeled off with the newly constructed machine and existing manual peeling method. For the evaluation process, three persons were used and each person was asked to peel each category of fruits with both methods. At each and every trail, the time taken to peel one fruit,

number of fruits peeled within one hour, time wastage for cleaning and adjustments, number of damaged fruits and injuries occurred during the experiment were recorded.

Theoretical capacity, actual capacity, efficiency, cost of peeling of both methods was calculated.

Following equation (equation no. 01) was used to determine the theoretical capacity of both methods.

$$\text{Theoretical capacity (No. of fruits/ hr)} = \{1/\text{time taken to peel off one fruit (s)}\} \times 3600 \dots\dots\dots(01)$$

Actual capacity of both methods were determined as the total number of fruits peeled off within one hour after taking all the time wastages into account. Equation number 02 was used to determine the efficiencies of both methods.

$$\text{Efficiency (\%)} = (\text{Actual capacity/ Theoretical capacity}) \times 100 \dots\dots\dots(02)$$

Equation no. 03 was used to calculate the damaged fruits percentage.

$$\text{Damaged fruits percentage (\%)} = (\text{No. of damaged fruits/ Total no. of peeled fruits}) \times 100 \dots\dots(03)$$

Experimental procedure of this experiment was Randomized Complete Block Design (RCBD) and all the data were analyzed by using Statistical Analysis Software (SAS 9.0).

Results and Discussion

According to the preliminary test carried out before designing of the machine, the mechanism and major dimensions of the machine were determined. The easiest way of removing the peel is peeling along the vertical axis of the fruit, since it requires less force than perpendicular direction. The maximum values of the dimensions of the palmyrah fruit are shown in table 1.

Table 1: Maximum dimensions of the fruit.

	Dimension	Value	
The product	Maximum height of the fruit	17 cm	final of the
	Maximum diameter of the fruit	15 cm	
	Maximum thickness of the peel	2 mm	

machine is shown by the figure 03. When peeling a palmyrah fruit, the fruit should be placed at the fruit holder. The fruit holder is adjustable and any size of fruit could be hold at the fruit holder. One side of the fruit holder can be drawn a side and maximum adjustable length of the holder is 17 cm. As the first step of peeling, the pericarp of the fruit should be cut into pieces in order to facilitate the peeling process. The operating handle of the sets of blades and hooks should be operated and the pericarp is cut while operating the main operating handle. Main operating handle rotates the fruit holder with the fruit. After making cuts on the pericarp, it is easy to remove the peel. Again, the operating handle of the sets of blades and hooks should be rotated to have the function of the hooks. Hooks can remove the peel and removed peels are collected to the peel collector which is underneath the set of hooks. The peel collector is just like a drawer and it can be unloaded when it is fully loaded.

Conclusions

According to the capacity (66 fruits/hr) and efficiency (94%) of the machine (for medium size), it can be concluded that, newly introduced mechanical way for peeling is satisfactory and it can replace the existing manual peeling method. As the capacities between 43 and 66 fruits per hour, this peeling machine is most suitable for small and medium scale palmyrah juice producers. Damaged fruits percentage of mechanical method is low compared to the manual method. Therefore, quality of palmyrah juice after extraction could be kept at a good level. Based on the above facts and figures, newly designed Palmyrah Peeler can be recommended as appropriate machinery for Sri Lankan who are engaging in palmyrah based products.

Suggestions and Recommendations

The efficiency of the machine can be improved by replacing the manual power by motorized power at an affordable price for the palmyrah producers. In addition to that, a proper extension programme should be implemented to disseminate this new invention to the farmers.

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