Mechanization of Palmyrah Peeling Process to Promote Palmyrah based Products

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Abstract
Palmyrah (*Borrssas flabellifer* L.) is a multipurpose perennial crop with more than 80 years of economic life span and is important in waste land development, for food and ecological security, and as a livelihood. Although, the juice extraction from peeled Palmyrah fruits is properly mechanized, the peeling of fruits is not yet mechanized and thus has become a limiting factor to promote the juice extraction technology. Therefore, to increase the annual Palmyrah juice production, an efficient way of peeling as an alternative to manual peeling should be introduced. Therefore, the goal of this study was to introduce time and labour efficient mechanical method to peel off the Palmyrah fruit. Before designing this Palmyrah peeling machine, a preliminary study was carried out to understand the arrangement of fiber in the peel and all the required dimensions of the fruit. As the major components of this machine the set of peeling blades, set of hooks, adjustable fruit holder, operating handle and peel collector were identified. After a series of trials and modifications, final prototype machine was fabricated and the performance was 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.

Keywords: Palmyrah juice production, Peeling, Palmyrah peeler
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Introduction
Approximately 78% of the population in Sri Lanka is living in rural areas. Most of them suffer from poverty, characterized by malnutrition and landlessness. The average household income of these rural people is comparatively low. In palmyrah growing districts, some people also belong to this category and are engage in self-employment activities other than their main livelihood of Agriculture.

Palmyrah (*Borrassus flabelliferL.*) is popularly known as "Celestial tree" (*Kaprukha*). From leaves to root of this tree help in waste land development, food security, livelihood security and ecological security (Balasubramaniam *et al.*, 1999). Average annual income from palmyrah products is about Rs. 150 million in 2012 (Annual Report of Palmyrah Development Board, 2012) and there is a significant increase in demand for palmyrah products in both local and export. Palmyrah Development Board produces 20,000 liters of Palmyrah pulp while the others produce 50,000 liters per year. But there is lack of supply to consumers for their demand (Annual Report of Palmyrah Development Board, 2012).
The mature fruit, yellowish color thick substitute which coated over fiber of mesocarp of palmyrah fruit (Nikawela, 2006) is usually embers to cook them mildly and the skin is peeled off manually to expose the juicy fruit (Kokulathasan, 1990). The Palmyrah juice extraction process is already mechanized by National Engineering Research and Development Centre. Palmyrah fruits should be properly peeled before juice extraction process. Therefore, according to the demand to offer the supply peeling off process must be mechanized. Palmyrah peel is strongly attached to the fruit fiber and very hard to remove manually. This is a highly labor consuming and important operation that needs special care as it leads to the quality and hygienic condition of the final product. Therefore the aim of this study is to design and develop a palmyrah peeling machine to promsuitable for small and medium scale farmers.

Materials and Methods
Designing and development of the palmyrah peeling machine were carried out at the Engineering workshop of the Faculty of Agriculture, Rajarata University of Sri Lanka. The height, diameter, weight and thickness of the peel of randomly selected fifty palmyrah fruits were measured to determine the optimum dimensions of the machine. There were five major components in this machine namely, a set of peeling blades, a set of hooks, adjustable fruit holder, operating handle and frame which are shown in Figure 1. Durable and readily available

materials in the local market were used to fabricate the prototype in order to make the repairs and maintenance easy at village level and to keep the cost of production at an affordable range. Series of preliminary test were carried out to identify the practical problems and appropriate modifications were applied to overcome all the problems.

The performance of the machine was compared with that of the most popular manual method, using fruits at different maturity stages. Fruits were 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).The machine was tested for theoretical machine capacity, actual machine capacity, efficiency, cost of peeling and breakeven point. The average time taken to peel one fruit and the number of peeled fruits within one hour were measured using a stop watch and the number of completely peeled fruits, incompletely peeled fruits and damaged fruits were counted. Five persons were engaged with this evaluation process with three replicates of each category of fruits.

Results and Discussion

According to the results of the preliminary test carried out to determine the dimensions of the machine, the maximum height of the fruit, maximum diameter of the fruit and thickness of the pericarp were 17 cm, 15 cm and 2 mm, respectively. Total production cost of the machine without labor was LKR 10500. Therefore this technology can be introduced as an affordable technology for rural palmyrah farmers. The technology and mechanism of the operation is not much complex and special skill is not required to operate.

The operator firstly adjusts the stainless steel blade and hook set holder according to the size of the fruit. The operator has to place the fruit in the fruit holder and the holder grip the fruit using pins. When the operating the handle of the holder, the fruit rotate and subjected to cut and peel. Sharp stainless steel blades were used to cut the pericarp of palmyrah fruits into parts in order to facilitate the peeling action. Blade set was hold nearly 15^0 angle to the surface of the fruit from the horizontal plane of the holder. This angle was adjusted according to the size of the fruit. Large size fruits had to give small angle and small size fruit had to give large angle. Peeling off of the peel from the fruit, it had to cut in segments. Therefore blade fixed side of the holder should use firstly. Giving the correct angle to the blade set and hold closer to the fruit and rotate the main operating handle to supply required power for peel off the fruit simultaneously. After that hook set should hold from giving the correct angle while operating the machine. Peel collector collects peels while operating the peeling machine. Correct angle should give to the blade and hook set were more important step of the machine peeling. It reduced the time wastage of machine peeling. Peels were collected into the peel collector that kept surrounding environment of the machine untidy. Theoretical time requirement for the operating the machine was taken as one hour. Actual time requirement was less than one hour due to the time taken for adjustments and movement of the peeler. Field tests were conducted for both manual and mechanical methods using three replicates and the results were tabulated in Table 1.

Results reveal that, the Palmyrah peeler performs well with the medium size fruits than other sizes. Palmyrah Development Board (PDB)

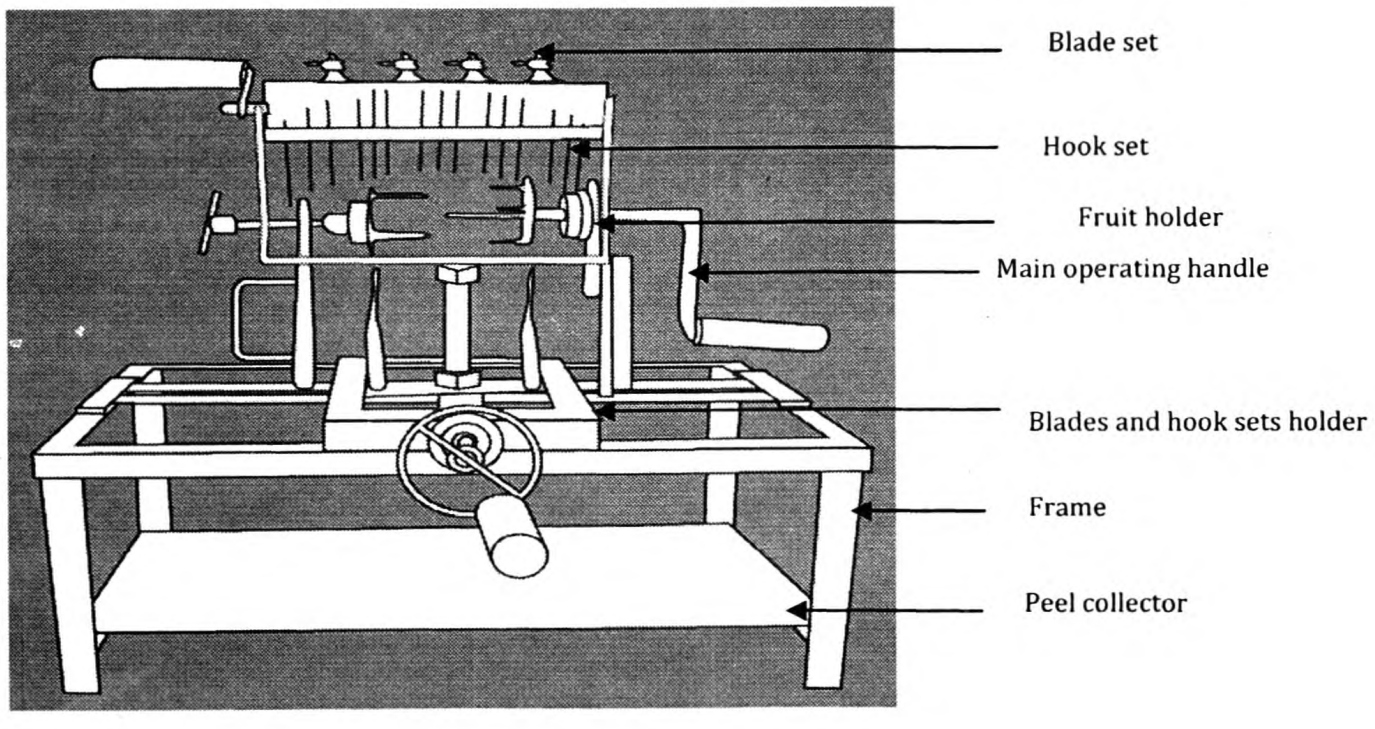

Figure 1: Components of the machine

Table 1: Performance of the machine and manual peeling

	Theoretical Capacity (Fruits per hour)		Actual Capacity (Fruits per hour)		Machine Efficiency	
	Machine	Manual	Machine	Manual	Machine	Manual
Small	87	60	54	36	62	60
Medium	69.67	45.95	66.122	42.24	94	91
Large	54	36	43.2	28.4	80	78

also recommended using medium size fruits to obtain the maximum benefit. The time wastage for adjustments was considerably lower when using medium size fruits and it is more compatible for a better operation. Results of the T test showed that, there was a significant difference ($p<0.05$) in efficiencies, capacities and damages occurred to the fruits between manual peeling and machine peeling. In manual method, the fruit has to be separated into two or three parts before peeling and it cause to bruise and drain out the juice.

The machine can be recommended for female operators too, as it requires less force to operate and any special skill is not needed. Therefore, the machine is more efficient than manual peeling. As the breakeven point of the machine is 1500 fruits per year, it can be concluded that it is highly suitable for small and medium scale palmyrah producers. The newly designed Palmyrah Peeler can be recommended as appropriate machinery for palmyrah producers.

References

Annual reports of Palmyrah Development Board, Jaffna, 2012.

Balasubramaniam K, Jansz ER and Ariyasena DD 1999. A monograph "Palmyrah" published by E.R. Jansz by International programme in Chemical Science, Sweden. 1- 39pp.

Kokulathasan S 1990. Studies on the yield of sap in palmyrah palm: MSc theisis, University of Jaffna. Pp10–24.

Nikawela JK 2006. "Palmyrah", Palmyrah Development Board: 1 – 18.