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Scope, Nutritional Importance and Value Addition in Palmyrah (*Borassus flabellifer* L.): An Under Exploited Crop

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Abstract

Palmyrah palm has great economic potential and every part of the palm is useful in one way or the other is considered as 'kalpaga tharu'. The palm is found growing widely in southern states of India. As the value addition in palmyrah is not standardized, the palmyrah products *viz.* tender fruit endosperm (*nungu*), *neera*, jaggery and tuber flour are not commercialized so far. Even though palmyrah is an economically important palm for its nutritional aspects, it has not received proper attention from the agricultural research workers, probably on account of the fact that it is very slow growing palm and mostly found in the wild state. In this context, knowing the physico-chemical properties and development of value added products and popularizing the same is essential.

Keywords: *nungu*, *neera*, jaggery, tuber flour, value addition

1. Introduction

Palmyrah (*Borassus flabellifer* L.) belongs to very ancient family of trees *i.e* Arecaceae and order Arecales. Palmyrah is also known as toddy palm and sugar palm. It is a tropical palm tree which is easily cultivated and also found to grow wild. It is native to Indian sub-continent and South-East Asia. It is widely cultivated from Western India through Indo-china to the lesser Sunda Islands of Indonesia including Bangladesh, Cambodia, China South-Central, Jawa, Laos, Malaya, Myanmar, Socotra, Sri Lanka, Sulawesi, Thailand and Vietnam.



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The name borassus was derived from a Greek word means leathery covering of the fruit and the word flabellifer means Fan bearer. *Borassus flabellifer* is a robust tree that can live more than 100 years and reach the height of 50 to 60 meters. These can be grown in waste lands, farm filed boundaries, sea costs, parks, industrial estates and house colonies. The trunk is grey, robust and old leaves remain attached to the trunk for several years before falling cleanly. The leaves are look like fan-shaped and it grow up to 3 meters long with robust black teeth on the petiole margins. The palmyrah palm throws out spathes during the flowering season and on tapping the young inflorescence a clear, transparent, sweet, pleasant smelling and refreshing and popular drink called *neera* is obtained with high nutritive value, delicious taste and agreeable flavor. The tapping of *neera* and making it into sugar candy was observed by Chinese traveler Magestanes. The different parts of the plant such as roots, leaves, seeds and fruits are used for various purposes. Now a day's palm trees are being cut by people because of not knowing the medical and commercial values.

In India, palmyrah adorns the dry landscape of the semi arid regions of Tamil Nadu, Andhra Pradesh, Gujarat, Odisha, West Bengal, Bihar, Karnataka and Maharashtra. Currently, palmyrah palm wealth of India is estimated as 102 million palms and half of them are in Tamil Nadu. Out of 51.90 million palms in Tamil Nadu, more than 50% of palms are concentrated in the Southern district of Thoothukudi [1]. Government of Tamil Nadu in the year 1978 recognized Palmyrah as State Tree.

Mccurrah [2] enlisted the following 7 species under the genus *Borassus* (Table 1).

Based on the pigmentation of fruit skin Palmyrah palm can be broadly classified into two varieties.

1. Black skin fruits

2. Red skin fruits

1.1 Black skin fruits

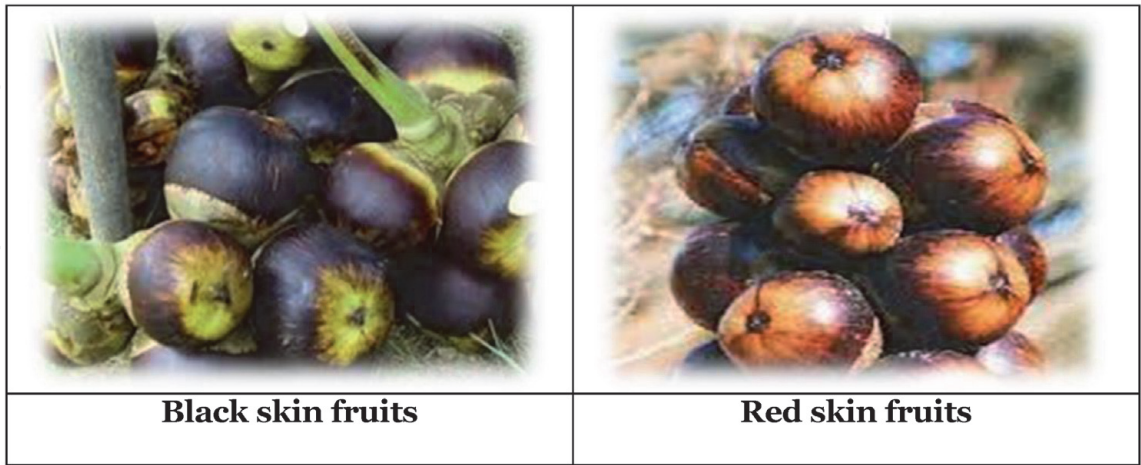
Less red pigment is found on the fruit skin. Yield is less but superior seedlings with more starch content and less fibre content noticed. Pulp extraction process is easier. Alkaloids, minerals and free amino acids are lesser than red coloured fruits.

1.	<i>Borassus flabellifer</i>	Indian and Malayan spp.
2.	<i>Borassus aethiopicum</i>	African spp.
3.	<i>Borassus deleg</i>	Sudan
4.	<i>Borassus heiniana</i>	New Guinea
5.	<i>Borassus madagascariensis</i>	Madagascar
6.	<i>Borassus sambiranensis</i>	Madagascar
7.	<i>Borassus machadonis</i>	Malaya

Table 1.
Species of *Borassus*.

1.2 Red skin fruits

Variable amount of black pigment observed on the fruit skin. Fruit yield per tree is significantly high. Pulp, sugar and starch content are less when compared to black skin fruits.



Both the black skin and red skin fruits are recorded for essential amino acids, lysine and methionine. In view of the fruit characters and sap yield the red skinned fruit varieties are seemed to favour for selection for commercial exploitation (Figure 1).

In order to prevent huge quantitative as well as qualitative losses in horticultural crops like plantation crops (cashew nut, areca nut, tea, coffee, oil palm, coconut and Palmyrah palm - as these are consumed mostly after the processing) all steps of improved postharvest technology must be carefully implemented from harvesting and ending with consumption and utilization of their products (value added products). In spite of adequate food production, there is existence of hunger and malnutrition. That might be due to the result of uneven distribution of food, losses and deterioration of available food produce. Hence, maximum utilization of available

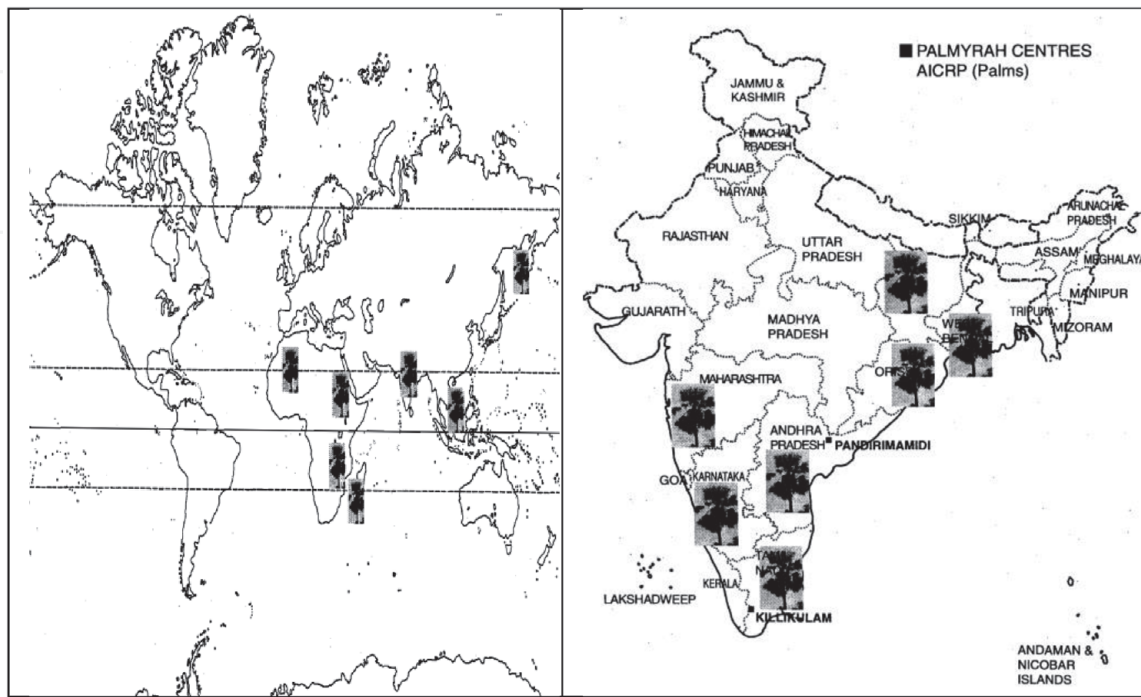


Figure 1.
Palmyrah palm distribution in Worldwide and India.

food and minimization of postharvest losses are absolutely essential in the current scenario.

Food material are subjected to spoilage. The aim of food processing or value addition is to protect food against deterioration or spoilage. The rate of spoilage of raw or fresh food commodities may be very high. The spoilage of food is due to three main causes: (1) microbial, (2) enzymatic and (3) chemical. Foods during storage are more or less infected with microbes that lead to decomposition of the food constituents, sometimes produce evil-smelling and toxic substances. Hence, prevention of microbiological spoilage is essential in any preservation method.

2. Need for post harvest management in palmyrah palm

Palmyrah nungu, neera, tuber flour are highly prone to post harvest losses due to spoilage because they are composed of living tissues. These tissues must be kept alive and healthy throughout the process of marketing. Several factors influence the post harvest losses in commodity. These includes primary factors like mechanical injuries, physiological changes, pathological infections or environmental factors such as temperature, humidity *etc.* Secondary factors which are responsible for deterioration of produces are inadequate facilities of proper harvesting, proper handling, post harvest treatments, packaging and storage. Palmyrah is one such crop where post harvest handling protocols and value addition was not standardized so far.

Post harvest life is also governed by moisture content, rate of respiration, ethylene production and external factors like temperature, relative humidity and atmospheric compositions. Post harvest losses can be considerably minimized and the shelf life can be greatly increased by careful manipulation of the above factors. Deterioration of palmyrah products like nungu, neera and tuber flour during storage depends largely on temperature. One way to slow down these changes can be achieved by lowering the temperature to an desirable level.

3. Scope of palmyrah natural and value added products

Value addition involves change in the physical form of the agricultural produce which leads to its greater acceptability, extended availability, enhanced market viability and increased cost to benefit ratio for the grower of the agricultural produce. The spatial and temporal availability of the produce is enhanced and it becomes less sensitive to price fluctuations in the market. Value addition involves commoditization of the agricultural produce. Therefore, value addition is desirable from both the producer's as well as the consumer's point of view and has aptly been termed as secondary agriculture as stated by United States Department of Agriculture.

However, with the increasing population, industrialization and urbanization, India is facing serious challenges in food security. In order to sustain the agricultural production and address the challenges of food and livelihood security, agricultural diversification has to be adopted through the concept of value addition by minimizing the dependency on main staple crops.

Introduction of new species in the agricultural production system in India is the need of the hour to increase the resiliency of agriculture. In this context, palmyrah palm is one such under exploited crop which have received less attention from agricultural research workers, probably on account of the fact that it is very slow growing palm found mostly in the wild state inspite of having a good number of

produce in fresh form (palm neera, nungu) as well as in value added form with a capacity to provide high nutritional value which is having the potential to overcome the problem of malnutrition in developing countries like India. Palmyrah palms are suitable for popularization through value addition (tuber flour, jaggery) which helps in income generation and thus it will improve food security to the poor and livelihood security of the marginal farmers. They can potentially reduce the dependency on few major species (wheat, sugar cane) while diversifying the agricultural production system and making it sustainable.

4. Importance of value addition in palmyrah

Fresh palmyrah tender fruit endosperm (*Nungu*), sap (*Neera*) and tuber flour are perishable and highly prone to post harvest losses due to spoilage. After removing from husk, outer skin of palmyrah tender fruit endosperm starts browning and loses appearance and will be fermented which causes sour odour. It is a main factor for consumer to judge its freshness. In normal conditions, *nungu* will have very short shelf life of 2–3 days. Palmyrah sap is naturally prone to fermentation within few hours of extraction and becomes alcoholic beverage (Toddy). Under these circumstances, the processing of tender fruit endosperm and sap into value added products with sufficient shelf life is most important to utilize the products further. Thus the shelf life, quality and availability of the products can be improved by concept of value addition and the value added products have to be commercialized.

Hence, there is a need to study the scope of postharvest techniques for value added products and their shelf life in palmyrah.

Postharvest treatments, packing material and storage conditions significantly increase shelf life, reduce postharvest losses and maintain nutritional quality of palmyrah tender fruit endosperm as well as sap. Hence, it becomes necessary to find out suitable postharvest treatments such as packing material and storage conditions to extend the shelf life and reduce losses of PTFE, neera and other value added products *viz.*, palm jaggery and palm tuber flour.

5. Uses and nutritional importance of palmyrah natural and value added products

Palmyrah is referred as tree of life with nearly 800 uses including food, beverage, fiber, fodder, medicinal and timber. Among the various uses of the palm, the sweet sap from the inflorescence for making *neera* obtained by tapping the tip of the inflorescence either male or female is traditionally collected in hanging earthen pots and used to quench thirst. The sweet sap collected early in the morning is refreshing and light drink called *neera* in telugu and marathi and “*pathaneer*” in tamil. *Neera* has sugary sweet in taste, oyster white in colour, translucent with high nutritive value but susceptible to natural fermentation at ambient temperature within a few hours of extraction [3]. The sap collected in the evening or after fermentation becomes sour which is called *kallu* in telugu and *tadi* in marathi. *Tadi* is mostly consumed by villagers as raw alcoholic beverage.

When the fruit is very young, the kernel is hollow, soft as jelly and translucent like ice and is accompanied by a watery liquid, sweetish and potable. The jelly part of the fruit is covered with a thin, yellowish-brown skin. These are known to contain watery fluid inside the fleshy white body. Palmyrah tender fruit endosperm (PTFE) contains 43 kcal of energy, 87.6 g of water, 0.8 g of protein, 0.1 g of fat and 10.9 g of carbohydrates per 100 g fresh weight of palmyrah tender fruit endosperm [4].

Palmyrah tuber is an important edible shoot grown in loose soil from the seed of ripe fruit. Tuber is eaten by many people directly by cooking in open fire after peeling off outer layer. Roasted, dried tubers are ground to make flour which is blended with wheat flour for baking. The flour can be made into a number of food items which are used traditionally. It is used in preparation of odiyal consumed as porridge called khool and a steamed product called pittu. *Odiyal* made from palmyrah tuber flour contains 1423 kcal of energy, 10.8 g of moisture, 3.1 g of protein, 77.1 g of carbohydrates and 5.6 g of crude fiber per 100 g [5].

Ripened fruit is used in preparation of various foods at home level. The soft orange-yellow pulp (mesocarp) of the ripe fruit is sugary, dense and edible, rich in vitamin A and C. Palmyrah also contains bitter compounds called flabelliferrins, which are steroidal saponins. Ripe fruit pulp can be processed into soft beverages, jam, spread, toffee, delicious food items and sweets [6].

The palm jaggery is processed from the unfermented palmyrah tree sap called *neera*. Palm jaggery contains of 65–68% sucrose and 5–15% reducing sugars which is directly used in ayurvedic preparations and believes to reduce the lung cancer. Hundred grams of palmyrah jaggery contains 0.35% of protein, 0.17% of fat, 90.6% of carbohydrates, 24 mg of vitamin B-1, 11.0 mg of vitamin-C and 0.74% of minerals [7].

6. Palmyrah value added products

See Table 2.

Plant part	Value added products
Edible value added products	
Inflorescence sap	Toddy, Jaggery, Sugar, Honey, Wine
Fruit	Toffee, Spread, Jam, Pickle, Sweets (Burfi), Beverages (RTS, Squash, Nectar)
Kernel	Canned products
Non-edible value added products	
Leaf	Mats, Baskets, Fans, Hats, Umbrellas, Buckets, Writing Material, Fence, Fibre extracted is used to make brushes and handicrafts
Fruits	Fibre extracted is used to make toys and fancy items
Stem	As poles for sheds construction and as timber source

Table 2.
Value added products of palmyrah palm (edible and non-edible products).

7. Value addition in palmyrah (edible products)

7.1 Neera

Increasing health consciousness among the population in India has boosted the growth of health drinks industry in India. *Neera*, also called palm nectar (phloem sap extracted with zero percent alcohol) extracted from the inflorescence of toddy palms which is used as a nutritious health drink. *Neera* is called sweet toddy since it contains zero percent alcohol and known as *padaneer* in Tamil Nadu and *kallu* in

Telugu. Toddy and *neera* can be called as fermented sap and non-fermented sap respectively. *Neera* is susceptible to natural fermentation at ambient temperature within few hours of extraction due to enzymatic and microbial fermentation since it is rich in sugars, vitamins, proteins and minerals [8]. Once fermented, *neera* becomes toddy which is unsuitable as health drink or as value added product.

Neera is rich source of sugars, minerals and vitamins. It contains substantial amounts of iron, phosphorus and ascorbic acid. It is more nutritious than any of the commercially marketed fruit juices available in the country. The nutritional composition of *neera* is given in **Table 3**. Palmyrah palm *neera* contain very low Glycemic Index (GI) of 35 (normal table sugar has GI 70), *neera* can be used by diabetic patients also.

The high nutritive value of *neera* makes it an emerging health drink. It is cool and good for improving the general health. It can be served to supplement the iron and vitamin deficiency. Clinical studies proved *neera* has potential medical applications for treating asthma, tuberculosis, bronchial suffocation and piles. It is believed to facilitate clear urination and prevent jaundice. High amount of glutamic acid is present in *neera*. It is the amino acid which is used by the body to build proteins. *Neera* can be used to treat eye abnormalities and eczema as it contain high amount of inositol. *Neera* can be used as stimulant and antiphlegmatic which is considered to be useful in treating inflammatory infections. Women suffering from anemia due repeated pregnancies are advised to take *neera* to ameliorate health.

8. Season and stage for tapping

The extraction of sap from the inflorescence is called tapping and tapping vary according to the sex of the palm and age of the inflorescence. Long tapping duration is noticed in female palms (April to December) when compared to male palms (December to February). Dry season tapping is done mostly in the low lying lands where palms do not suffer due to moisture stress during drought period. The spathe is considered ready for tapping when the inflorescence opens or is just about to

Physico chemical parameter	Neera	Endosperm/Nungu	Jaggery	Tuber flour
Moisture (%)	—	—	09.02	09.32
TSS (°Brix)	10.00	08.50	07.50	05.10
Ph	04.28	06.44	05.51	05.54
Titration acidity (%)	00.57	00.06	—	00.40
Total sugars (%)	14.85	08.83	09.30	14.39
Reducing sugars (%)	05.16	05.11	05.10	08.50
Non reducing sugars (%)	09.69	03.72	04.20	05.89
Starch (%)	—	—	—	32.96
Fiber (%)	—	—	—	10.20
Protein (%)	—	—	—	02.96
Phenols (mg)	00.28	—	00.16	10.43
Browning (%)	—	00.01	—	—
Alcohol content (%)	02.00	—	—	—

Table 3.
Proximate physico chemical composition of palmyrah natural and value added products on initial day of storage [9].

burst. The female flowers within the unopened spadix causes a swelling at the base and this indicates the appropriate stage for tapping.



Neera is widely consumed in countries like India, Sri Lanka, Africa, Malaysia, Indonesia, Thailand and Myanmar. It is a potential health and therapeutic drink since it is rich source of Vitamin C and vitamin B complex, having more calories which fight against diabetes, cancer, electrolyte deficiency and even hair fall. *Neera* is rich source of sugars, essential elements micronutrients and minerals. It contains acids like nicotinic acid (Vit.B3) and riboflavin (Vit.B2) and also can be consumed by people suffering from diabetes since it has a low glycemic index (GI) [10]. Consumption of *neera* prevents jaundice and also facilitates clear urination. It keeps the human biological system cool and helps to improve digestion. In a large scale *neera* production is noticed in an un-organized manner with major consumption by rural population. Hence, there is a wide scope for commercializing the product.

9. Tapping in male palm

9.1 Aripandai

Sap extracted from 2 weeks old inflorescence by removing the sheet covering the inflorescence and the inflorescence is kept to dry for three days. Later a new surface is made by cutting and pot is tied directly to the inflorescence to collect the sap. In this method no pressing or stroking to the inflorescence is made as like other methods of tapping.

9.2 Vallupanai

Sap is extracted from one month old inflorescence. In this tapping method male spikes bearing sessile flowers are subjected to pressing and stroking and such three to six spikes are brought together wrapped with palmyrah leaves kept in a pot for collection of the sap.

10. Tapping in female inflorescence

10.1 Tattupalai

Sap is extracted from the young inflorescence by softening the tissues. The inflorescence main axis is hitted with iron rod and fork is used to give a small press in the region where the fruits used to develop.

10.2 Kaivetty

The sap is extracted from the inflorescence at an age of two to three months where the matured fruits on the inflorescence are sliced for collection of the sap (July to November).

10.3 Nungu (palmyrah tender fruit endosperm)

The tender fruit endosperm is a summer delicacy consumed in the southern and eastern parts of India. On the hot summer day *nungu* acts as a coolant for the parching throat. It provides a proportionate balance of minerals and sugar which is required for the body during the summer season to attain cooling. The tender fruit endosperm, which is available in abundance during the summer season, is rich in vitamin B, iron, calcium niacin and riboflavin. It is used to cure ulcers, urinary infections and heat rashes which mainly occur during summer months [11].



The palmyra tender fruit has the outer fibrous layer containing the sugary gelatinous endosperm. Fresh tender endosperm is perishable and highly prone to postharvest losses due to spoilage as it is composed of living tissues. These tissues must be kept alive and healthy throughout the process of marketing. Several factors influence the postharvest losses of most commodities. These include primary factors *viz.*, mechanical injuries, physiological changes and environmental factors such as temperature, humidity *etc.* Secondary factors which are responsible for deterioration of produce is due to inadequate facilities for harvesting, handling, postharvest treatments, packaging, transportation, storage.

10.4 Jaggery

Palmyrah jaggery is superior to cane jaggery. Cane jaggery is sweet, but Palm jaggery is sweet and delicious it can be produced worth crores of rupees. Palm jaggery gives mineral salts too. Doctors have told me to eat jaggery and I always eat Palm jaggery. Nature has made this product in such a way that it cannot be manufactured in the Mills, it is produced in the Cottages. Where there are Palm trees, this jaggery can be easily produced. Andhra Desha has thousands of Palm trees, there jaggery is produced in every hamlet. This is the way to banish poverty from the land. This also is an antidote to poverty.” (From a speech delivered at the opening of the village industry exhibition in Brindawan Bihar on 3 May 1939 by Mahatma Gandhi) which speaks about the potentiality of palmyrah jaggery.

Jaggery is a natural sweetener made by concentrating the palmyrah fresh neera with clarification to remove impurities and uniform heating in open pan. As the jaggery is made up of longer chains of sucrose it is complex in nature when

compared to sugar that makes the jaggery to digest slowly than sugar and releases energy slowly and not spontaneously which provides the energy for a longer period of time so it is not harmful for the body. It is a sensitive product, getting affected by number of factors right from collection of neera to processing and storage of jaggery. The jaggery industry is still at cottage level because of some technological drawbacks in its export quality processing and storage. The keeping quality of jaggery largely depends on the atmospheric temperature and relative humidity [12].

Jaggery is mostly spoiled during the monsoon period because of the presence of higher humidity in the atmosphere. The major problem associated with jaggery storage is the presence of invert sugars and mineral salts which are hygroscopic in nature. In the coastal region of the country, where atmospheric humidity and rainfall very high as it is very difficult to store jaggery. The study showed that about 5–10% of stored jaggery get spoiled every year leading to a huge loss [12].

In India, the jaggery storage facilities at producer/farmer level are very poor as it is stored in godowns, household kitchens and cheap storage systems where hygienic conditions are not strictly maintained, which attract several pathogenic and non-pathogenic microorganisms. Cold storage godown is being used in west Godavari and Vishakhapatnam districts of Andhra Pradesh, Kolhapur district of Maharashtra and Muzaffarnagar area of Uttar Pradesh in India. But for small farmers storing jaggery in the cold storage is very difficult due to cost and energy consumption factor [13].

11. Preparation of palmyrah jaggery

Palmyrah sap (neera) was collected in slacked lime treated earthen pots for experimental purpose. The cleared sap after lime sedimentation and filtration was transferred into the galvanized iron pan and boiled to 110°C. Few castor beans were crushed and put into iron pan to prevent over boiling. During boiling, a white scum arises on the surface which was skimmed off (removed with a ladle). Neera gets transformed into viscous fluid at 110°C. The fluid was stirred continuously to avoid charring at the bottom of vessel. Placing a few drops of fluid into cool water, the correct stage of formation of jaggery was judged. The hardening of fluid in the cold water is the indication of right stage of conversion of neera into jaggery. At this stage, jaggery fluid was poured into moulds and allowed to cool, then after some-time, fluid jaggery solidified in the moulds. The solid jaggery cubes were removed from the moulds and used in the experiment.



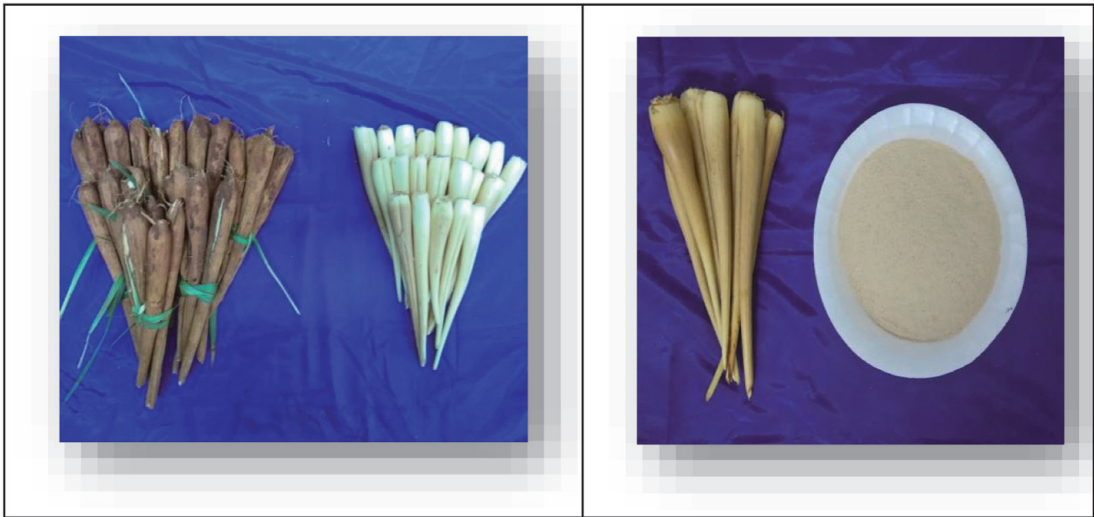
12. Palmyrah tuber flour

Tuber is an edible shoot grown in loose soil from the seed of ripe fruit. Tuber is eaten by many people directly by cooking in open fire after peeling off outer layer. Palmyrah tuber is rich in starch and fibre, which is helpful in controlling various diseases especially diabetic. Regular consumption of palmyrah tuber flour increase

the body strength, reduce hunger and mixing of palmyrah tuber flour with other foods would positively reduce the malnutrition [14].

13. Bio active components in palmyrah tuber flour

Starch is the main carbohydrate present in palmyrah tuber flour. The starch has low viscosity and gelatinization temperature but exhibit good settling property as such food starch. The palmyrah tuber flour starch is devoid of bitterness as it is inherent property of palmyrah tuber and has a grain size of 40 μm similar to potato starch.



14. Palmyrah fruit

Palmyrah fruit pulp can be utilized to prepare food items and animal feed. About 40% pulp is obtained from the fruit which is dark yellow in colour with a characteristic taste, flavor and bitterness. Palmyrah pulp is mixed with other fruits to making jam, cordial, cream etc. As the palmyrah pulp is bitter in taste, it is better to prepare mixed fruit jam instead of palmyrah jam separately.



15. Extraction of pulp from palmyra palm

Fully ripened fruits obtained from the palm are washed, peeled and pulp is to be extracted manually by rubbing with the traditional Palmyra extractor. Additional water was used in the proportion of 1:1 ratio to extract the pulp which is adhered to the seeds. Heat treatment (70°C for a period of 10 min) was given to the pulp to obtain maximum pulp recovery [15]. Then the pulp is sieved to remove the fibrous material.

16. Preparation of palm spread

The best recipe for preparing palmyrah palm spread (pulp-1 kg, sugar-1 kg, skimmed milk powder-100 g, small cardamom-4 number citric acid-5 g) for the preparation of palm with good Total Soluble Solid (TSS) and acidity. For the preparation of palm spread, extracted pulp is mixed with other ingredients, heated at low flame with continuous stirring till the TSS reaches 65–68°Brix. Then cooked material was removed from heat, filled into broad mouth sterilized glass bottles, capped, labeled and stored at both room and refrigerated temperature.

17. Bio active components in palmyrah fruit pulp

Palmyrah fruit pulp consists of 75–80% moisture and the main components are carbohydrates. It also contains free amino acids like lysine, aspartate and glutamate. The main digestible carbohydrates found in palmyrah fruit pulp are sucrose, glucose and fructose. The content of carotenoids (beta carotenes) found but they varied.

Flabelliferrins (steroidal saponins) are reported to be the compounds which are responsible for the cause of bitterness in palmyrah fruits. A wide range of flabelliferrins were reported which act as anti-microbial properties. The term flabelliferrin was coined from specific word flabellifer (**Figure 2**).

17.1 Palm sugar

Palm sugar can be used as a substitute for cane sugar. To prepare palm sugar *neera* is strained through wire mesh to make the *neera* free from debris and it is boiled in an alloy vessel. *Neera* is boiled uniformly and the liquid is allowed to cool all the sediments have to be removed. Clarification is carried out by adding triple super phosphate to form insoluble calcium calcium phosphate as it react with the lime which is already present. Later it is heated to a temperature of 110°C for 2 hours until it reach honey like consistency then allowed to cool and passed through a crystallizer. After forming sugar crystals, it is centrifuged to collect sugar and dried and powdered to store.

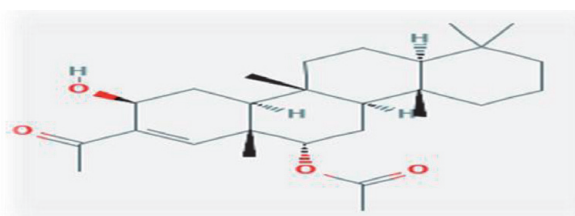


Figure 2.
Structure of flabelliferrin.



17.2 Palmyrah honey

Fresh *neera* is heated for 2 hours to obtain honey like consistency and it is transferred to mud pots. Ripe, dry and shelled tamarind fruits devoid of seeds are added to the boiled syrup. To prepare 10 liters of syrup about 1 Kg of tamarind fruits are required. The pot is closed with cloth and containers are kept in a shock proof, cool and dry place for a period of 130–180 days.

17.3 Toddy

Toddy is formed as a result of fermentation of neera/sap by wild yeasts and bacteria, which come into contact with the sap after tapping. This is an uncontrolled natural fermentation by number of different strains of yeast and bacteria. The alcohol content in naturally fermented toddy is reported to be 5%. But fermentation of palmyrah sap by using pure yeast culture gives about 7.8% alcohol content under laboratory conditions. The major sugars that are present in partly fermented toddy is sucrose, glucose and fructose but these will be gradually converted into ethyl alcohol during the process of fermentation [16].

17.4 Wine

Unfermented sap (*neera*) is sterilized which can be fermented with suitable strains of yeast to obtain palmyrah wine. Sweet toddy having a pH of 6–7, is sterilized and inoculated with good yeast that produces a very clear straw coloured wine. The alcohol strength increases by adding extra sugar to the sap. The wine prepared by this method is pleasant to drink which mask the specific characteristic toddy flavour and distinctive sour taste of the acids present in toddy [17].



18. Value addition from non edible products

18.1 Palmyrah leaves

The tender leaves which are in ivory colour are harvested from the palm are sized into narrow strips that can be utilized for making toys, flowers, garlands and fancy goods. Whereas, the matured leaves are used for making of containers. The harvested leaves have mid ribs that can be utilized for making of the brooms.




18.2 Palmyrah fibre

Fibre is extracted from the bifurcated base of leaf stalk. The palmyrah fibre is the product that having good export market in countries like Australia and United Kingdom and Japan. The fibre obtained from palmyrah palm leaf stalks is mainly valued for its high tensile strength leading itself for many industrial applications.

Naar is the fibrous material obtained from stalk of the fronds. Karukku are the longitudinal splits which are obtained by soaking the stalks after removing the sharp serrated margins of the petiole which can be used for tying purpose.

18.3 Palmyrah timber

Palmyrah timber is most valued for the construction of houses in the villages and sometimes the timber is also utilized as rafters and beams. The timber obtained from palmyrah palm is also used as fire wood.

		
Palmyrah leaves	Palmyrah fibre	Palmyrah wood

19. Research and development organizations on Palmyrah

All India Coordinated Research Project on Palmyrah (AICRP ON Palms (Palmyrah)).

Palmyrah is a mandatory crop under All India Coordinated Research Project on Palms (AICRP). Horticultural Research Station, Pandirimamidi under Dr. YSR Horticultural University, Andhra Pradesh and Horticulture College and Research Institute, Killikulam in Tamil Nadu are the two research centers under AICRP on palmyrah where the collection, conservation and evalution of existing germplasm in palmyrah and hybridization for developing dwarf types are focused.

Palmyrah Development Board (PDB), 244, Gallie Road, Bambaalapitiya, Colombo, Sri Lanka.

20. Conclusion

Palmyra tree plays an important role in human life. Every part of the tree is used for preparation of various types of products and it gives more health benefits. But everyone is not aware of this tree. So, it is necessary to create awareness regarding palmyrah natural (neera, nungu) and value added products (palm sugar, honey, toddy, wine, jaggery and flour). Post harvest losses can be considerably minimized and their storage life can be greatly increased by careful manipulation of moisture content, rate of respiration and atmospheric composition.

Value addition involves change in the physical form of the agricultural produce which leads to its greater acceptability, extended availability, enhanced market viability and increased cost to benefit ratio for the grower of the agricultural produce. However, with the increasing population, industrialization and urbanization, India is facing serious challenges in food security. In order to sustain the agricultural production and address the challenges of food and livelihood security, agricultural diversification has to be adopted through the concept of value addition by minimizing the dependency on main staple crops. Introduction of new species in the agricultural production system in India is the need of the hour to increase the resiliency of agriculture. In this context, palmyrah palm is one such under exploited crop having a good number of produce in fresh form (palm neera, nungu) as well as in value added form with a capacity to provide high nutritional value and having the potentiality to overcome the problem of malnutrition in developing countries like India. Palmyrah palms are suitable for popularization through value addition (tuber flour, jaggery) which helps in income generation and thus it will improve food security to the poor and livelihood security of the marginal farmers.

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