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Review Article

A review on nutritive, medicinal and commercial aspects of Asian Palmyra palm fruit

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Abstract

The Asian Palmyra palm (*Borassus flabellifer L.*) is an economically important tree widely distributed in the Indian subcontinent and Southeast Asia. The multifaceted uses of the Palmyra palm fruit as food, wood, and medicine, make it a viable industrial crop. It is among the most beneficial species that have economic and medicinal value. It is found to posses anti-inflammatory, anti-arthritic, cytotoxic, antibacterial, analgesic, antipyretic, hypoglycemic, and anti-oxidant properties. The plant has a very close connection with the rural livelihood, and cottage and agro-based industries of Indian economy. Unfortunately, over 60% of the annual fruit yield is often lost within ten days after harvesting due to rot in storage. The value of Palmyra fruit is not yet materialized, as no Palmyra products are commercialized so far. Even though Palmyra is an economically important palm for its nutritional aspects, it is underutilized and has not received proper attention in agricultural research, since it is a very slowly growing palm and is mostly found in the wild state. Hence, this paper attempts to give a view on Palmyra fruit's historical importance, chemistry, nutritional properties, medicinal properties, and commercialization.

Keywords: *Borassus flabellifer* L., Palmyra fruit pulp, nutritional properties, medicinal values, commercialization

1. Introduction

The Palmyra palm (*Borassus flabellifer* L.) belongs to the family Arecaceae and is a widely adapted tropical dioecious palm distributed along the coastal belts of India, northern Sri Lanka, southeast Asia and eastern Indonesia. Borassus is a term derived from the Greek word 'Borassos' meaning 'the membrane surrounding the date palm' (Quattrocchi, 2012) and 'flabellifer' comes from the Latin word 'flabellatus' meaning 'fan-bearer'. It has a life span exceeding 100 years and it reaches a height of 30 m (Gummadi, Battu, SKDM, & Manda, 2016). It is a sturdy tree of sizeable financial significance with nearly all elements of the tree having multifaceted uses (Rao *et al.*, 2021). It is the countrywide tree of Cambodia, the kingdom tree of Tamil Nadu, India, and is an iconic image of the Palakkad district of Kerala, India. The tree is visible across the premises of the well-known Angkor Wat temple in Cambodia (Sridevi *et al.*, 2021). It is considered an underutilized palm in Asia and Africa, requiring very low or restrained agronomic input (Siju & Sabu, 2020)

The coconut like fruit are 3 sided while younger, turning into rounded or greater or much less oval, 12-15 cm wide, and capped at the bottom with overlapping sepals (Janick & Paull, 2008). Palmyra has a tremendous monetary significance, as it is used for the welfare of the people, and it serves as meals (fruit, sap, younger shoots), and also as a construction material (the stem, the leaves) (Suma, Ketut, & Ketut, 2017). It is likewise used in the pharmacopoeia (roots, male inflorescence) and the leaves are broadly used to make various objects, such as brooms, baskets, fences and roofs. Palm wine is also extracted and Palmyra has an important role in the diet. Fruits mature in the course of August, and the ripe ones fall from the palm in September and October. The mature fruit are normally tossed with burning mildly, and the skin is peeled off to obtain the juicy fruit. This is squeezed

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and the pulp removed. The pulp itself is good and creamy and is scrumptious to eat. The pulp is normally sucked at once from the fibres of the fruit (Saranya & Poongodi, 2016). The sparkling pulp is reportedly rich in vitamins A and C. Palmyra fruit pulp can be commercially applied in meals, objects, and animal feed.

2. Historical Importacne of Palmyra

Palmyra is a well-known tree, and due to its wide distribution throughout the country and its simple contribution in rural and cottage industries, and its effects on rural livelihood, it is honoured as the state tree of Tamil Nadu since 1978 (Jana & Jana, 2017). It is a plant that adapts to various agro-climatic situations starting from seashores, plains, valleys and hills, up to an altitude of 762 meters above the sea level (Miranda *et al.*, 2018; Nishinari, Fang, & Rosenthal, 2019). The historical sages, rishis and students used the matured leaves of Palmyra as writing substance to engrave historical scriptures onto, to secure their obtained know-how and expertise over more than 2500 years (Vengaiah, Kumara, Murthy & Prasad, 2015). The palm is nature's gift that has multifaceted benefits. A book named 'Thalavilasam' in Tamil, authored with the aid of Thiru Arunachalam, offers evidence of importance of Palmyra in historical India, and has discovered over 801 cases of using this tree (Naveen, Gajanan, Deshmukh, & Menon, 2018). Mahatma Gandhi, the father of our nation, claimed this tree to be the cure of poverty. It is likewise known as 'Karpakatharu' in Tamil and this translates to desire tree in English (Assoi *et al.*, 2016). Palmyra trees are given this character due to the financial utilization of the complete elements of the plant and its potential to face up to excessive drought and different unfavourable climatic situations (Aman, Rajni Rajan, & Suparna Sinha, 2018).

3. Distribution and Habitat

The natural development of Palmyra palm is known in Asian (India, Pakistan, Bangladesh, Sri Lanka, Malaysia, Thailand, Myanmar and Indonesia) and African countries (Nigeria, Congo, Sudan and Tanzania) (Tariq, Sana, Muhammad & Mehnaz, 2015). Table 1 shows Borassus species in various countries.

In India, this palm is prevalent throughout all agro-ecological regions (coastal belt, agricultural margins, waste lands and secondary forests), but especially concentrated in Tamil Nadu, Andhra Pradesh, Kerala, Karnataka, Maharashtra, Madhya Pradesh and Chhattisgarh (Bhaskar, 2017). It is drought tolerant by its nature, because of excessive chlorophyll balance index and relative water content (Irene Darkwa & Nana Ama Boansi Boakye, 2016). India harbours almost 102 million Palmyra palms. Figure 1 shows a photo of an Asian Palmyra palm tree (*Borassus Flabellifer L.*).

4. Palmyra Palm Fruit and their Extraction Procedure

Palmyra palm fruit can be utilised in food products and animal feed (Saidi, Efendi, Azara, & Hudi, 2018; Wijewardana, Nawarathne, & Wickramasinghe, 2016). From the Palmyra palm fruit about 40% of pulp can be obtained, which will be dark yellow in colour and has a characteristic taste, flavour, and bitterness (Aman, Rajni, & Suparna Sinha, 2018). This pulp can be mixed with other fruits in-order to produce novel and nutritive food products (Gummadi, Battu, SKDM & Manda, 2016). Figure 2 shows a photo of Asian Palmyra palm fruit (*Borassus flabellifer L.*). The pulp extraction can be easily done from fully ripened Palmyra fruit after washing and peeling (Ullah, Ullah, Khan, Ullah, & Badshah, 2018). The pulp can be extracted manually by rubbing with a traditional Palmyra extractor. Additional water can be used in order to liquefy the pulp in roughly 1:1 ratio, to extract the pulp that adheres to the seeds. For maximum recovery of pulp, a heat treatment at 70°C for 10 minutes can be used (Chaurasiya, Chakraborty, & Saha, 2014).

Table 1. Species of Borassus

Species	Country
Borassus flabellifer	Indian and Malayan
Borassus aethioticum	African
Borassus deleg	Sudan
Borassus heiniana	New Guinea
Borassus madagascariensis	Madagascar
Borassus sambivanensis	Madagascar
Borassus machadonis	Malaya

Figure 1. Asian Palmyra palm tree (*Borassus Flabellifer Linn*)

4.1 Physicochemical properties

From the different physicochemical analyses carried out, it was reported that the water content of the Palmyra palm (B. Aethiopum) can be between 79.13± 0.64 and 81.38 ± 1.94g/100 FM, whereas the total sugar content of the fruit can be in the range from 4.47± 1.07 g/100g FM to 5.62± 1.3g/100g FM. The soluble sugar content can be from 81.00 to 84.11% and protein content can be between 0.73g/100g FM and 0.85g/100g FM. The total lipid content can be less than 0.20g/100g FM and crude fiber content can vary from 5.72 to 7.89 g/100 g FM. The total carotenoid content of the pulp can be between 26 and 28 mg/ 100 FM. Vitamin C can be in the range from 134.82± 3.94 to 161.33 ± 262 mg/100g FM. The total ash content can vary around 0.74± 0.01g/100g FM. From the different analyses of the ash, it was estimated that 100g FM can contain 100 mg of calcium, 21 mg of magnesium, 567 mg of phosphorus, and >2 mg of iron (Ahmed, Djibrilla, Clerge, & Clement, 2010).

Figure 2. Asian Palmyra palm fruit (*Borassus flabellifer* L.)

4.2 Nutritional properties

The nutritional analysis of the fruit revealed the presence of calcium, ascorbic acid, maltose, starch, fats, and amino acids. The amino acid average profile was found to have aspartic acid at 2.6g/100g, glutamic acid at 0.41g/100g, alanine at 0.7g/100g, proline at 6.3g/100g, phenyl alanine at 0.41g/100g, lysine at 0.8g/100g, tryptophan at 3.3g/100g, aspargine at 2.6g/100g, and glutamate at 0.41g/100g (Artnarong, Masniyom, & Maneesri, 2016). The main digestible carbohydrates found in Palmyra fruit pulp are sucrose, glucose, and fructose. Carotenoids (beta carotenes) were found but they varied. Flabelliferins (steroidal saponins) are reported to be the compounds responsible for the bitterness in Palmyra fruits (Bhaskar, 2017). A wide range of flabellifer were reported that have anti-microbial properties (Quattrocchi, 2012). The nutritive value of palm fruit per 100g of the raw ingredient is shown in Table 2.

Table 2. Nutritive value of palm fruit per 100 g of raw ingredient

Nutrition	Amount
Water	77 g
Protein	1 g
Fat	0.8 g
Carbohydrates	21 g
Fibre	2 g
Calcium	8.76 mg
Phosphorus	33 mg
Thiamine	0.04 mg
Riboflavin	0.02 mg
Niacin	0.3 mg
Vitamin C	5 mg
Energy	102.83kcal
Iron	1.2mg
Magnesium	10.2mg
Zinc	3mg
Copper	10mg
Sodium	20mg
Potassium	21.5mg

4.3 Medicinal properties

Palmyra products are found to have anti-inflammatory, anti-arthritic, cytotoxic, antibacterial, analgesic, antipyretic, hypoglycemic, and anti-oxidant properties Gummadi, Battu, SKDM, & Manda, 2016). The antioxidant activity could be due to the availability of large amounts of flavonoids, phenolic compounds and saponins. It is also being used in folk medicine to cure various diseases. It contains pectin as well as an appreciable amount of saponin, which imparts important medicinal properties. Because of the presence of special substances like phytochemicals, polyphenols, vitamins, minerals, proteins, etc. in leaves, bark and roots, consumption of these has a role to play in promoting human health with disease prevention benefits (Mani, Krishna & Dutta, 2018). To keep the body hydrated during summer, palm fruit can be consumed (Sumonsiri *et al.*, 2021). The edible products possess multiple medicinal properties (Vengaiah, Kaleemullah, Madhava, Mani & Sreekanth, 2021). The different edible and non-edible products produced from Palmyra palm are given in Table 3.

Table 3. Commercial aspects of edible and non-edible value-added products from palmyra palm

Palmyra plant part	Value-added products
Edible value-added products	
1. Inflorescence sap	Toddy, sugar, jaggery, wine, honey
2. Fruit	Toffee, candy, spread, pickle, jam, sweets, beverages
3. Kernel	Canned products
Non-edible value-added products	
1. Leaf	Baskets, mats, hats, fans, buckets, umbrellas, fence, writing material, brushes and handicrafts can be made from extracted fibre.
2. Fruit	Fibre extract is used to make toys and fancy items.
3. Stem	Stems are timber source and can be used for construction.

4.3.1 Non-edible uses of Palmyra

1) Palmyra palm bark

Charcoal made of the bark serves as a dentifrice and bark decoction. With salt, it is used in mouth washes (Morton, 1988).

2) Palmyra palm spadix

To relieve heartburn and enlarged spleen and liver, ash of the spadix of the *Borassus flabellifer* is taken (Dennis, 2011). Sap from the flower of the matured tree stalk is prized as a tonic, diuretic agent, stimulant, laxative and anti-phlegmatic and amebicide, considered to be the best for day to day life (Vengaiah, Kumara, Murthy & Prasad, 2015). It also possesses antacid and anti-bilious properties.

3) Palmyra palm seed

For treating cough and pulmonary affections, the seeds are used in the Siddha system of medicine. A methanol extract of the seed coat showed consistently significant inhibitory activity against bacterial species like *Staphylococcus aureus*, *Bacillus subtilis*, *Klebsiella pneumoniae*, and *Serratia marcescens* (Duddukuri *et al.*, 2011).

4) Palmyra palm fruit

Skin inflammations can be cured by fruit pulp (Gawkowska, Cybulska, & Zdunek, 2018). It is used to treat nausea and vomiting, worm infestation, as expectorant, and

also as a liver tonic. A thin layer of palm fruit jelly applied to the affected area has a soothing effect and immediately alleviates the itchiness associated with prickly heat (Vengaiah, Kaleemullah, Madhava, Mani, & Sreekanth , 2021).

5) Decorative items

The Mesocarp of the ripened Palmyra fruit contains notable quantities of fibre. The fibre is utilized by the ornamental industry in preparing fancy decorative items and toys (Sridevi Krishnaveni *et al.*, 2020).

4.3.2 Edible uses of palmyra

1) Neera / Palm sap

The sap extracted from the inflorescence of Palmyra palm is known as 'Neera'. It is also called sweet toddy since it contains zero percent alcohol. The tapped sap of the palm flower undergoes natural fermentation because of yeast that is found in the sap itself (Naveen, Gajanan, Deshmukh, & Menon, 2018). Fermentation begins and evolves quickly after the sap is accrued, and within hours it becomes excessive, while the alcohol level stays much below four percent. However, the brief shelf life is only 24 hours. Hence, in order to extend the shelf life of the product, it is first filtered using a wire mesh to remove unwanted particles and debris. The Palm sap is then clarified using a pilot scale cross-flow microfiltration system, and later Pasteurized by heating at 90-95°C for 3-7mins. Then the product is packed and stored under refrigerated condition, which can extend the shelf life to up to 10 weeks. The commonly used packing materials for Neera / palm sap are High-Density Polyethylene (HDPE) as 50 micron pouch, Polyethelene Terapthalate (PET) bottles, and glass bottles (Chandra, Swami, Ashok, Salomi, Sujatha, & Sekar, 2021).

2) Palm endosperm

It is the jelly like endosperm of young fruit (60 – 70 days) in tender Palmyra fruit pulp before the fruit ripens. It is crystalline, white in colour, very nutritive, and is a summer delicacy. It is proven to have a cooling effect when consumed.

3) Palm jaggery

It is likewise known as palm gur. It is steeply-priced because of its dietary and medicinal properties. It has an earthy, severe taste paying homage to chocolate. The jaggery is processed from the unfermented tree sap (Neera). Initially, the sap is accrued in slacked lime within earthen pots with the aid of using tappers. The cleared sap, after lime sedimentation and filtration, is transferred into galvanized iron pan on a conventional furnace and boiled at 110°C. Few castor beans are crushed and added, which prevents over boiling. The liquid Neera gets transformed into a viscous fluid. Extraction of pulp is done by using heat treatment. Usually 1 kg jaggery will be obtained from 8 litres of Neera/sap (Vengaiah, Ravindrababu, Murthy & Prasad, 2013)

4) Palmyra palm sugar

As the palm sugar has a low glycemic index, it helps in reducing obesity and diabetes. It is used in herbal and ayurvedic medicines as a healthy and excellent substitute for artificial sugar. To counteract poisoning, sugar made from this sap is used and it is prescribed for liver disorders.

4.3.3 Value added potential uses

1) Palm toffee

Extraction of palm fruit pulp is first carried out by selecting the ripe palm fruits. The fruit are then washed in potable water and the skin is peeled off. The pulp is now extracted manually by rubbing the fruit against a traditional Palmyra extractor. Palm toffee is prepared by mixing 500g of fruit pulp with 500g sugar, 200g skim milk powder, 50g glucose, 50g all-purpose flour, and 100g starch. The aggregate is cooked with regular stirring for about 40 minutes. Drop test in water is adopted to identify the endpoint, similar to when manufacturing gummy candies (Amjadi, Ghorbani, Hamishehkar, & Roufegarinejad, 2018). The product is then removed from the heat; the toffee aggregate is spread on an aluminium tray that is smeared nicely with oil/butter and kept for a single day in air. Then the toffee is cut into 3 x 1.5cm size, wrapped with butter paper, and stored at room temperature.

2) Palm candy

Neera, free from debris, is boiled in an alloy vessel adding a small quantity of superphosphate (Golly *et al.*, 2017). The liquid is allowed to cool when it has reached a consistent boiling temperature. After removal of sediments, it is heated to 110° C for 2 hours until it reaches honey like consistency (Ullah, Ullah, Khan, Ullah, & Badshah, 2018) or it is boiled at 180°C until 67 OB is achieved (Mani, Krishna & Dutta, 2018). The fluid is then allowed to cool and is poured into crystallizer. Sugar crystals start forming after 45-60 days. The product is then removed and washed by spraying water. Finally, sun drying is done at a temperature of 40-80°C for about 2hrs.

3) Toddy

Toddy is a fermented product. Sap from the Palmyra tree is accumulated through slicing the tip of the unopened flower. The sap oozes out and is accumulated in a small pot (earthen or metal) tied underneath. Usually the pot is pre-inoculated with small quantity of toddy for fermentation. 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 a number of different strains of yeast and bacteria. The alcohol content in naturally fermented toddy is reported to be 5%, but fermentation of Palmyra sap by using pure yeast culture gives about 7.8% alcohol content under laboratory conditions. Alcohol content in toddy is predicted to be within 4 to 8% (Kurian & Peter 2007). Sucrose, glucose, and fructose are the primary sugars in toddy. As fermentation takes place, the sugar is converted to ethyl alcohol.

4) Palmyra yoghurt

For the preparation of palm yoghurt, 10 % Palmyra fruit pulp, 0.5 % gelatin and pasteurized milk are mixed thoroughly. The mixture is heated at 95°C for 10 minutes in a stainless-steel vessel. Now the mixture is cooled to around 42°C. For the preparation of Palmyra yoghurt, yoghurt culture containing freeze dried Lactic culture (direct vat set) Thermophillic Lactic culture (STI- 12) is used. Once the mixture is cooled to 42°C, it is inoculated with the starter culture at 5%w/v and incubated at 42°C (Pagthinatha, Nafees, & Jeganathan, 2016).

5) Palm spread

Palm spread is a sweet dish prepared using Palmyra fruit pulp, sugar, skim milk powder, citric acid, and cardamom as flavourings. Equal portions of pulp and sugar (1 kg) are mixed along with 100 g skim milk powder, 5g citric acid and 4 pieces of crushed cardamom. They are mixed thoroughly and heated on low flame with constant stirring. The end point of the palm spread is identified based on the total soluble solids content (TSS) of the product. The heating is stopped once the TSS reaches 65-68 °brix. The prepared product is filled in containers and stored at refrigerated condition (Chaurasiya, Chakraborty, & Saha, 2014).

6) Palmyra wine

Unfermented sap (Neera) is sterilized, and it can be fermented with suitable strains of yeast to obtain Palmyra wine. Sweet toddy having a pH of 6–7, is sterilized and inoculated with good yeast that produces a very clear straw colored wine. The alcohol strength increases on adding extra sugar to the sap. The wine prepared by this method is pleasant to drink, masking the specific characteristic toddy flavor and the distinctive sour taste of acids present in toddy. The alcohol content of palm wine is around 5-8 % with a pH of 4.5- 6.0. Yeast and bacteria are the key microorganisms reported in palm wine. Lactobacillus, Leuconostoc, Bacillus, Streptococcus, and Saccharomyces are the probiotic organisms present in palm wine. It helps to produce vitamins and digestive enzymes, and stimulates the immune system. The main yeast species found are Saccharomyces and Candida (Chandrasekhar, Sreevani, Seshapani, Pramodhakumari, 2012)

5. Conclusions

The Palmyra Palm (*Borassus flabellifer L.*) is a native tree with various ecological, medicinal, economic, and sociological benefits, and was the focus of this review. The fruit of the Palmyra palm is a good source of sugar, vitamin C, provitamin A, minerals and fibers, which could be used in various edible, value-added, and non-edible products. The ripe Palmyra palm pulp may be utilized for the preparation of Neera, palm jaggery, palm sugar, palm oil, palm candy, palm spread, palm burfi, palm pickle, canned palm, palmyra yogurt, palm cola, palm honey, and toffee, which are not only nutritionally rich and commercially viable but also extremely palatable. However, efforts should be directed towards the proper utilization of underutilized Palmyra palm fruit, since they are suitable for popularization in value-added products, which help in income generation and thus it will improve food security to the poor and livelihoods of the marginal farmers.

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