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An Insight into the Polymeric Structures in Asian Palmyra Palm (*Borassus flabellifer* Linn)

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ABSTRACT

Palmyra Palm (*Borassus flabellifer* Linn) is a native tree with various ecological, medicinal, economic, and sociological benefits from Asian countries. Palmyra Palm tree-based self-reliant lifestyle and Eco-friendly community living which leads to sustainable development can be called palmyra culture. For each component, Palmyra Palm is the most beneficial species that has economic and medicinal value that could sustain adverse climatic conditions and resist natural calamities. Non-edible, edible, and value add-based uses could be widely categorized into the utility of the plant. Palmyra palm tree is working like a non-stop biochemical factory, creates sugars and many other useful chemicals. It also produces many useful polymeric compounds such as pectin, cellulose, hemicelluloses, pentosan polysulfate, polyphenols, and lignin. The current review gives an insight into the structural, biological, and polymeric elements of Asian palmyra.

1. Introduction

Palmyra Palm, *Borassus flabellifer* Linn (Family: Arecaceae) is the most economically important species, mainly distributed in Asian countries such as India, Sri Lanka, Bangladesh, Myanmar, Indonesia, Thailand, and particularly in dry African tropical regions^[1]. It is also the official tree of the Government of Tamil Nadu. Asian Palmyra Palm leaves, fruit, and pit are known to provide a livelihood for many small-scale

industries in the Asian region for their economic uses^[2]. Palmyra Palm is a long-lived tree that can live more than 100 years with a canopy of leaves and a large trunk^[3]. Each toddy palm tree can endure 6-12 bunches of about 50 fruits per year, 350 fruits are an average crop. In many traditional food items, pulp obtained from ripe fruit is used to cure various diseases of folk medicine^[4]. Palmyra palm has important non-food applications, such as marketable mats, oils, baskets, timbers, dyes, and fibers^[5]. The treatment of contaminated water as an

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absorbent of complex hexavalent and trivalent chromium compounds [6], the potential treatment of heartburn, dermatitis, respiratory problems, and diarrhea in traditional medicine [7]. Palmyra Palm trees play an important role in agriculture in the countries of Asia. Palmyra Palm tree-based self-reliant lifestyle and Eco-friendly community living which leads to sustainable development can be called palmyra culture. Asian palm sugar is known by other names such as palm jaggery, palm jaggery, Neera, and Gur. It has a unique taste and produces less energy than cane sugar [8]. The sap is used for wine, palm jaggery, and palm sugar, all rich in vitamins and minerals [9-10]. Several pharmacological advantages of Asian palmyra have also been reported in traditional medicine, such as antidiabetic [11], analgesic [12], anti-inflammatory [13], wound healing [14], antioxidant [15].

Although the Asian palmyra is widely used, it is reported to be underused and left to spoil most of the fruits, sap, and other parts of the tree. Recovery, reduction, and recovery of post-harvest losses may maintain sustainable agricultural practices with minimal impact on the environment and improve food security [16]. Due to the once widespread use of most of its parts, such as the trunk, foliage, husk, nut, and flesh, Palmyra palm is a “miracle” plant. For furniture and handicraft products, the trunk can be used. To make some crafts, dried leaves and the flexible sticks in the front are woven. To brew wine and vinegar and to make sugar, palm nectar is used. Edible is the flesh inside the nut. The husk or mesocarp can be extracted from a natural food coloring substance. Palmyra palm tree is working like a biochemical factory and creates sugars and thousand of chemicals. Among them, many are polymers such as pectin, Cellulose, Hemicelluloses, pentosanpolysulfates, polyphenols, and lignin. The present review focuses on the reporting of the biological and polymeric components contained in the Asian Palmyra Palm.



Figure 1. Young, matured Asian Palmyra tree and collected Palmyra fruits for the plantation of 4000 seeds at Panaiyaanmai (Palmyra culture)-The centre for self-reliance and sustainable development, Kadayam, Tamil Nadu

2. Main Components of Palmyra Palm

Pectin is found in plant tissue in the intercellular or middle lamella region [17]. Pectin, also known as water-soluble fiber, is a polysaccharide. It is employed as a gelling agent and functional food in both the food and pharmaceutical industry. In multiple food processing areas such as jam, jellies and marmalade, low sugar and calorie foods, bakery, further processed meats, and acidified milk drinks, pectin is used in which gelling and viscosification are significant physicochemical properties [18]. Palm fruit provides an inexpensive and environmentally friendly raw material for the extraction of pectin. The economical manner and yield pectin with unique properties of gelling, viscosification, and emulsification. The increasing interest in the Palmyra palm is due to the increasing awareness of the unexploited potential of this tropical resource [5]. It is reported that the Palmyra palm meat obtained from the young inflorescence was found to have a high potential pectin source [19]. The pectin extraction and their yield levels using both ripened and young Asian Palmyra palm sugar meat by altering the microwave irradiation were reported [20]. Palmyra palm fruits have great potential for the pectin sector as an alternative, commercially viable source of pectin. Depending on the extraction conditions, the identified differences in structural and functional properties provide the basis for the extraction.

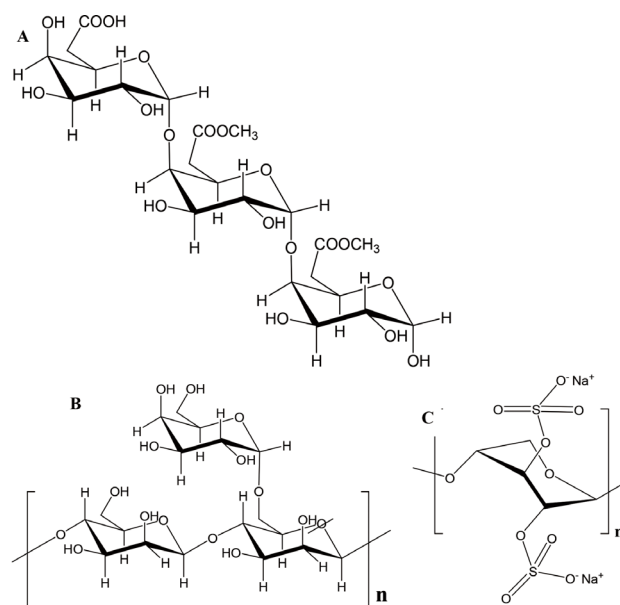


Figure 2. Structures of A) Pectin, B) Galactomannan, and C) Pentosanpolysulfate

Palmyra palm, limited in fat and protein, is a good source of carbohydrates, calcium, magnesium, iron, and fiber. A fibrous kernel is progressively hardened and de-

veloped by the tender of Asian palmyra palm pulp. The presence of galactomannan from the soft palmyra kernel was reported [21] and showed that it consisted of mannose and galactose. It is reported that the free radical scavenging effects of carotenoids from Asian palmyra palm pulp and the nature of free sugars and polysaccharides present in the kernel [22].

As it is obtained from renewable resources and is the most abundant biopolymer on the planet, cellulose has become an important polymeric material [23]. Paper is a sheet consisting of cellulosic fibers that are normally produced using mechanical or chemical processes to separate wood cells. Subsequently, the isolated fibers are re-arranged and randomly distributed into a sheet-like framework. The cellulose pulp from hardwood and softwood is usually obtained by the pulp and paper industries. However, an insufficient supply of wood for growing demand has caused industries, such as non-wood fiber plants, to search for alternative fiber sources. A further fibrous source used as a raw material for pulp and papermaking has been the mesocarp of Palmyra palm fruits. There seem to be fewer references in the scientific literature to the pulping of palmyra palm fruit fiber.

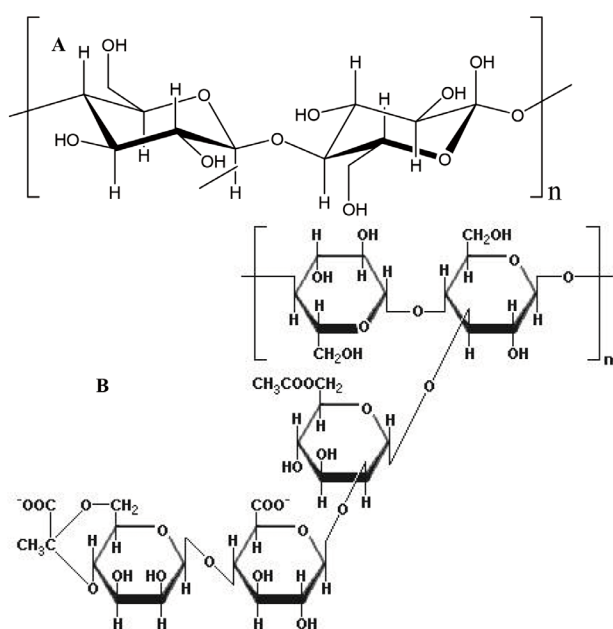


Figure 3. Structure of A) Cellulose and B) Hemicellulose [34]

Palmyra palm fruit fibers have the characteristics to be used for papermaking as an alternative raw material for cellulosic pulps. The chemical composition of the strands of palmyra palm fruit fiber from palmyra palm fruits such as holocellulose, cellulose, pentosan sulfate, lignin, and extractives was examined [24] and it was found that the mechanical and physical properties of the acid and alkaline pulps were verified to be of acceptable paper-making quality.

An effective alternative source of cellulose for paper

pulp production is the mesocarp of Palmyra palm fruits. Their findings suggested that the fibers of Palmyra palm fruit are an effective alternative raw material for paper pulp. It offers acceptable properties for pulp and paper sheets and thus makes it possible to profitably exploit agricultural residues from major economic activity.

The natural Palmyra palm fruit fiber cellulose microfibrils contain cellulosic semisolid flush that is armored by the fibers. The fibers of ripened Palmyra palm fruits, which are inexpensive, abundantly available, and environmentally friendly, have been extracted from the waste, and it is, therefore, essential to explore their potential usefulness to the technical world. The yield of cellulose in Palmyra palm fruit fibers was found to be more than 50 percent [25].

It is promising to utilize Palmyra palm fruit fiber as the primary source of cellulose. A campaign of studies that extracted cellulose microfibrils could prove to be a useful alternative raw material for biopolymer composites, biofuel and cellulose derivatives, and paper pulp applications. An increase in the alpha-cellulose content and a decrease in the lignin and hemicellulose content of cellulose microfibrils over raw fibers is shown in the chemical analysis of palmyra palm fruit. For cellulose microfibrils extracted from Palmyra palm, an easy and cost-effectively feasible way will further assist in determining appropriate end uses for these fibers and microfibrils, which will add value to the harvest [23].

Hemi-cellulose is a cellulose-related polysaccharide. But unlike cellulose, hemicellulose, in addition to glucose, is derived from several sugars. In comparison to a cellulose chain, it consists of a shorter chain [23]. The main hemicellulose in hardwoods consists of compounds that contain glucuronoxylan compounds.

Two saponins in the fruit pulp and tuber flour were identified [26]: steroid spirostmonoglucoside and monorhamnoside-5en-3fi-o11 (25R). Palmyra (*Borassus flabellifer* L) fruit pulp's main bitter principle has been tentatively identified as a tetraglycoside (flabelliferin II) steroidal saponin containing two glucose and two residues of rhamnose. By the action of naringinase on both crude bitter extracts (containing flabelliferin I and II) and natural fruit pulp, bitterness can be removed. To produce other flabelliferins, naringinase has released glucose and rhamnose, two of which occur naturally in the palmyra tuber. As a tetraglycoside of spirost-5en-3fiol called flabelliferin11, the main bitter principle of palmyra fruit pulp is identified. Naringinase action, which results in a beverage with a pleasant mango cordial-like color, flavor, and texture, can remove bitterness. In various studies, the structural and biological properties of flabelliferin11 are reported [27-29].

The chemical constituents of *Borassus flabellifer* in-

clude gums, albuminoids, fats, steroidal glycosides, and carbohydrates like sucrose. The fresh pulp is reportedly rich in vitamins A and C. The fresh sap is reportedly a good source of vitamin B-complex. The male inflorescence constitutes borassosides and dioscin, spirostane-type steroid saponins [29]. Six new spirostane-type steroidal saponins, borassosides, were isolated from the methanolic extract together with 20 known steroidal glycosides (β -sitsosterol 3-O-b-D-glucopyranoside), dioscin, to increase serum glucose levels in rats loaded with sucrose [11].

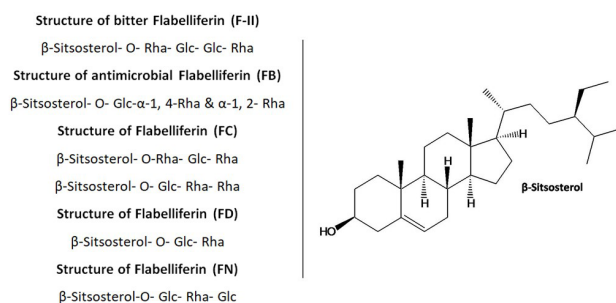


Figure 4. Structure of β -Sitsosterol and Flabelliferins [33]

Palmyra fruit pulp (PFP) extracted from the fruit is said to contain 0.42 g of amino acids per 100 g of pulp (dominated by lysine, phenylalanine, and glutamate). A rich source of carotenoids is the PFP. Although PFP is included in several recipes, due to the presence of a saponin known as flabelliferin11, use has been limited [30]. GC-MS was analyzed for the palmyra palm fruit bunch oil compositions. Campesterol, ethanol, 2- [2-(4 pyridyl) ethylamino], benzene-1,3,5-D3, phenol, and phenol derivatives were the major bio-oil compounds. As a result, pyrolysis products can be used as a source of hydrocarbons and can be used directly as a low-grade fuel or upgraded to high-quality liquid fuel. After separation, the components and their derivatives found in the GC-MS analysis are used for medicinal or chemical feedstock [31]. Alpha-glucosidase inhibitory activity was shown by palmyra palm extract and isolated compounds (tyrosol, and glucosyl-(6-1)-glycerol) [32].

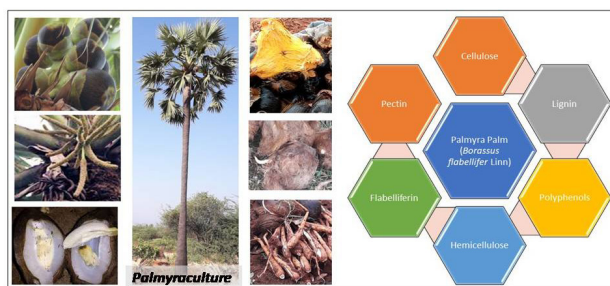


Figure 5. Images of some important Palmyra components and representation of organic polymeric compounds in Palmyra palm

3. Conclusion

Palmyra culture is very helpful in achieving a self-reliant lifestyle and eco-friendly community life that leads to sustainable development. The Palmyra trees are unique in providing us with food and non-food products. They produce many useful polymers such as pectin, cellulose, hemicellulose, pentosan sulfate, poly-phenol, and lignin. Although the palm tree is the official tree of Tamil Nadu, the government of Tamil Nadu has prohibited the production of palm toddy. Palm toddy has a high nutritional and medicinal value and is used as a therapeutic vehicle in the medicine of Tamil. The Tamil Nadu Government must therefore revisit the current policy and allow the people to produce, drink and sell palm toddy, as toddy is a natural drink, and therefore its extraction is a fundamental right under the Indian Constitution. Palmyra trees are destroyed as never before and have never been taken care of, and have always been taken for granted, despite various advantages and benefits. Efforts should be directed towards the planting of more trees, the protection of existing trees, the promotion of self-help groups for palmyra farmers (palmyra warriors), and the cultivation of more plants around water bodies. By producing more value-added products from *Borassus flabellifer* Linn, Linn provides an opportunity for a self-reliant lifestyle, eco-friendly community living, green economy, biodiversity/ecosystem, and sustainable development.

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