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A review on date palm (*Phoenix dactylifera*) fibers and its polymer composites

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Abstract. Date palm (*Phoenix dactylifera*) is the most significant agricultural crop, found abundantly in the Arabian Gulf in Saudi Arabia, Northern Africa, Pakistan, India, and the United States (California). Huge deposition of more than 15000 tons of date palm leaves and trunk are generated as wastes alone in Saudi Arabia. The date palm fibers from trunk and leaf possess considerable mechanical strength and modulus to many of the natural fibers and higher with respect to E-glass fibers and many aluminium alloys. Wide varieties of both thermosets and thermoplastics polymers have been modified by the reinforcement of date palm fibers derived from leaf and trunk. Date palm fibers represent a promising alternative substitute to synthetic fibers in polymer composite industries for both advanced structural and semi-structural applications. Present review article designed to be a comprehensive source of recent literature and study on date palm fibers origin, cultivation and its surface modifications. This article also intended to covers the recent findings in date palm fibers reinforced polymer composites with some interest on physical structure and chemical compositions, including their different commercial applications.

1. Introduction

The continuous growing demands and needs for minimizing the usage of synthetic fibers in polymer composites derived from petroleum products drive the concern of academicians towards the introduction of natural fibers in modern engineering endeavours. Natural fibers found naturally in all animals and plants, and exhibits superior, integrated, graded structures that commonly exhibit multifunctional performance [1]. Mimicry of these integrated microstructures and micro-mechanisms offers considerable potential to engineers in the design and continual improvement of composite material performance [2]. Natural fibers offers promising alternatives to costly synthetic fibers having an impact on environment [3]. Natural fiber reinforced polymer composites are leading competitors as component materials to improve the efficiency of many mechanisms, due to lightweight, high strength and effective stiffness. The effective utilization of natural fibers derived from renewable resources provides environmental benefits with respect to utilization of raw material and ultimate disposability. Currently, natural fibers as bio-fillers are gaining great attraction as they offer considerable advantages such as low cost, low density per unit volume, minimal tool wear, comparable specific strength and cost effective besides renewable, non-carcinogenic and degradable characteristics compared to synthetic fibers based polymer composites [4]. It may lead to the production of high durable consumer



products from natural fibers that can be easily recyclable [5]. However, their wider exploitation are constraint due to water absorption tendency, relatively poor compatibility between polymer matrix and fibers, meagre performance under impact loading that leads to a significant reduction in strength, stiffness and stability [5-6].

Currently, plant fibers such as kenaf, coir, abaca, sisal, pineapple, cotton, jute, bamboo, banana, palmyra leaf, date palm, hemp and flex have achieved commercial success in the development of polymer composites, hybrid composites and green composites with varied types of polymer matrices.

Date palm fiber (DPF) is one of the waste materials in agriculture sector, which is widely grown in Saudi Arabia as well as Asia. Date (*dactylifera*) found to be the most essential tropical fruits available commercially throughout the world after pineapple and citrus. Date fruits and leaves are considered as waste materials of date trees and are extensively used for producing natural fibers [7]. The major constituents of DPF are same to that of other lignocellulosic fibers including holocellulose (60– 75 %), lignin (20 %), and ash (1.18 %) [8].

1.1 Natural Fibers

To the present situation, it is believed that source of petroleum based products are limited and uncertain, thus diverting the utilization of an alternative cheap, sustainable and easily available raw material. The countries growing plant and fruit are not for only agricultural purpose but also to generate raw materials like natural fibers for industries. Most of the emerging countries make business of lignocellulosic fibers for improving economic condition of poor farmers as much as country support. Natural fibers are the major classification of fibers, and can be further classified into vegetable, animal, and mineral fibers, displayed in Fig. 1.

Depending on their origin, plant fibers can be generally classified as bast, leaf, or seed-hair fibers [9]. In plants, bast and leaf fibers provide mechanical support to the stem or leaf, respectively, as is the case in date palm, flax, hemp, jute, or ramie. Fruit fibers are taken from fruits like dates, coconut (coir) fiber. Stalk fibers are obtained from husk and straw of crops like wheat, date palm, rice, barley, and so forth. Tree wood can also be used as fiber. Natural fibers have been used for a long period in many developing countries as cement materials [10].

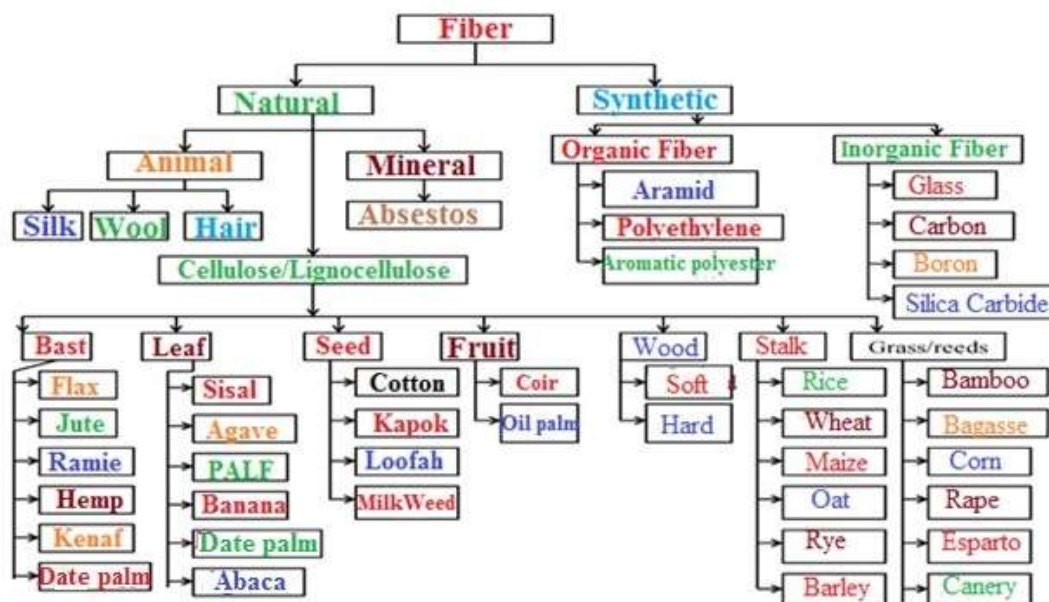


Figure 1. Classification of natural and synthetic fibers [11].

In general natural fibers have a hollow space (the lumen), as well as nodes at irregular distances that divide the fiber into individual cells. The surface of natural fibers is rough and uneven and provides good adhesion to the matrix in a composite structure. The low density, tensile strength and elongation at failure of natural fibers such as hemp, flax, ramie and synthetic fibers can compete with E-glass fibers properties and hence shows remarkable importance in composite technology [12]. The specific modulus and elasticity are better in natural fibers than the synthetic fibers [13]. A comparison of various parameters between natural and glass fibers is described in Table 1.

Table 1. Comparison between glass fiber and natural fibers [14].

Properties	Natural fiber	E-Glass fiber
Density	Low	Double
Cost	Low	High
Renewability	Yes	No
Recyclability	Yes	No
Energy Consumption	Low	High
Distribution	Wide	Wide
CO ₂ Neutral	Yes	No
Abrasion To The Machine	No	Yes
Health Risk When Inhaled	No	Yes
Disposal	Biodegradable	Non Bio Degradable

Natural fibers consist of complicated and systematic internal cell wall structure, divided into three major parts[15]. The micro-fibril angle and arrangement inside the cell wall determine the fiber properties[16]. The mechanical strength of the fibers,(which determines the stiffness and tensile strength of composites) and dimensional stability of fibers depends on the lignin content[9]. The bio-fiber structure is shown in Fig.2.

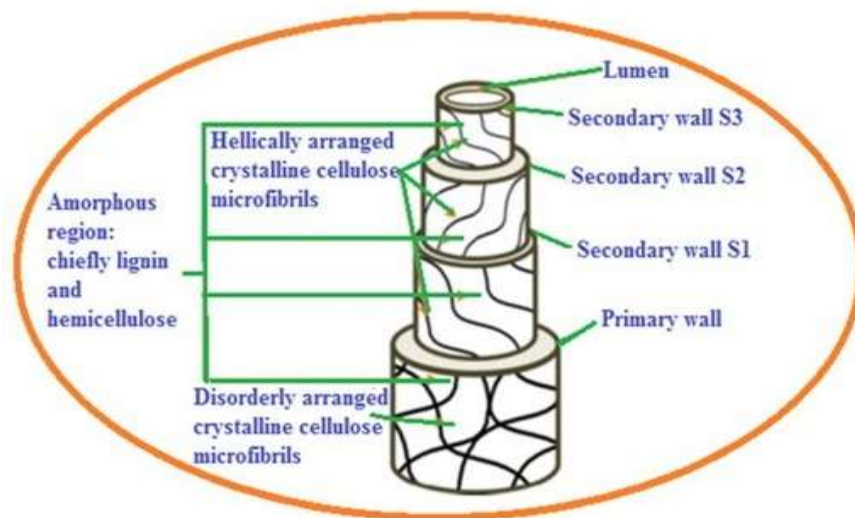


Figure 2. Structure of bio-fiber [17].

1.2 Polymer (Matrix)

Thermosets and thermoplastics are the major classification of polymer, where thermoset composite formulation is more multipart than thermoplastic. It depends on several parameters including, resin, curing agents, catalysts, and hardeners. The cross-linked structures are tough, creep resistant, and also

tremendously resistant to solvents. Thermoplastics offer more advantage over thermoset polymers. Thermoplastics matrix composite possess low processing cost, flexible design, and easiness in moulding complexity. It is very simple method for processing of composites such as extrusion or inoculation moulding methods. A varieties of thermoplastic polymers like polyethylene, polypropylene, polystyrene and polyvinyl chloride (PVC) and their products are petroleum products are not entirely eco-friendly and non-biodegradable [18-19].

1.3 Natural fibers reinforced polymer composites

Polymers and their composites benefited modern industries and replaced conventional materials due to their high specific strength, light weight, cheaper, recyclability, biodegradability along long durability [20-21]. Natural fibers reinforced polymer composites is introduced for commercial reason, to provide the increasing of biodegradable and renewable materials. Natural fibers play a crucial role as they are used as engineered materials in composites, these advantages have attracted many scientists and researchers over the other fillers [7], [22], besides this they offered some restrictions and drawbacks [23-24]. In natural fiber composites, natural fiber provides tensile strength and stiffness and the matrix keeps the fibers together and transmits the applied shear forces. Reinforcements of fiber boost the property up to 80% because of the alignment property of fibers. Different components of plants and fruits obtained from agricultural crops and agricultural residues acts as the raw materials for fibers reinforced polymer composite industries. In literature review it has been reported that large varieties of natural fiber to reinforce different polymer matrices which includes wood [25-26], cotton[27], bagasse [28-29], rice straw [29-30], rice husk [31-32], wheat straw [33-34], flax [35], hemp [36-37], pineapple leaf [38] coir [39], oil palm [39-40], date palm [41], doum fruit [42], ramie [43], curaua [44-45], jowar [46], kenaf [47], bamboo [32, 48], rapeseed waste [49], sisal [50] and jute [51-52]. Moreover, synthetic fibers based polymer composites like glass fibers possess relatively high density with considerable high cost. Depending upon the chemical composition of fiber characteristics like recyclability, weather resistance, degradability, fungi attack are present in the natural fiber reinforced polymer composites [8, 53].

1.4 Date Palm Tree

The date palm, which belongs to the family Palmae (Arecaceae) is grown in tropical and subtropical regions since ancient period. Majorly dates are produced in the countries like Egypt (1,352,950 metric tons), Saudi Arabia (1,078,300 metric tons), Iran (1,023,130 metric tons), UAE (775,000 metric tons) and Algeria (710,000 metric tons) reports considerable improvement in industrialization of dates, worldwide production and its utilization. It plays a very significant role in the daily life of people of Arabian peninsula since last 7000 years [54].

Among date palm species, *Phoenix dactylifera* is the tallest species with the height of more than 30 m and the fruit size ranging up to 100 mm × 40 mm size. A tropical date palm tree is characterized by trunk which is covered with greyish leaf bases and many offshoots which are present at its base. The fruits are juicy and nutritious [55]. Date palms have uniqueness that adapted them to various circumstances. Fig. 3 shows the young date palm tree with offshoots and date fruits. Date palm trees usually grown particularly in the sand, but it are not erinaceous since they have air spaces in their roots they can also grow well where soil water is close to the surface. Date palm rarely grows in saline conditions and their growth depends mainly on quality soil and water.

Branch of date palm tree has elongated leaves which are pinnate divided and sharp needle fronds. These leaves are subtended by a cylindrical sheath of rough reticulate mass and fibrous material at its base which forms firm protective covering for terminal bud [56, 57]. Around 10-20 new leaves are produced annually which are adapted to both hot and dry conditions but it is not a xerophyte and copious water is needed [55-56]. Fig. 4 shows detailed morphological characteristics of date palm leaf highlighting length of leaf, thickness angle, leaflet length, thickness of rachis and number of leaflets [58].

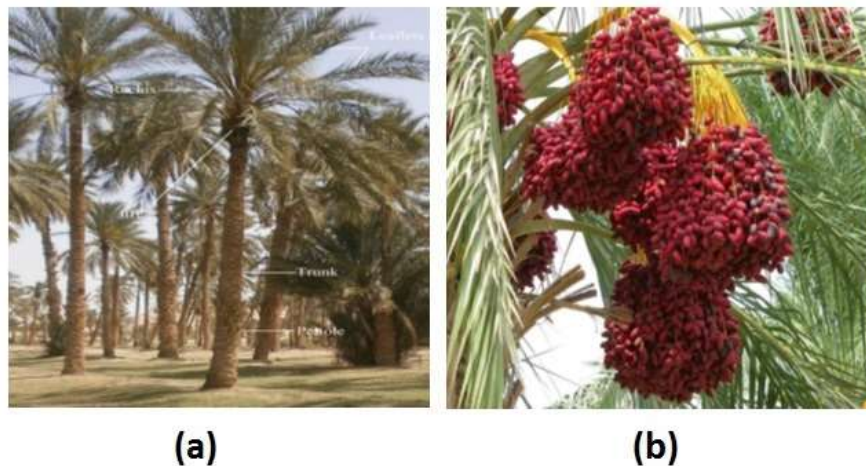


Figure 3. Date palm tree (a) and Date fruit (b) [8].

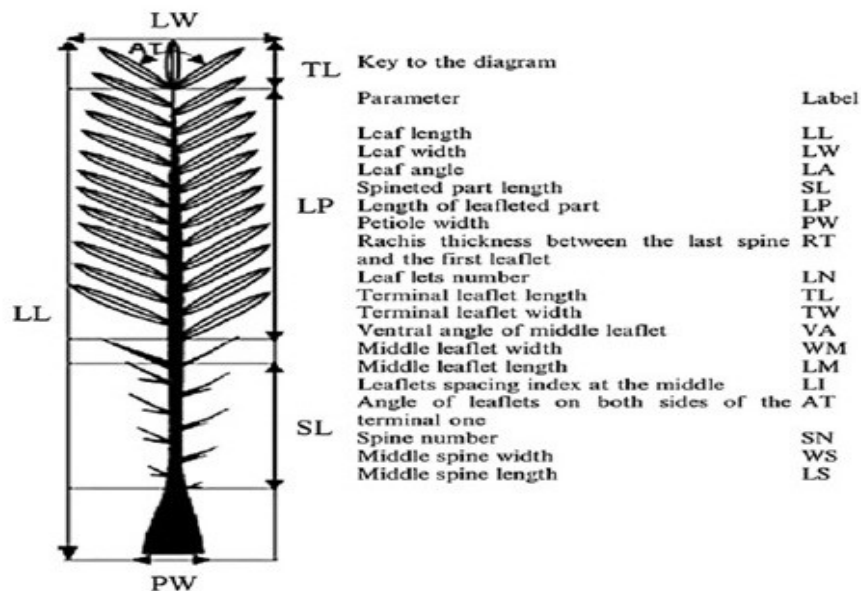


Figure 4. Detailed morphological traits of date palm tree leaf [58].

1.4.1 Extraction of Date Palm Fibers (DPF). There are different techniques opted for extraction of date palm fibers from leaves and trunk of date plant. The extraction of bast stem, leaf, and seeds from the plants can be done in a bundle form; therefore it is referred as fiber bundles. Extraction method of fibers is alike in both bast stem and leaf, while seed fibers have various methods like cotton lint extracted from ginning process. The extraction of strip fiber bundle is obtained from stem and leaf. Decorticator method is recommended for extraction process, followed by retting technique either dry retting and water retting, involving chemicals and biological treatment for removing fibers from stem [59]. Dew retting is most well-liked in Europe, but it's not accurate as water retting. Water retting technique is being used in Asian countries [60].

1.4.2 Date Palm Fiber. The worldwide production of date palm fiber annually is 42 % more compared to coir and 20-10 % more compared to hemp and sisal. Each stem of palm tree is surrounded by a mesh of single cross fibers which appears as a natural woven mat of fibers with different diameters. Normally this mat is separated and cleaned to make baskets and ropes. Figure 3A

shows the shape of date palm fiber which is cylindrical in shape. The shape and structure of DPF resembles coir fiber, each DPF is an aggregation of 2-5 μ sized multicellular fiber containing a central void [lumen] [61]. Due to this structure, surface modification is very much necessary to purify and clean the surface of the fibers from large amount of impurities and uncompleted growth, which may cause poor adhesion of fiber and matrix.

Extraction of fibers from date palm fiber is carried out by retting technique[8, 59]. Date palm fiber is more compatible natural fiber resource and constitutes a good chemical composition and possesses better mechanical strength than other natural fiber. DPF is multicellular lignocellulosic fiber containing polysaccharides cellulose (38-40 %), lignin in minor amount and a few minor components like fat, wax, pectin, inorganic substance, and so forth [8]. Many literatures have reported on cultivation of date palm fiber, their usage and purpose of utilizing date fruit and oil production. However, very little information available on the proper utilization of wastes of date palm trees particularly the leaves and the trunk. Separated date palm tree trunk and leaf rachis and fibers are illustrated in Fig 5.

Many researchers reported industrial applications of date palm fibers based on the property of these fibers in forming polymer composites for automotive components. These fibers are used as effective filler in both thermosetting and thermoplastics materials [8, 62-63]. The competitiveness of the date palm fibers in forming polymer composites suitable for automotive industrial components were reported by researchers [8].

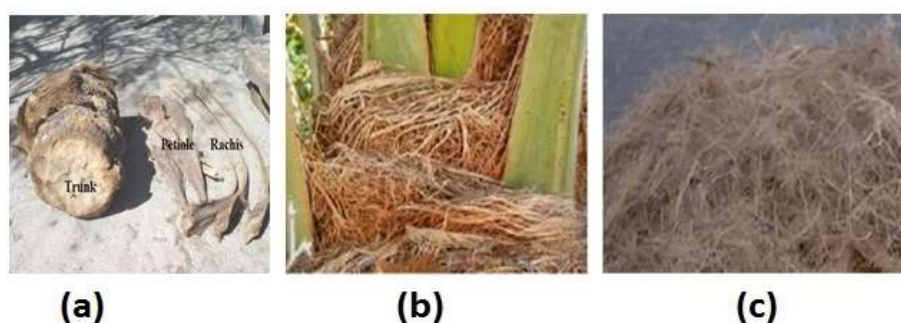


Figure 5. Date palm tree trunk, leaf rachis (a) and (b-c) fibers [7].

1.4.3 Date Palm Tree Leaf Fibers. Traditionally, date palm leaves are utilized in fabricating baskets, mats, and ropes in many areas of the world. Competent utilization of this natural resource in synthesizing natural fiber-reinforced composite would have a high optimistic impact on the environment and improve the economic standard of working-class people [64]. Now, few works have been adopted by various researchers to develop polymer composite materials using fibers, obtained from different portions of date palm leaf. Mahdavi et al [7] have investigated the mechanical and morphological properties of wood plastic composites designed by reinforcing the fibers obtained from trunk, rachis, and petiole of date palm tree in high-density polyethylene (HDPE) matrix. The tensile strength of fibers obtained from leaf and stem of date palm tree has been investigated and compared with other natural fibers [65]. Researchers have studied the effect of different chemical modifications on date palm fiber surrounding the stems of date palm tree are shown in **Table 2** [66-67].

Table 2 .The average weight percentage of chemical composition of the date palm fibers from leaf (leaflet and rachis) [66-67].

Constituents		Cellulose		Hemicelluloses		Lignin		Ash		Extractive	
Leaflet	Leaf ^a	40.21	54.75a	12.8	20.00a	32.2	15.30a	10.54	1.75a	4.25	8.2a
Leaf		38.26		28.17		22.53		5.96		5.08	

Note: a-value obtained from Sbiai et al. 2010 [67]

From their investigation, it has been clearly observed that 1 % of NaOH-treated date palm fiber shows the optimum mechanical properties, whereas HCl-treated date palm leaves show deterioration in mechanical properties. The average weight percentage of chemical composition of the date palm tree leaf and their fiber properties [66-67]

1.4.4 Chemical Constituents of Date Palm Fiber. Comparison of cellulose and lignin content of date palm fiber with that of other fibers demonstrates effectiveness and appropriateness of date palm fiber for being potential filler for natural fiber composites, shown in Fig. 6. Literature review illustrated that due to the presence of negligible amount of cellulose date palm fiber provides desired mechanical properties, lowered ability of absorbing water when compared to hemp and sisal. Additionally, it has greater content of cellulose than lignin, which has effective role in automotive industry [8].

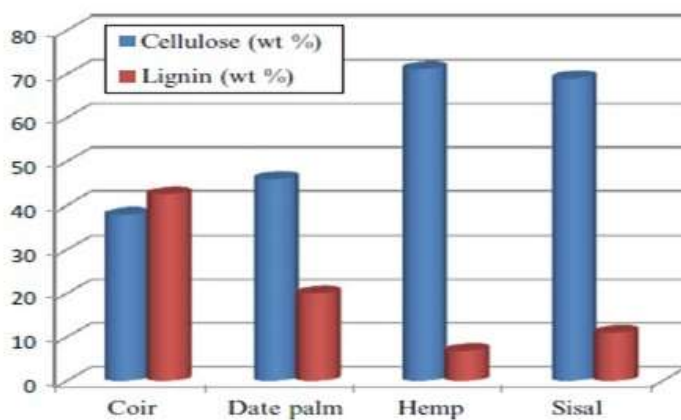


Figure 6. Comparison of cellulose and lignin contents between DPF and other natural fibers [8].

1.4.5 Properties of Date Palm Fiber. Properties such as density, fiber's length, diameter, thermal conductivity, aspect ratio (length/diameter), cost, and availability of the natural fibers are important to determine their compatibility for different natural fiber polymer composites industrial applications[8, 20, 68]. Date palm fiber is the most readily usable natural fibers having highest cellulosic content nearly 50 % as compared with other natural fibers. Fig.7 shows the density property comparison of date palm fibers and other natural types. Because of lower density of date palm fiber when compared to other natural fibers it is evident that it is accepted and reliable in the field of natural fiber composites.

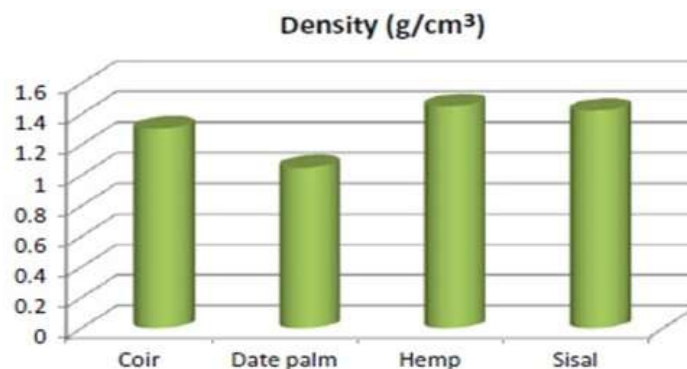


Figure 7. Density of date palm and other natural fibers [8].

Table 3 shows comparison of other physical properties of date palm fibers. Apparently, the physical properties of date palm fibers like diameter length, density and microfibril are quite efficient and display wide range of applications in the field of automotive and space industries [8, 21, 67]. Moreover, researchers reported that it has different industrial applications because it has optimum value of aspect ratio compared to other natural fibers [8].

Table 3. Comparison of physical properties of the date palm fibers with other natural fibers [8].

Properties	Fibers			
	Coir	Date palm	Hemp	Sisal
Density (g/cm ³)	1.15–1.46	0.9–1.2	1.4–1.5	1.33–1.5
Length (mm)	20–150	20–250	5–55	900
Diameter (μm)	10–460	100–1,000	25–500	8–200
Annual world Production	100	4,200	214	378
Cost Per Weight (USD/Kg)	0.3	0.02	1.2	1
Thermal Conductivity (W/mK)	0.047	0.083	0.115	0.07

1.4.6 Mechanical Properties of Date Palm Fiber. Research studies evaluates that factors such as chemical composition, structure, cell dimension, microfibrillar angle and defects influences the mechanical properties of natural fibers [53, 69-70]. In Table 4, mechanical properties of DPF and other natural fibers are listed. Young's modulus of DPF shows highest tensile strength on comparison with other natural fibers.

Table 4. Mechanical properties of various natural fibers [71]

Properties	Diameter (μm)	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation at break (%)
Jute	25–200	393–773	13–26.5	1.16–1.5
Flax	10–40	600–2,000	12–85	1–4
Sisal	50–200	468–640	9.4–22.0	3–7
Coir	100–450	131–175	4–6	15–40
Raw-date palm fiber	100–1,000	58–203	2–7.5	5–10

2. Challenges for Date Palm Fibers as Reinforcement

2.1 Date Palm Trunk Fibers

It has been reported in the literature, the use of stem fibers of date palm trees as reinforcement in polymeric materials. This research aims to study the potential of DPF by various treatments. The physical, mechanical and chemical properties obtained were compared to other common natural fibers. Evaluation of thermal stability, surface morphology, ultimate tensile strength and density upon chemical treatment of DPF were also done.

Treating DPF with different methods shows different properties of DPF. Researchers studied the effect of different treatments on DPF. They observed that the soda-treated fibers show highest increase in tensile strength and thermal degradation resistance whereas dioxin bleached fibers shows vice-versa. This difference will yield a variation of composites with different properties due to difference in interfacial adhesion between matrix and fiber [68].

2.2 Palm Fruit Stalk Fiber

Using ultrafine grinding technique micro fibrillated cellulose (MFC) was isolated from date palm fruit fiber stalks. These fibers were subjected to enzymatic pre-treatment with xylanase enzymes; it resulted

in isolation of larger diameter of MFC molecules when compared with those isolated from untreated pulp. It was also observed that, the MFC molecules are obtained by enzymatic treatment has high density, tensile strength properties (dry and wet), lower water absorption and lower air permeability. MorFi analysis system are used to determine the percentage of fines at different grinding times which can be used as indicator to investigate the progress of fibers fibrillation into MFC [72]. It is an advanced rapid optical technique, which is found to be more reliable, more accurate and less expensive than the existing tools and could supply additional information on the fibers morphology, fine elements and the shives compared to Kajaani. MorFi brings great revolution in the area of paper and pulp industries with more statistical and reliable results on mechanical and chemical pulp fibers characterization, fiber biometry, fiber characteristics and fine elements.

2.3 Date Palm Leaf

Date palm leaf fiber show lower degree of compatibility with hydrophobic polymers due to its hydrophilic nature [8]. Existence of natural waxy substance on surface of fiber layer provides low surface tension, and hence does not allow a strong bond with polymer matrix. DPF can be effectively used as reinforcing component as it is lighter in weight and can be easily chemically modified to improve the efficacy of tensile and flexure strength in fiber reinforced biocomposites, to use as civil construction materials [41]. In future other strong fibers such as (coconut, sabai grass, elephant grass, sisal grass) can also be modified chemically and used as an alternative for heavy weight civil engineering materials as DPF.

2.4 Treatment of Date Fibers

To increase the bond ability and wettability between the cellulosic fiber and polymer matrix, different surface modifications such as chemical, physical and mechanical have been done. Date palm fibers like other natural fibers are treated in order to minimize the limitations and to amend the compatibility between date palm fibers and polymer in date palm reinforced polymer composites.

Many studies reveal that the effectiveness of the date palm fibers can be increased by chemical treatment [41, 62, 67-68, 73]. Alawar et al. [71] investigated the date palm fiber using different alkali treatments with a wide range from 0.5 to 5 % and acid treatment with 0.3 N, 0.9 N and 1.6 N were used for 1h at 100 °C are used to modified the fiber surface . The results obtained showed and proved morphology improvement. Chemical treated fibers showed increase in tensile strength and considerable morphology advancement, whereas fibers treated with HCL were found to have negative impact on tensile strength and morphology. Fig. 8 shows effectiveness of the DPF upon chemical treatment where untreated fibers possess a weak outer layer that prevent strong bonding with the polymer matrix, while in treated DPF, the weak outer layer was removed during the treatment process leading to stronger bonding with the matrix present in the polymer composites.

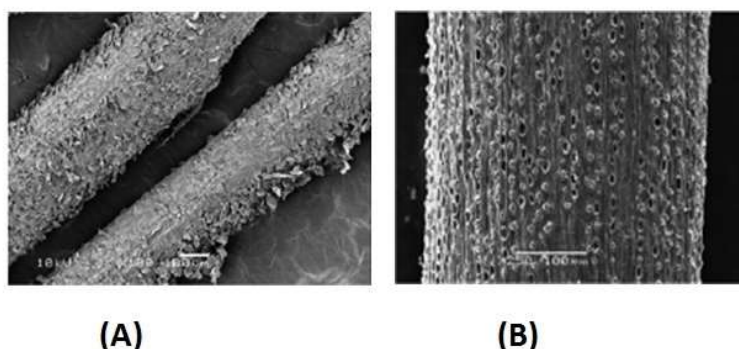


Figure 8. SEM of Untreated date palm fiber (A) and Treated date palm fiber with 1.5 % NaOH (B) [71].

Fig. 9 shows the effect of chemical treatment on the mechanical properties of date palm fibers. It depicts that proper chemical treatments enhances the tensile strength and Young's modulus of the

fiber. Fig.10 illustrates stress strain curves of DPF when treated with different concentrations of NaOH.

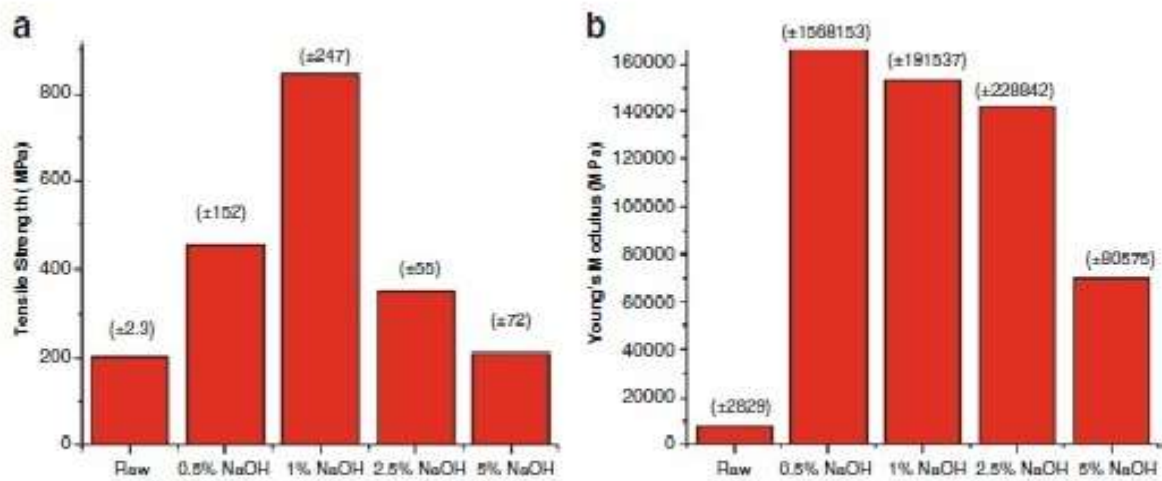


Figure 9. Effect of NaOH treatment on tensile strength (a) and Young's modulus of date palm fibers (b) [71].

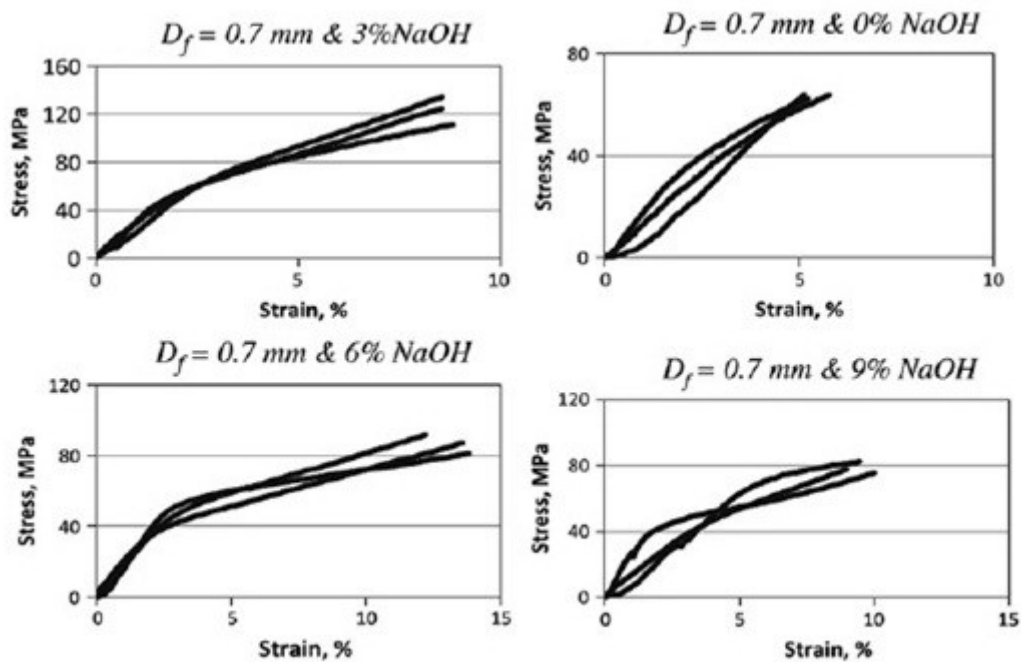


Figure 10. Stress/strain curves of date palm fiber with 0.7 mm diameter at different NaOH Concentration [73].

2.5 Matrices for Date Palm Fibers

In literature review it has been reported that matrices used for reinforcing date palm fibers for fabricating composites includes epoxy, polypropylene, polyester, high density and low density polyethylene (HDPE and LDPE) and ethylene terephthalate. Fig. 11 shows SEM micrograph of fracture surface of DPF/polyester composites. In other study unlike flax fibers and starch based

composites, DPF are combined with other types of fibers to make a complete, eco-friendly, biodegradable hybrid composite [74]. Most generally, it has been established that reinforcing of date palm fibers with different polymers exhibit considerable enhancements in, thermal and acoustical properties, mechanical properties like Young's modulus, flexural strength and tensile strength [62, 68, 73], indicating its wider industrial applications [8].

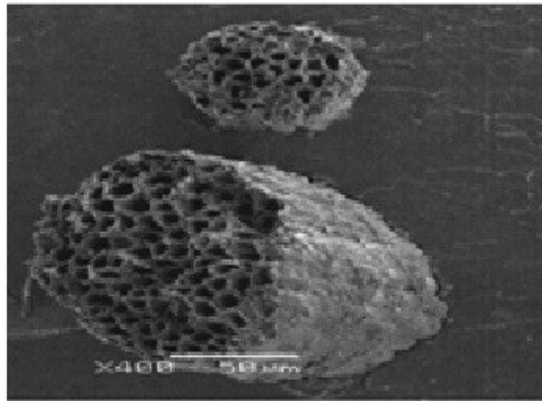


Figure 11. SEM micrograph of fracture surface of date palm fiber/polyester composite [75].

2.5.1 Date Palm Fiber Reinforced Polymer Composites. Table 5 display recent works on date palm fiber based composites. Using date palm fibers as reinforcement in composites resulted that the mechanical properties of DPF/polyester composites is influenced by fiber content and fiber treatment method [68]. Soda treated fibers show high mechanical properties while poor interface between fiber and matrix which is due to fracture surfaces attributes to low mechanical properties of DPF/polyester composites is observed in the study. Surface modification of the fibers increases the water absorption and improves adhesion thus leading to improvement in the mechanical properties [68].

2.5.2 Date Palm Fiber Reinforced Hybrid Polymer Composites. Hybrid composites are composites in which two or more fibers reinforced into a single matrix. Researchers develop a high-performance, cost-effective, and lightweight date leaf fibers and glass fibers as the reinforcement based hybrid composites. Composites and hybrid composites with DPLF are shown in Table 5.

Table 5. DPF biocomposites and hybrid composites with thermoset and thermoplastics.

Reinforcements	Polymers	References
DPF	Polyester	[75]
DPLF	Epoxy	[67]
DPF	Polyethylene	[7]
Bleached date palm leafs fiber	LDPE	[22]
Bleached date palm leafs fiber	PP	[22]
DPF/coconut cell particulate	Epoxy	[76]

Note: Low-density polyethylene-(LDPE); Polypropylene-(PP)

3. Applications

3.1 Date Palm Fiber Applications and Future Prospects

Date palms are multipurpose trees due to ancient cultivation, processing and utilization. Every part of the date palm can be used for one or more uses. Table 6 illustrates some uses of various parts of date palms. Date palm fibers presents several applications such as in textile, sports item, baggage, automobiles, cabinets, mats. Moreover, surface modified DPF are being introduced for making machine parts like transmission cloth, air-bag tying cords, conveyor belt cord and some cloths for

industry uses. When the bundles of leaves are dried, they are known as “Barusti” which is used to make roofs, shades, enclosures and wall separators. Fishing traps are made up of ribs of these leaves [77]. DPF possess comparable mechanical and physical properties with respect to other natural fibers, making it suitable for its broader application as building and construction materials, textiles, furniture and automotive components besides as daily life materials.

Table 6. Diverse applications of various parts of date palms (<http://hubpages.com/living/The-Various-Uses-of-Date-Palm-Tree>).

Date Palm Part	Usages
trunk and wood	Timber, wood, or fuel
Trunk Fiber and Leaves	Baskets, cords, camel saddles, bags, crates, fans, food covers, twines, mats, trays, ropes, paper, and furniture
Dried leaves	Shades, roofs, separating walls, and enclosures
Leaf Ribs	Fishing boats and traps.
Leaf Base and Fruit Stalks	Fuel
Palm Pith	Date palm flour
Terminal buds (palm heart)	Salad and cooked vegetable
Date seeds	Livestock food and decoration beads
Date Seed Oil	Soap
Date fruit	Drugs and medical treatment for sore throat and cold, intestinal problems, fever, edema, cystitis, liver, and abdominal problems.
Groves	Environmental niches for local wildlife
Date Palms	Control of desertification and land reclamation and ornamental and landscape purposes

3.2 Applications of Date Palm Fibers Reinforced Polymer Composites and Hybrid Composites

Date palm fiber is one of the widely available natural fiber, due to its potentiality and competitiveness it has many industrial applications importantly in automotive ones. The peculiarity of this fiber is that it produces strong composites with different polymer matrices. To guarantee the marvellous properties of DPF and to ensure it to be used as ideal fiber in the automotive industry, various comparisons have been done between DPF and other commonly used fibers. In almost all comparisons, DPF was excellently chosen among different types as it has specific young's modulus to cost ratio criteria. It has been also found that the final mechanical properties of DPF and also its reinforced polymer composites can be increased by chemical treatment. The tremendous properties of DPF such as its performance, eco-friendly, cost effectiveness and its societal aspect has forced automotive industry to adopt DPF as it improve productivity and also it is highly sustainable. Moreover, adopting DPF has momentous environmental influence as waste management can be efficiently practiced. Natural fillers such as date palm fabric fiber and coconut shell particle filler can be used effectively as reinforcing materials for epoxy composites. It can be said that composites prepared from these fillers can replace synthetic fillers in some applications where high strength and stiffness is not the major concern.

4. Conclusions and Future Perspectives

Date palm fibers are the cheapest fibers among other natural fibers. Date palm fiber is very common in tropical regions and very easy to extract fibers from its leaves. Date palm fibers possess satisfactory definite Young's modulus to cost ratio criterion. Date palm fibers have very competitive properties toward enhancing the sustainability and productivity of automotive industry as well as solving and managing an environmentally waste problem issue. Date palm fibers is widely accepted in textile sector and already used in our daily life materials.

The mechanical properties of the composites can be increased by reinforcing the date palm leaf fibers into polymers. The use of date palm fiber in composite material is a new source of materials which can be economic, eco-friendly, and recyclable. Date palm fibers are successfully reinforced in

epoxy, polypropylene and unsaturated polyester polymer to develop date palm fibers / polymer composites with improved properties. Hygroscopic nature of date palm fibers can be overcome by surface treatments with chemicals like NaOH, silane and others. Surface-treated date palm fibers reinforcement improves the mechanical and thermal properties of the polymer composites due to improved adherence between the date palm fiber and the polymer matrix.

In present article revealed that very limited study and research are reported in the literature improving the thermal properties including, electrical properties, thermal conductivity, dynamic mechanical analysis and modelling of date palm fibers reinforced polymer composites.

In future work, development of nano sized date palm fibers and its reinforcements in different varieties of thermosets and thermoplastics would be highlighted to fabricate nanocomposites and hybrid nanocomposites with enhanced properties. We also attribute that the development of biocomposites and hybrid composites by reinforcing date palm fibers in order to expand its applications also need major concerns.

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