Date Palm fibre reinforced composite by multiple resin to enhance the properties of a composite - A Review

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Abstract: - Numerous applications of the composites have been increased in this Era. The Research on polymer matrix composites using Natural fibre is wide. Natural fibres are one of the most abundant resources that exist in nature. In this paper, Date palm fibre is discussed for making of composites as it is one of the most available natural fibres in the world. It is the basic agricultural crop, especially in Middle East countries. Specific strength is the Parameter which makes date palm fibre superior compared to other fibres. To improve proper adhesion, the natural fibres are to be chemically treated to attain the better properties when compared to the untreated fibres. However, resins play a vital role in preparing a Composite. There are multiple resins used as matrices to make a composite. Hence, this paper is to analyse the date palm fibre-based polymer matrix composites for different resins for their Mechanical properties and Thermal properties. The Properties of various Natural fibres are also discussed in this paper.

Key words: Natural fibres, Date palm fibre, Polymers, Multiple Resins.

1. Introduction
Composite materials play a vital role in day to day life for its applications in many fields like (Aerospace, Automobile, Locomotives, structural and building, Industrial applications, sports goods, Prosthetics etc). Synthetic and Traditional are the two main classification of Composites. Synthetic composites are used for its wide range of Applications, whereas the Traditional composites already exists for many years. Natural fibres exist in both animals and plants. Natural fibres dominate the synthetic fibres for its availability, low cost, low density, recyclability & biodegradability. The classification is shown in Fig.1.

The wide varieties of natural fibre include Abaca, Cotton, cane, grass, silk, jute, Kenaf, flax, Hemp, Date palm, banana, sisal, wheat, barley, rape etc. However chemical treatment is needed to improve proper adhesion between the polymer and fibre surface. Chemically treated fibres dominate in many aspects and properties than untreated fibres. The waxy layer removal from the natural fibre makes the rougher surface of natural fibres.

2. Date palm fiber.
Date or date palm is the major agricultural crop in Middle East countries. Date fruits are good in nutrition especially in hot climatic conditions. Date palm trees consists of different residues consists of tree trunks, bunch stalks and leaf stalks. The fibres are extracted from the different parts from Mesh, Rachis, and Petiole and bunch. Date palm wastes rather will pollute the Environment. The waste form Date palm can be utilised for its Eco friendly in nature. Date palm fibre provides superior chemical composition and holds good mechanical strength in contrast with other natural fibres. Fig.2 and Fig 3 shows Date palm classifications.
Figure 1. Classification of fibres [1]

Figure 2. Date Palm Tree (a) Date Palm fruit (b) [1]
Figure 3. Date palm tree trunk with leaf rachis (a) and (b-c) Date Palm fibres [1]

2.1 Date palm fibre Reinforced polymer matrix.
Many researchers have reported that, Date palm fibre provides better results when it is chemically treated compared to chemically untreated fibres. It is also observed that Date palm fibre provides better strength when treated with chemical adhesives. The chemical treatment carried out by many researchers for palm date fibres are alkaline treatment, Silane treatment and Acetylation treatment.

2.1.1 Polymer matrix classification.
Polymer matrix is further classified into thermosetting matrix and Thermoset Matrix. Thermoplastic polymers are formed by addition polymerisation at elevated Temperatures. The properties remain same when it is melted and reformed into different shapes. Most used thermoplastics resins are polyethylene, polypropylene, and polystyrene. Thermoset polymers are formed by condensation polymerisation. They have better dimensional stability, stronger and harder than thermosetting polymers. Most used thermosets are epoxies, polyesters, alkyds and amino. Table.1 shows the classification of polymers.

| Polymers                      | Thermoplastics | Thermosets     |
|-------------------------------|----------------|----------------|
| Polycarbonate                 |                | Phenolic Resins|
| Acrylic                       |                | Polyester Resins|
| Acetal copolymer Polyoxymethylene |            | Amino Resins   |
| Nylon                         |                | Epoxy Resins   |
| Polyethylene                  |                | Silicon Resins |
| Polyvinyl chloride            |                | Polyurethanes  |
| Polystyrene                   |                |                |
| Polypropylene                 |                |                |
| Teflon                        |                |                |

3. Discussion on properties with Different Types of fibres.
Many Investigations have been made to identify the most used resins for making the composite. However, the Thermal properties and Mechanical properties of a composite are most essential based on its applications.
3.1 Discussion on Thermal Properties.

Mohamed Hamdy Gheit, et al [2], studied Flexural, thermal, and dynamic mechanical properties of date palm fibres reinforced epoxy composites and reported that date palm fibre with 50% of composition have improved the Thermal stability of composite. The resin used was Epoxy. P.Noorunnisa Khanam, et al[3], studied Improvement of ternary recycled polymer blend reinforced with date palm fibre and reported that polymer ternary blends includes, Recycled low density polyethylene, Recycled high density polypropylene and Recycled polypropylene were used for better thermal stability. N. Saba, et al [4], studied Date palm reinforced epoxy composites: tensile, impact and morphological properties and reported that by using epoxy resin D.E.R 331 based on diglycidyl ether of bisphenol A (DGEBA), and the epoxy hardener (curing agent) Joint-mine 905-3S, concluding that of date palm fibre reinforcement with 50 % composition have the higher Mechanical stability. However Thermal Property was not discussed by the researchers. Ampol Wongsa et al., [5] studied the sisal and coconut fibre incorporated with geo polymer mortar and compared the results with synthetic (Glass fibre) and controlled geopolymer mortars. Researchers concluded that the modest increase in Thermal Conductivity using natural fibre (coconut and sisal) in geopolymer mortars compared to Synthetic glass fibre and controlled geopolymer mortars. Rather the results indicated the thermal conductivity tends to increase with increase in density of geo polymer mortars. However, resins were not used for the making of composite. Fabio da Costa Garcia Filho et al., [6] studied the piassava fibre and their epoxy composites. Researchers used a coating of graphene-oxide to piassava fibre and further Epoxy resin was used for making a composite. The results concluded that the slight increase in Thermal properties by incorporating graphene-oxide coated piassava fibre with epoxy resin compared to a neat Piassava fibre with Epoxy Resin. Sangeetha Dharmalingam et al.,[7] studied Amine functionalized Luffa fibre and Epoxy Resin an Interfacial adhesion and Researchers concluded, the increase in thermal stability by Amine functionalized Luffa fibre and epoxy composite compared to unfunctionalized fibre. A. Parre et al., [8] studied the Banana fibre treated with NAOH and untreated Banana fibre. Thermo gravimetric analysis has been carried out with 10 mg of untreated banana fibre and with 1%, 3%, 5%, 7% & 9% NAOH treated Banana fibre. The result concluded that NAOH treated by 5% banana fibre showed the elevated Thermal strength compared to untreated fibre. P. Madhu et al., [9] studied Agave Americana Fibre for Composite Reinforcement on Various Chemical treatments effects. The Agave Americana fibre was treated with four different chemicals NAOH, Potassium permanganate, Benzoyl-peroxide and Stearic acid. The result concluded; surface modified Agave Americana fibre shows better thermal stability. Rather the Researchers included that the chemical treatment of fibre produces better quality fibre compared to untreated fibre for making a composite. Siew Choo Chin et al., [10] studied on Bamboo fibre reinforced composites. The Bamboo fibre was chemically treated with 10% NAOH with soaking duration varied for 0, 24, 48 and 72 hours. Researchers concluded that 10% NAOH chemically treated bamboo fibre soaked to 48 hours exhibits good thermal stability.

The Figure.4 indicates, the Thermal stability comparison of 50% Date Palm fibre with Epoxy [2] and Recycled Ternary polymer blend with Maleic Anhydride [3]. The Results indicates that Recycled Ternary blend with Maleic Anhydride, enhances better Thermal stability.

![Figure.4](Comparison of Thermal stability of Plain Epoxy and Ternary Recycled Blend composite [2][3])
3.2 Discussion on Mechanical properties.

Mohamed Hamdy Gheith, et al [2], studied Flexural; thermal and dynamic mechanical properties of date palm fibres reinforced epoxy composites and reported that date palm fibre with 50% composition have good flexural strength and modulus. P. Noorunnisa Khanam, et al [3], studied Improvement of ternary recycled polymer blend reinforced with date palm fibre and reported that polymer ternary blends includes, Recycled low density polyethylene, Recycled high density polypropylene and Recycled polypropylene were used for better tensile strength and improved hardness of recycled polymer blend matrix. The resin used was Epoxy. N. Saba, et al [4], studied Date palm reinforced epoxy composites: tensile, impact and morphological properties and reported that by using epoxy resin D.E.R 331 based on diglycidyl ether of bisphenol A (DGEBA), and the epoxy hardener (curing agent) Joint-mine 905-3S, concluding that of date palm fibre reinforcement with 50% composition have the higher Mechanical stability. Ampol Wongsa et al., [5] studied the sisal and coconut fibre incorporated with geo polymer mortar and compared the results with synthetic (Glass fibre) and controlled geopolymer mortars. The researchers concluded that the flexural strength, tensile strength and compressive strength of sisal and coconut fibre incorporated with geo polymer mortar is increased when compared to Synthetic and Controlled geopolymer mortars. Sangeetha Dharmalingam et al., [7] studied Amine functionalized Luffa fibre and Epoxy Resin an Interfacial adhesion. The conclusion by researchers is that the Tensile strength, Flexural strength, and impact strength is increased in Amine functionalized luffa fibre when compared to unfunctionalized luffa fibre. P. Madhu et al., [9] studied on Agave Americana Fibre for Composite Reinforcement with the Effect of Various Chemical treatments. The researchers concluded that the tensile strength is improved in Agave Americana fibre composite when it is chemically treated. Mohammad Asim et al., [11] studied Effects of date palm fibres loading on mechanical and thermal properties of Date Palm reinforced phenol composite and reported that 50% of date palm fibre improved the impact properties also with better tensile modulus but reduced strength in flexural and Tension. The resin used as matrix for making the composite is Bio-Phenol Resin. H. Khakpour, et al [12], studied Mechanical properties of structural adhesives enhanced natural date palm fibre and reported that Different structural adhesives including Araldite AY 103-1 / HY 991, UHU plus end fest 300, ADEKIT H 9951 T and Eponate were considered to be used as matrix. These are all two-component epoxy adhesives. Two types of UHU adhesive, with dissimilar resin to hardener weight ratio, UHU1 ratio 100R:80H by weight and UHU2 ratio 100R:120H by weight were considered as two different matrices. The results concluded that the date palm fibre could significantly increase the tensile strength of structural adhesives. F. Delzendehrooy, et al [13], studied adhesively bonded lap joints with palm date fibres for strength improvement and reported that UHU plus end fest 300, a solvent-free two-component epoxy based adhesive, an adhesive to mix aluminium substrates and concluded that the overall strength increased by using more qualified fibres. A. Shalwan, et al [14], studied Influence of date palm fibre and graphite filler on mechanical and wear characteristics of epoxy composites and reported that the thermoset resin epoxy (R246TX) and kinetix (H160 medium) hardener was used as matrix for engineering applications and concluded with improved Mechanical properties, enhanced wear and frictional characteristics. T. Krishnan et al., [15] studied alkaline-treated Sun hemp fibre reinforced polyester composites and concluded higher Impact, Flexural and tensile strength of alkali treated sun hemp fibres compared to untreated fibres. ES Zaini et al., [16] studied rice husk composite. The Polypropylene copolymer is used as a Resin. The composite was made on 15%, 30% and 51% of rice husk, respectively. The result concluded that 15% of rice husk produced good Mechanical Properties. Raghavendra et al, [17] studied different samples of date palm fibres from five different regions and specimens are prepared. Mechanical properties like Tensile, impact and flexural strength are evaluated and found better results. Also, Fourier transforms infrared spectroscopes (FTIR) were used to analyse functional groups.

Figure 5 and 6 indicates the comparison on Tensile strength, Tensile Modulus and % elongation of break, of Recycled Ternary blend with Maleic Anhydride [3] and Plain Epoxy Date composite [4]. Table 2 indicates the composition of Ternary blends A1, A2, A3 and A4. The results from the comparison, [3][4],
concluded that 50% of Date palm fibre with epoxy and the A3 composition of Recycled Ternary blend composites provides better results.

![Figure 5](image-url)

**Figure 5.** Tensile strength, Tensile Modulus and Elongation at break % of Recycled Ternary Blend composite [3]

**Table 2.** Composition of Recycled Ternary blend composites [3]

|   | A1                  | A2                  | A3                  | A4                  |
|---|---------------------|---------------------|---------------------|---------------------|
|   | 0% of Date palm leaf| 20% of Date palm leaf| 20% of Date palm leaf| 20% of Date palm leaf|
|   | 20% of Recycled low-density polyethylene | 10% of Recycled low-density polyethylene | 10% of Recycled low-density polyethylene | 10% of Recycled low-density polyethylene |
|   | 40% of recycled high-density Polyethylene | 35% of recycled high-density Polyethylene | 35% of recycled high-density Polyethylene | 35% of recycled high-density Polyethylene |
|   | 40% of Recycled Polypropylene | 35% of Recycled Polypropylene | 35% of Recycled Polypropylene | 35% of Recycled Polypropylene |
|   | 0% of Maleic Anhydride | 0% of Maleic Anhydride | 1% of Maleic Anhydride | 2% of Maleic Anhydride |
Figure 6. Tensile strength, Tensile Modulus and Elongation at break % of Plain Epoxy Date palm fibre [4].

4. Discussion on properties of hybrid natural fibre composites and its Applications.

K. P. Prashanth, et al [18], studied Synthesis and Characterization Study of Chitosan Based Natural Fibre: Biodegradable Polymer Composite and the Researchers concluded that the pre treated fibres increases the surface smoothness of fibres for the applications in food packaging and tissue engineering. L Prabhu, et al [19], studied Mechanical, Chemical and Acoustical behaviour of Sisal – Tea Waste – Glass Fibre Reinforced Epoxy Based Hybrid Polymer Composites and concluded that the Flexural strength, Impact strength, Tensile strength and Tensile modulus were increased with hybridisation of sisal in glass fibre for its various applications in automobile. R Bhoopathi, et al [20], studied on mechanical strengths of hemp-glass fibre reinforced epoxy composites and results concluded that good tensile strength and flexural strength of composites for its applications in automobiles. J Inbakumar Parivendhan, et al [21], studied Mechanical, wear and thermal behaviour of hemp fibre/egg shell particle reinforced epoxy resin bio composite and concluded with improved Mechanical property on load bearing capability of hybrid composite and increase in egg shell particles improved the initial mass stability for the use of its composites in industrial and structural applications. MR Sanjay, et al [22], studied The hybrid effect of Jute/Kenaf/E-glass woven fabric epoxy composites for medium load applications: impact, inter-laminar strength, and failure surface characterization and concluded with better impact strength of laminate due to hybrid effect and for its applications in automobile industries. GR Arpitha, et al [23], studied an overview on mechanical property evaluation of natural fibre reinforced polymers and concluded that good mechanical properties can be possessed by Natural fibres for its various applications. M Ramesh, et al [24], studied Plant fibre based bio-composites: Sustainable and renewable green materials and concluded that treating of fibres with different alkaline solutions will enhance the various properties which includes Flexural strength, Impact strength, Tensile strength and Fatigue strength for its various applications. M Ramesh, et al [25], studied Evaluation of mechanical and interfacial properties of sisal/jute/glass hybrid fibre reinforced polymer composites and concluded that good Flexural strength, Impact strength and Tensile strength possessed by sisal/jute and glass fibre.
reinforced hybrid composites. M Ramesh, et al [26], studied Impact behaviour analysis of sisal/jute and glass fibre reinforced hybrid composites and concluded that jute glass fibre reinforced polymer composites attains the maximum impact strength compared to sisal jute glass fibre reinforced polymer composites. M Sakthivel, et al [27], studied Production and characterization of luffa/coir reinforced polypropylene composite and concluded with improved mechanical properties when compared to polymer pure for its automotive applications. M Ramesh, et al [28], studied Mechanical property evaluation of sisal–jute–glass fibre reinforced polyester composites and concluded that jute glass fibre reinforced composite possesses maximum tensile strength, Jute and sisal glass fibre reinforced composite possesses maximum flexural strength and sisal glass fibre reinforced composite possesses maximum impact strength. MR Sanjay, et al [29], studied on mechanical properties of banana/e-glass fabrics reinforced polyester hybrid composites and concluded that nine layers of pure glass laminates provides Maximum tensile strength, Flexural strength, and impact strength. M Ramesh, et al [30], studied Biocomposites Reinforced with Animal and Regenerated Fibres and concluded that the animal and regenerated fibres possess low density and good mechanical strength for its few industrial applications. Ramesh, et al [31], studied Life-cycle and environmental impact assessments on processing of plant fibres and its bio-composites: A critical review and concluded the resin utilisation as the major factor for reinforcing with fibres and also concluded that the plant fibre reinforced composite have better applications compared with synthetic fibre composites

5. Conclusions.

- The recent papers by the researchers of the natural fibres concluded that the quality of the composite mainly depends on the proper resins used and the chemical treatment carried out on fibres to make a composite.
- Researchers have chosen multiple resins, in both the thermoplastic polymers and Thermoset polymers.
- However, majority of the researchers reported that Epoxy, the thermoset resin is commonly used, since it has better dimensional stability and good stiffness, better chemical Resistance, Cheaper and widely used upon other resins for Engineering Applications.
- Though researchers reported that the composite from Palm date fibre yield good Flexural properties, Thermal properties and dynamic mechanical properties and tensile strength, Still the Date palm fibre-based composites face several challenges in many of its applications.
- As per the figure 4, the Thermal stability is increased in Recycled Ternary blends compared to plain Epoxy date palm fibre and in contrast from figure 5 and figure 6, the Mechanical properties have minimum deviations in Recycled Ternary blends.
- As per the discussion of various authors, Hybrid natural fibre composites plays a vital role for its vast applications in automobile and industrial applications for its good Mechanical properties.
- The proposed research would be carried out on incorporating 50% of date palm fibre reinforced polymer matrix by blending different types of Resins and to test the Results for the Enhancement of the Mechanical and Thermal Properties.

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