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Areca Fibre Reinforced Composites in UAV Manufacturing: The Future of Lightweight and Sustainable Technology

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Abstract: Unmanned Aerial Vehicles (UAVs) play an important role in various industries, demanding constant innovation in materials to enhance safety, performance, and sustainability(1,2). This paper investigates the feasibility of integrating Areca fibre-reinforced composites into UAV manufacturing, offering a lightweight and eco-friendly alternative to traditional materials, which are costly compared to these composites. Derived from the Areca palm tree, Areca fibres offer advantages such as biodegradability, renewability, and competitive mechanical properties. This paper reviews the lightweight characteristics of Areca fibres, making them particularly suitable for UAV applications where weight reduction is crucial. However, challenges like moisture absorption, limited processing techniques, and durability concerns are acknowledged(3,4). Addressing these challenges through proper coatings, processing optimization, and ongoing research is essential. The potential cost-effectiveness of Areca fibres further adds to their appeal in the UAV industry(5,6). This abstract highlights the need for rigorous testing, certification processes, and collaboration between researchers and industry experts to establish Areca fibre-reinforced composites as a viable and sustainable option in UAV manufacturing. Overall, this exploration of Areca fibre-reinforced composites in UAV industry contributes to the growing reliance on environmentally conscious materials in aerospace engineering.

Keywords: *Unmanned Aerial Vehicle; Areca Fibre composite; Sustainable Aerospace Material; Light Weight Composite Structure; Eco-Friendly UAV Manufacturing.*

Nomenclature:

- *UAV - Unmanned Aerial Vehicle*
- *EPP - expanded polypropylene*
- *EPO - expanded polyolefin*
- *MPa - Megapascal*
- *GPa - Gigapascal*
- *g/cm^3 - Gram per Cubic Centimetre*
- *kJ/m^2 - Kilojoule per Square Metre*

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I. INTRODUCTION

The realm of Unmanned Aerial Vehicles (UAVs) is undergoing a transformative evolution, driven by the pursuit of enhanced performance, safety, reliability, extended flight capabilities, and a commitment to sustainable manufacturing practices that support the environment. In this context, Areca fibre-reinforced composites have emerged as a compelling prospect for revolutionizing the construction of fixed-wing UAVs to a great extent. The unique properties of Areca fibres, coupled with their lightweight composition and sustainability, position them as a promising material to redefine the landscape of fixed-wing UAV manufacturing.

Fixed-wing UAVs, characterized by their aerodynamic stability, reliability and prolonged flight durations, offer a distinct set of challenges and opportunities in the aviation industry. Minimizing weight is crucial for optimizing aerodynamics, achieving efficient fuel consumption, and extending operational ranges. Areca fibres derived from the Areca palm possess inherent mechanical strength and a lightweight nature that make them particularly well-suited for aerospace applications(7,8). The fibres' potential to reinforce composites introduces a paradigm shift in fixed-wing UAV manufacturing where structural integrity and weight optimization are paramount considerations.

One of the key features of Areca fibres is their biodegradability and renewability(9,10). In the current era, marked by increasing awareness of environmental sustainability, the integration of Areca fibre-reinforced composites aligns with the aerospace industry's commitment to eco-friendly practices with cost-efficient and reliable solutions. This paper aims to shed light on the environmental advantages of also utilizing Areca fibres, emphasizing the potential for reducing the ecological footprint of fixed-wing UAV manufacturing processes.

Despite the promising attributes of Areca fibre-reinforced composites, challenges such as moisture absorption, processing techniques, and durability must be addressed to ensure their seamless integration into fixed-wing UAV structures(4,11); this research endeavors to explore these challenges and discuss potential solutions, providing insights that can guide further developments in materials engineering for UAV applications.

As the aerospace industry continues to seek innovative solutions that balance performance with sustainability, the exploration of Areca fibre-reinforced composites in fixed-wing UAV manufacturing emerges as a frontier with the potential to reshape the trajectory of unmanned flight technology. This paper contributes to the growing body of knowledge in this field, driving conversations and advancements that propel fixed-wing UAVs into a future characterized by lightweight efficiency and environmental responsibility.

II. COMPARISON OF PROPERTIES AMONG VARIOUS MATERIALS

➢ *Mechanical Properties*

A comparison of the mechanical properties among Areca fibre-reinforced composite, carbon fibre-reinforced composite, plastic, EPP, EPO, and thermocol is shown in Table 1.

Table 1. Mechanical Properties Comparison.

MATERIAL	Tensile Strength (MPa)	Young's Modulus (GPa)	Density (g/cm³)	Flexural Strength (MPa)	Impact Strength (kJ/m²)
Areca Fibre-Reinforced Composite	10-50(7,12)	1-7(13,14)	1.2-1.4	100-150	10-15
Carbon Fibre-Reinforced Composite	300-3700(15,16)	5-280(17,18)	1.5-2.2	500-700	50-150
Plastic	20-60	0.1-5	0.9-2.3	40-200	10-80
EPP	20-40	0.2-1.8	0.02-0.04	20-30	10-20
EPO	20-50	0.5-3	0.015-0.03	20-30	10-20
Thermocol	NA	NA	0.02-0.03	NA	NA

Tensile strength ranges from 100-200 MPa. Young's modulus of 7-10 GPa makes it a suitable material for structural applications by using appropriate manufacturing methods. Areca fibre-reinforced composites typically exhibit a density ranging from 1.25-1.50 g/cm³, contributing to a favorable balance between weight and strength(19). Flexural strength ranges from 100-150 MPa. The impact strength ranges between 10-15 kJ/m²(12).

➢ *Thermal Properties*

Thermal properties comparison between Areca fibre-reinforced composite, carbon fibre-reinforced composite, plastic, expanded polypropylene (EPP), expanded polyolefin (EPO), and expanded polystyrene (thermocol) is shown in Table 2.

Table 2. Thermal Properties Comparison.

MATERIAL	Thermal Conductivity	Specific Heat Capacity	Coefficient of Thermal Expansion
Areca fibre Reinforced Composite	Low	Moderate	Moderate
Carbon fibre Reinforced Composite	Low	Low	Low
Plastic	Varies	Varies	Varies
EPP	Low	Low	Low
EPO	Low	Low	Low
Thermocol	Low	Low	Low

Areca fibre-reinforced composite is a natural and environmentally friendly material. Its low thermal conductivity makes it an excellent choice for applications where heat transfer needs to be minimized (20). With a moderate specific heat capacity and coefficient of thermal expansion, it offers a good balance between thermal stability and flexibility.

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III. MANUFACTURING PROCESS FOR ARECA FIBRE-REINFORCED COMPOSITES

The manufacturing process of Areca fibre-reinforced composites involves several steps. Quality, reliability and performance of the final product are the key factors to be considered in this process. The Areca palm tree produces the Areca fibres(9) which integrate with a matrix material to create a strong and durable composite(7). The steps involved in this manufacturing process are given below:

- *Extraction of Fibre:*

The extraction of fibres from the Areca palm tree is the first step involved in the manufacturing process. The harvesting of leaves are carefully done and processed to obtain long, slender fibres, which serve as the reinforcing component of the composite. The extraction process is important in determining the quality of the final composite. This is a crucial process involved in the manufacturing process of the Areca fibre reinforced composite.

- *Treatment of Fibre:*

Once extracted, the Areca fibres undergo a treatment process to enhance their compatibility with the matrix material. This treatment typically involves washing the fibres to remove impurities and applying a surface treatment to improve adhesion properties (21). Treated fibres are then dried and prepared for the next stage of the manufacturing process.

- *Preparation of Matrix Material:*

Simultaneously, the matrix material is prepared. The matrix serves as the binding agent that holds the Areca fibres together and provides additional strength and stability to the composite. There are many matrix materials which can be used, including thermosetting resins, thermoplastics, or bio-based polymers, depending on the specific requirements of the UAV application. The matrix material is carefully mixed and prepared to ensure uniform distribution and consistency. This ensures smooth preparation of the material.

- *Fibre-Matrix Integration:*

The next step involved is combining the treated Areca fibres with the prepared matrix material to form a homogeneous mixture. This integration process ensures that the fibres are evenly dispersed throughout the matrix, maximizing their reinforcing effect. The mixture is typically achieved through techniques such as hand lay-up, vacuum infusion, or compression molding, depending on the desired end product (22).

- *Curing and Solidification:*

Once the fibre-matrix mixture is formed, it undergoes a curing process to solidify the composite. Curing involves subjecting the mixture to heat and pressure, allowing the matrix material to harden and bond with the fibres. The specific curing conditions, such as temperature and duration, depend on the matrix material being used (23). Proper curing is essential to achieve the desired mechanical properties and durability.

- *Shaping and Finishing:*

The next step after curing is that the solidified composite is shaped and finished to meet the desired specifications of the desired UAV component. There are various ways involved in this like cutting, trimming, sanding, or other machining processes which helps to achieve the desired dimensions and surface finish (8). The final product is then ready for assembly into the UAV structure.

In summary, the manufacturing process of Areca fibre-reinforced composites for UAVs involves fibre extraction, treatment, matrix material preparation, fibre-matrix integration, curing, and shaping. Each step plays a crucial role in creating a strong and durable composite material suitable for UAV manufacturing. By carefully following this process, manufacturers can ensure the production of high-quality Areca fibre-reinforced composites that meet the stringent requirements of the aerospace industry.

IV. APPLICATIONS OF ARECA FIBRE REINFORCED COMPOSITES IN UAV MANUFACTURING

Areca fibre-reinforced composites are increasingly finding a wide range of applications in UAV manufacturing due to their exceptional properties and characteristics. These composites offer unique advantages, making them suitable for various components of UAVs, contributing to improved performance and durability. Below are some key applications of Areca fibre-reinforced composites in UAV manufacturing:

- *Fuselage and Structural Components:*

Areca fibre-reinforced composites are extensively used in the construction of UAV fuselages and other structural components. The high strength and stiffness of these composites ensure the structural integrity of the UAV, allowing for safe and reliable operation. Additionally, the lightweight nature of Areca fibre composites reduces the overall weight of the UAV, improving flight performance and fuel efficiency (24).

- *Payload Enclosures:*

Areca fibre-reinforced composites are ideal for constructing payload enclosures for UAVs. These enclosures protect sensitive equipment such as cameras, sensors, and communication systems from external environmental factors. The durability and corrosion resistance of Areca fibre composites ensure the safety and longevity of the payload, even in harsh operating conditions (8).

- *Battery Housings:*

UAVs rely on batteries for power, and the housing for these batteries must be both lightweight and robust. Areca fibre-reinforced composites provide an excellent solution for battery housings, offering the necessary strength and protection while minimizing weight. The low density of Areca fibre composites contributes to increased flight endurance by reducing the overall weight of the UAV (21).

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➢ *Internal Components and Connectors:*

Areca fibre-reinforced composites can also be used in the construction of internal components within UAVs. These components require materials that are lightweight, durable, and possess excellent electrical insulation properties. Areca fibre composites meet these requirements, allowing for the efficient and reliable operation of UAVs (22,23).

In summary, Areca fibre-reinforced composites have a wide range of applications in UAV manufacturing. From fuselages and structural components to wing and rotor blades, these composites offer exceptional strength, stiffness, and lightweight properties. The use of Areca fibre composites in payload enclosures, battery housings, and internal components further enhances the overall performance and durability of UAVs. By incorporating this eco-friendly material into various UAV components, manufacturers can achieve improved flight performance, increased payload capacity, and enhanced fuel efficiency.

V. ADVANTAGES OF ARECA FIBRE REINFORCED COMPOSITES IN UAV MANUFACTURING

Areca fibre-reinforced composites offer numerous advantages in the manufacturing of UAVs. These composites, derived from the Areca palm tree, possess exceptional mechanical properties and are environmentally friendly (22). By incorporating Areca fibre-reinforced composites into UAV manufacturing, manufacturers can benefit from their unique characteristics and contribute to sustainable practices.

Firstly, Areca fibre-reinforced composites offer remarkable strength-to-weight ratios. This means that UAVs constructed using these composites can achieve the desired structural integrity while significantly reducing weight (25). The lightweight nature of these composites allows for improved manoeuvrability and increased payload capacity, enhancing the overall performance of UAVs. Furthermore, the reduced weight leads to improved fuel efficiency, enabling longer flight durations and extended operational capabilities.

Another advantage of Areca fibre-reinforced composites is their renewable and biodegradable nature. Unlike petroleum-based materials commonly used in UAV manufacturing, Areca fibre composites are derived from a sustainable source—the Areca palm tree (24). This makes them an environmentally friendly option that aligns with the growing emphasis on sustainable manufacturing practices. Additionally, Areca fibre composites have a low carbon footprint, further reducing their environmental impact.

Moreover, Areca fibre-reinforced composites exhibit excellent resistance to corrosion and fatigue. This makes them highly suitable for UAVs that often operate in harsh environments, including extreme temperatures and high altitudes (8). The durability and long lifespan of these composites ensure that UAVs constructed using them can withstand the rigors of aerial operations, minimizing the need for frequent repairs or replacements.

In summary, the advantages of using Areca fibre-reinforced composites in UAV manufacturing are undeniable. These composites offer exceptional strength-to-weight ratios, contributing to lighter UAVs with improved flight performance and fuel efficiency. Additionally, their renewable and biodegradable nature aligns with sustainable manufacturing practices, reducing reliance on petroleum-based materials. The corrosion and fatigue resistance of Areca fibre composites further enhance their suitability for UAVs. By embracing this eco-friendly material, UAV manufacturers can revolutionize the industry and contribute to a greener future.

VI. CONCLUSION

The manufacturing process for Areca fibre-reinforced composites generally requires less energy and emits fewer greenhouse gases compared to carbon fibre-reinforced composites (21). The reduced environmental impact during the production stage contributes to a lower carbon footprint overall. It is important to consider that the overall impact of using Areca fibre-reinforced composites in UAV manufacturing will depend on various factors, including the specific application, design, and manufacturing processes employed. Proper life cycle assessments and environmental analyses are necessary to comprehensively evaluate the carbon emission reduction potential of Areca fibre-reinforced composites in UAV manufacturing.

In conclusion, understanding the mechanical properties of various materials is crucial for choosing the right material for specific applications. Areca fibre-reinforced composite and carbon fibre-reinforced composite offer excellent strength and stiffness, making them suitable for structural purposes (26). Plastic materials, while versatile, have lower mechanical properties compared to the fibre composites. EPP and EPO foam materials provide lightweight solutions with good impact resistance. Thermocol, on the other hand, is primarily used for insulation and packaging purposes due to its low density. The impact of Areca fibre-reinforced composites in UAV manufacturing for reducing carbon emissions cannot be overstated. These eco-friendly materials offer numerous advantages, such as reduced carbon emissions, lightweight yet high-strength properties, and cost-effectiveness. As the world moves towards a greener future, incorporating sustainable alternatives like Areca fibre-reinforced composites in industries like UAV manufacturing is a crucial step in mitigating climate change and reducing our environmental footprint.

REFERENCES

[1]. Shakhatreh H, Sawalmeh A, Al-Fuqaha A, Dou Z, Almaita E, Khalil I, et al. Unmanned Aerial Vehicles (UAVs): A Survey on Civil Applications and Key Research Challenges. IEEE Access [Internet]. 2019 Jan 1 [cited 2026 Mar];7:48572–634. Available from: https://doi.org/10.1109/access.2019.2909530

[2]. Mohsan SAH, Khan MA, Noor F, Ullah I, Alsharif MH. Towards the Unmanned Aerial Vehicles (UAVs): A Comprehensive Review. Drones [Internet]. 2022 June

15 [cited 2026 Mar];6(6):147–147. Available from: https://doi.org/10.3390/drones6060147

[3]. Swamy RP, Kumar GCM, Vrushabhendrappa Y, Joseph VC. Study of Areca-Reinforced Phenol Formaldehyde Composites. Journal of Reinforced Plastics and Composites [Internet]. 2004 Sept 1 [cited 2025 Nov];23(13):1373–82. Available from: https://doi.org/10.1177/0731684404037049

[4]. Santhosh N, Praveena BA, Kesarla MK, Ammarullah MI. Synergistic advances in natural fibre composites: a comprehensive review of the eco-friendly bio-composite development, its characterization and diverse applications. RSC Advances [Internet]. Royal Society of Chemistry; 2024 Jan 1 [cited 2025 Aug];14(25):17594–611. Available from: https://doi.org/10.1039/d4ra00149d

[5]. Dinakaran K, Ramesh H, Joseph A, Ramu M, Jothi S. Development and characterization of areca fibre reinforced polymer composite. Materials Today Proceedings [Internet]. 2019 Jan 1 [cited 2026 Mar];18:934–40. Available from: https://doi.org/10.1016/j.matpr.2019.06.528

[6]. Shahar FS, Sultan MTH. A Comparative Analysis Review of Plant Fibres in Advanced Bio-based Material for Sustainable Drone Construction. Pertanika journal of science & technology [Internet]. 2024 Oct 29 [cited 2025 Aug];32:103–22. Available from: https://doi.org/10.47836/pjst.32.s5.05

[7]. Rajkumar R, Arumugam CAK, Palanisamy S, Ayrılmış N. Mechanical properties of epoxy composites reinforced with Areca catechu fibres containing silicon carbide. BioResources [Internet]. 2024 Feb 22 [cited 2025 Oct];19(2):2353–70. Available from: https://doi.org/10.15376/biores.19.2.2353-2370

[8]. Gokarneshan N, Sathya V, Lavanya J, Shabnum S, Habeebunisa, Anton SM. A Review of Significant Advances in Areca Fibre Composites. IntechOpen eBooks [Internet]. 2023 Jan 3 [cited 2026 Jan]; Available from: http://dx.doi.org/10.5772/intechopen.108028

[9]. H MHA. Study of Properties and Prospects of Areca Fibres and its Applications. International Journal of Science and Research (IJSR) [Internet]. 2023 Mar 5 [cited 2026 Mar];12(3):569–71. Available from: http://doi.org/10.21275/sr23312173717

[10]. Sunny G, Rajan TP. Review on Areca Nut Fibre and its Implementation in Sustainable Products Development. Journal of Natural Fibres [Internet]. 2021 Jan 17 [cited 2025 Nov];19(12):4747–60. Available from: https://doi.org/10.1080/15440478.2020.1870623

[11]. Pavlović A, Valzania L, Minak G. Effects of Moisture Absorption on the Mechanical and Fatigue Properties of Natural Fibre Composites: A Review. Polymers [Internet]. 2025 July 21 [cited 2025 Nov];17(14):1996–1996. Available from: https://doi.org/10.3390/polym17141996

[12]. Miniappan PK, Marimuthu S, Kumar SD, Sharma S, Kumar A, Salah B, et al. Exploring the mechanical, tribological, and morphological characteristics of areca fibre epoxy composites reinforced with various fillers for multifaceted applications. Frontiers in Materials [Internet]. 2023 July 3 [cited 2025 Oct];10. Available from: https://doi.org/10.3389/fmats.2023.1185215

[13]. Farmakovskaya AA, Okorokova NS, Perchenok AV. Investigation of mechanical properties of composite materials reinforced with carbon fibres. E3S Web of Conferences [Internet]. 2023 Jan 1 [cited 2025 Oct];389:1085–1085. Available from: https://doi.org/10.1051/e3sconf/202338901085

[14]. Sumesh KR, Palanisamy S, Khan T, Arivendan A, Ahmed OS. Mechanical, morphological and wear resistance of natural fibre / glass fibre-based polymer composites. BioResources [Internet]. 2024 Apr 11 [cited 2025 Oct];19(2):3271–89. Available from: https://doi.org/10.15376/biores.19.2.3271-3289

[15]. Bondyra A, Łusiak T. Analysis of Strenght Properties of Carbon Fibre-Reinforced Composites. Transactions of the Institute of Aviation [Internet]. 2023 Mar 1 [cited 2025 Oct];2023(1):45–66. Available from: https://doi.org/10.2478/tar-2023-0005

[16]. Sánchez DM, Grésil M, Soutis C. Distributed internal strain measurement during composite manufacturing using optical fibre sensors. Composites Science and Technology [Internet]. 2015 Sept 29 [cited 2025 Oct];120:49–57. Available from: https://doi.org/10.1016/j.compscitech.2015.09.023

[17]. Lee SH, Waas AM. Compressive response and failure of fibre reinforced unidirectional composites. International Journal of Fracture [Internet]. 1999 Jan 1 [cited 2025 Sept];100(3):275–306. Available from: https://doi.org/10.1023/a:1018779307931

[18]. Dai G, Mishnaevsky L. Carbon nanotube reinforced hybrid composites: Computational modeling of environmental fatigue and usability for wind blades. Composites Part B Engineering [Internet]. 2015 Apr 6 [cited 2025 Oct];78:349–60. Available from: https://doi.org/10.1016/j.compositesb.2015.03.073

[19]. Venkateshappa SC, Bennehalli B, Kenchappa MG, Ranganagowda RPG. Flexural behaviour of areca fibres composites. BioResources [Internet]. 2010 July 15 [cited 2025 Oct];5(3):1846–58. Available from: https://doi.org/10.15376/biores.5.3.1846-1858

[20]. Shanmugasundaram N, Rajendran I, Ramkumar T. Characterization of untreated and alkali treated new cellulosic fibre from an Areca palm leaf stalk as potential reinforcement in polymer composites. Carbohydrate Polymers [Internet]. 2018 May 1 [cited 2026 May];195:566–75. Available from: https://doi.org/10.1016/j.carbpol.2018.04.127

[21]. Dhanalakshmi S, Ramadevi P, Bennehalli B. A study of the effect of chemical treatments on areca fibre reinforced polypropylene composite properties. Science and Engineering of Composite Materials [Internet]. 2016 Apr 18 [cited 2026 May];24(4):501–20. Available from: https://doi.org/10.1515/secm-2015-0292

[22]. Srinivasa CV, Bharath KN. Water absorption of Areca fibre-reinforced polymer composites. Int J Mater Biomater Appl. 2012;2.

[23]. Kumar MA, Reddy GR, Reddy KH, Reddy YVM, Reddy PR, Reddy NS. Fabrication and performance of hybrid betel nut (Areca catechu), short fibre (Sansevieria cylindrica : Agavaceae) epoxy composites.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jun714

2011 Jan 1 [cited 2025 Oct];53(4):375–86. Available from: http://eprints.nmlindia.org/4801/

[24]. Venkateshappa SC, Jayadevappa SY, Puttiah PKW. Mechanical behavior of areca fibre reinforced epoxy composites. Advances in Polymer Technology [Internet]. 2011 Oct 31 [cited 2026 May];31(4):319–30. Available from: https://doi.org/10.1002/adv.20255

[25]. Desai RH, Krishnamurthy L, Shridhar TN. Effectiveness of Areca (betel) fibre as a reinforcing material in eco-friendly composites: A review. Ind J Adv Chem Sci. 2016;

[26]. Prabakaran J, Santhosh S, Saravanakumar C, Rabins RS, Sudhanraj S. Investigation of Mechanical Properties in Areca (betel nut) and Sisal Fibre. IJSRD : international journal for scientific research and development [Internet]. 2017 May 1 [cited 2025 Oct];3(2):23–7. Available from: http://www.journal4research.org/articles/J4RV3I2025.pdf