EXPLORE THE VIABILITY OF UTILIZING JACKFRUIT LEAVES (ARTOCARPUS HETEROPHYLLUS) AS A SUSTAINABLE RESOURCE FOR THE PRODUCTION OF PARTICLEBOARD FOR INTERIOR APPLICATIONS

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Abstract: This research investigates the potential of utilizing jackfruit leaves as a sustainable material for particle boards in interior applications. With the increasing concern for environmental sustainability and the need for alternative materials in the design industry, exploring natural resources like jackfruit leaves offers a promising avenue.

The study begins with a comprehensive literature review, examining the availability, properties, and environmental impact of jackfruit leaves, as well as the standards of a particle board. The research methodology involves experimental sampling, data collection, and analysis, supplemented by a survey to assess viability and preferences. Key findings include the identification of optimal ratios of jackfruit leaves, water, and adhesive for particle board formation, along with physical and mechanical properties testing to evaluate suitability. Additionally, the research examines the aesthetic appeal and practicality of jackfruit leaf particle boards in interior design contexts.

The results demonstrate that jackfruit leaves can indeed be utilized effectively, yielding particle boards with comparable properties to traditional materials. This study contributes to the growing body of research on sustainable materials and offers practical insights for the utilization of agricultural waste in manufacturing processes.

Keywords: *Jackfruit leaves, Particle board, interior application, experimental study, physical properties*

1. Introduction

The rapid depletion of traditional wood resources and the increasing demand for sustainable materials in construction necessitate the exploration of alternative resources. This study investigates the potential of jackfruit leaves (Artocarpus heterophyllus) as a viable raw material for producing particleboard for interior applications. Jackfruit leaves are abundant and underutilized agricultural waste in many tropical countries. Their potential use in particleboard production could provide an eco-friendly solution to waste management and reduce reliance on wood-based materials. Previous studies have shown the feasibility of using various agricultural residues in particleboard manufacturing, but the use of jackfruit leaves remains unexplored. This research aims to fill this gap by evaluating the mechanical properties and sustainability of jackfruit leaf-based particleboard.

1.1 AIMS AND OBJECTIVES

The primary aim of this research is to explore the viability of utilizing jackfruit leaves as a sustainable resource for the production of particleboard tailored for interior applications. This study seeks to investigate the potential of jackfruit leaves as a value-added building material within the context of interior This research also seeks to identify the optimal processing conditions for producing high-quality particleboard from jackfruit leaves.

2. Literature Review

To assess the feasibility of using jackfruit leaves for particleboard production
To analyze the local particleboard market
To investigate local binding agents for particleboard production
To gather industry expert insights on practical applications of jackfruit leaf particleboards.

The utilization of plant-based materials for particle board production, specifically jackfruit leaves, has garnered significant attention due to their sustainability and mechanical properties. This bac kground study explores the potential of jackfruit leaves in particle board production for interior applications, focusing on their abundance, renewable nature, and favorable properties. Jackfruit, a staple in Sri Lankan agriculture, offers an abundant supply of leaves that are often considered waste. These leaves, characterized by their high fiber content and low moisture levels, exhibit properties such as flexibility, durability, and moisture resistance, making them ideal for particle board production. Studies have shown that particle boards made from jackfruit leaves possess high tensile strength and water repellency, indicating their suitability for humid environments (Goonewardane, 2021; Thilakarathne et al., 2020).

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Figure 1 Usage of Jackfruit Tree (Author developed)

Comparative analyses reveal that jackfruit leaves outperform other agricultural waste materials, such as rice husks and coconut coir, in terms of mechanical properties and environmental benefits. Utilizing jackfruit leaves reduces deforestation, lowers carbon emissions, and mitigates waste disposal issues, aligning with the principles of sustainability and the circular economy. The local availability of jackfruit leaves in Sri Lanka makes them a cost-effective raw material, further supported by research highlighting their economic viability for particle board production (Fernando et al., 2021; Sohan et al., 2019). The adoption of jackfruit leaves for particle board manufacturing can significantly reduce environmental impact while providing a renewable and biodegradable alternative to conventional wood-based materials.

The integration of jackfruit leaves into the local particle board market in Sri Lanka faces potential challenges, such as competition with established materials and regulatory approvals. However, the increasing demand for eco-friendly building materials presents a promising market opportunity. Studies have demonstrated the feasibility of using jackfruit leaf boards for various interior applications, such as furniture and wall panels, highlighting their strength, durability, and aesthetic appeal. Future research should focus on optimizing manufacturing processes and validating the findings through experimental studies to further enhance the sustainability of interior materials and contribute to a greener built environment (Dissanayake et al., 2021; Wu et al., 2018; De Silva et al., 2020).

2.1 JACKFRUIT LEAVES AVAILABILITY IN SRI LANKA AND COST EFFECTIVENESS

Jackfruit (Artocarpus heterophyllus) is a staple in Sri Lankan agriculture and culture, widely cultivated for its versatile fruit. Often referred to as the ‘tree of rice’, jackfruit's significance in Sri Lanka is second only to rice. Jackfruit was introduced to Sri Lanka from Malaysia in 1918 by Arthur V. Dias, who recognized its potential to combat food shortages exacerbated by colonial neglect of rice cultivation (Goonewardane, 2021). Over time, jackfruit became embedded in the country's home gardens and culinary traditions.

Jackfruit is a staple in Sri Lankan diets, consumed in various forms such as boiled flakes with grated coconut or ‘pol sambol’, mature flakes cooked in coconut milk (‘kiri kos’), spiced tender fruit curry (‘polos curry’), and pickled polos and malluma (flakes mixed with mustard and grated coconut). Jackfruit seeds can be preserved in sand, while dried flakes (‘Atu Kos’) provide long-term usage. The versatility of jackfruit makes it a favorite in vegan cuisine, often used as a meat substitute (Goonewardane, 2021).

2.2 PROPERTIES OF JACKFRUIT LEAVES

Jackfruit leaves, often overlooked as agricultural byproducts, possess unique characteristics that make them valuable for various applications. These leaves are large, broad, and leathery in texture, with a glossy dark green color. They are typically elliptical or oblong in shape, with prominent veins running through them. In Sri Lanka, jackfruit trees are cultivated in home gardens, orchards, and agroforestry systems, ensuring a steady supply of leaves throughout the year.

Jackfruit leaves possess a range of physical and mechanical properties that make them suitable for particle board production. These properties include flexibility, durability, moisture resistance, and dimensional stability. The leaves are

composed of cellulose, hemicellulose, lignin, and other natural polymers, which contribute to their strength and structural integrity.

Figure 3. Young Jackfruit Leave

Figure 4 Mature Jackfruit Leave

- High Fiber Content: The leaves contain a significant amount of cellulose, which contributes to the strength and rigidity of the particle board.
- Low Moisture Content: Proper drying of the leaves results in low moisture content, reducing the risk of warping and dimensional instability in the final product.
- Binding Affinity: The natural fibers in jackfruit leaves have good binding affinity with various adhesives, enhancing the structural integrity of the particle board.

Studies have shown that jackfruit leaf particle boards exhibit favorable properties such as high tensile strength, bending strength, and impact resistance (Srivastava et al., 2017). The unique microstructure of jackfruit leaves, characterized by closely packed fibers and vascular bundles, enhances the mechanical performance of the resulting particle boards. Additionally, the natural waxy coating on the leaf surface provides a degree of water repellency, making jackfruit leaf boards suitable for humid environments.

2.3 COMPARATIVE ANALYSIS WITH OTHER AGRICULTURAL WASTE MATERIALS

In recent years, there has been growing interest in utilizing agricultural waste materials for particle board production as a means of promoting sustainability and reducing environmental impact. Comparative studies have evaluated the properties and performance of jackfruit leaf particle boards in comparison to other agricultural waste materials such as rice husks, coconut coir, and bamboo.

- Fiber Strength: Jackfruit leaves have higher fiber strength compared to many other agricultural waste materials, resulting in more robust particle boards.
- Availability: In regions like Sri Lanka, jackfruit leaves are more readily available compared to other agricultural waste materials, ensuring a consistent supply.
- Eco-Friendliness: Utilizing jackfruit leaves helps reduce agricultural waste and promotes sustainable practices.

Fernando et al. (2021) compared the properties of various agricultural waste materials and found that jackfruit leaves exhibit superior mechanical properties and environmental benefits, making them a viable alternative for particle board production. Research by Sohan et al. (2019) conducted a comparative analysis of particle boards made from jackfruit leaves, banana leaves, and coconut coir. The study found that jackfruit leaf boards exhibited superior mechanical properties, including higher tensile strength and modulus of elasticity, compared to boards made from other agricultural waste materials. These findings suggest that jackfruit leaves offer a viable alternative for sustainable particle board production, with advantages in terms of strength and durability.

2.4 ENVIRONMENTAL IMPACT AND SUSTAINABILITY CONSIDERATIONS

The environmental impact of using jackfruit leaves for particle board production includes:

- Reduced Deforestation: Utilizing agricultural waste instead of timber helps preserve forests and reduces deforestation.
- Lower Carbon Footprint: The production process for jackfruit leaf particle boards generates lower carbon emissions compared to conventional particle boards.
- Waste Reduction: Repurposing jackfruit leaves mitigates waste disposal issues and contributes to a circular economy.

The utilization of jackfruit leaves for particle board production aligns with principles of environmental sustainability and circular economy. By repurposing agricultural waste into value-added products, such as interior materials, the industry can reduce reliance on finite natural resources and minimize waste generation. Jackfruit leaf particle boards offer a renewable and biodegradable alternative to conventional wood-based materials, contributing to the conservation of forests and biodiversity.

Research by Wu et al. (2018) conducted a life cycle assessment of particle boards made from agricultural waste materials, including jackfruit leaves. The study found that jackfruit leaf boards had lower environmental impacts in terms of resource depletion, global warming potential, and acidification compared to conventional wood-based particle boards. These findings highlight the environmental benefits of utilizing jackfruit leaves as a sustainable material for interior applications.

2.5 STANDARDS FOR PARTICLE BOARD

Particle board is a versatile engineered wood product made from wood chips, sawmill shavings, or sawdust bonded together with a synthetic resin or other suitable binder. This review discusses the required standards for particle board, focusing on physical, mechanical, and environmental performance as specified by various organizations and standards bodies.

Figure 5 Existing particle boards in the market (source: FX Cabinets Warehouse)

Physical and Mechanical Properties:

Particle boards must meet specific physical and mechanical standards to ensure their suitability for construction and furniture manufacturing. Key properties include density, moisture content, thickness swelling, internal bond strength, modulus of rupture, and modulus of elasticity, specifically targeting density, water absorption, and thickness swelling.

- **Density**: Density is a critical factor influencing the mechanical properties of particle board. According to the European Standard EN 312, the density of particle board typically ranges from 600 to 800 kg/m^3 (European Committee for Standardization [CEN], 2010). The moisture content should be between 5% and 13%, which ensures stability and reduces the risk of dimensional changes (American National Standards Institute [ANSI], 2016).
- **Water Absorption**: Water absorption is a critical parameter that influences the dimensional stability and durability of particle boards. Excessive water absorption can lead to swelling and deterioration of the board's mechanical properties. According to the ANSI A208.1 standard, particle boards should not exceed a water absorption rate of 8% after 24 hours of immersion in water (ANSI, 2016). The European Standard EN 317 specifies a maximum water absorption rate of 15% for general-purpose particle boards (CEN, 2010).
- **Thickness Swelling**: Thickness swelling is a measure of the board's dimensional stability when exposed to moisture. According to the ANSI A208.1 standard, thickness swelling should not exceed 8% after 24 hours of water immersion for interior-grade particle boards (ANSI, 2016). The European Standard EN 317 specifies a maximum thickness swelling rate of 15% for general- purpose particle boards (CEN, 2010).Physical and Mechanical Properties

2.6 ANALYSIS OF THE LOCAL PARTICLEBOARD MARKET

Analysing the local particleboard market in Sri Lanka involves evaluating product attributes and consumer trends to identify integration prospects and hurdles for jackfruit leaf particle boards:

- Product Attributes: Key attributes such as strength, durability, and aesthetic appeal are crucial for market acceptance. Jackfruit leaf particle boards must meet or exceed the standards of conventional particle boards.
- Consumer Trends: There is a growing demand for eco-friendly and sustainable building materials. Consumers are increasingly aware of the environmental impact of their purchases and are seeking greener alternatives.
- Integration Prospects: The versatility and cost-effectiveness of jackfruit leaf particle boards present significant opportunities for integration into the market.
- Hurdles: Potential hurdles include competition with established materials, regulatory approvals, and consumer scepticism regarding the performance of new materials.

Rajapakse et al. (2021) conducted a market analysis revealing a positive consumer attitude towards sustainable materials, suggesting a promising market for jackfruit leaf particle boards in Sri Lanka.

2.7 BINDING AGENTS COMPATIBILITY

The production of particle boards from jackfruit leaves necessitates the use of binding agents to ensure the particles adhere effectively and enhance the overall structural integrity of the boards. A variety of binding agents, both synthetic resins and

natural adhesives, can be employed in conjunction with jackfruit leaf particles to create boards with diverse properties and performance characteristics.

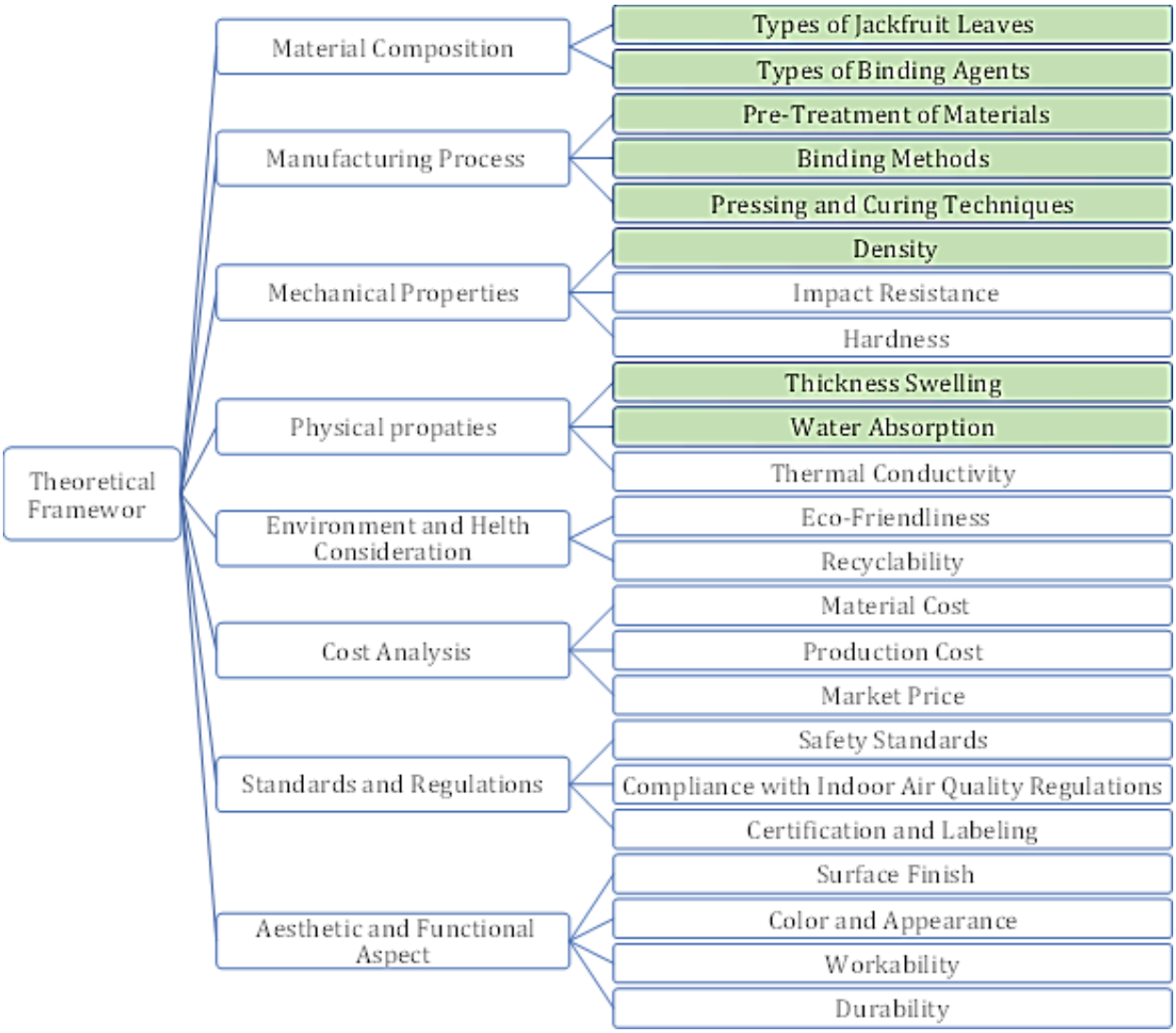
Table 1 Comparison of Binding Agents

Binding Agent	Strength	Cost	Environmental Impact	Water Resistance
PVAc	High	Moderate	Low (non-toxic)	Moderate
Urea- Formaldehyde	High	Low	High (formaldehyde)	Low
Phenol- Formaldehyde	Very High	High	High (formaldehyde)	High
Isocyanate-based	Very High	Very High	Moderate (toxicity)	Very High

PVAc has been chosen as the binding agent for this research due to its balanced properties of strength, environmental safety, and cost-effectiveness. It ensures the production of durable, reliable, and eco-friendly particle boards from jackfruit leaves.

By exploring the use of PVAc glue with jackfruit leaf particles and comparing it with other bio-waste materials and their binding agents, this research aims to contribute valuable knowledge to the field of sustainable material production and its potential applications in interior design. This investigation will help establish PVAc as a viable adhesive for creating particle boards that are both environmentally friendly and structurally sound.

Flow chart 1 Theoretical Framework



key aspects that this research aims to explore and uncover

This research focuses on specific aspects, including the types of jackfruit leaves, binding agents, pre-treatment processes, and mechanical properties, to lay a foundational understanding of the feasibility of using jackfruit leaves as a material for particleboard. Given the exploratory nature of the study and resource constraints, certain tests were prioritized to provide initial insights into the material's potential. Future research could build upon these findings by exploring additional variables, such as long-term durability, environmental resilience, and broader performance characteristics, to develop a more comprehensive profile of jackfruit leaf-based particleboard.

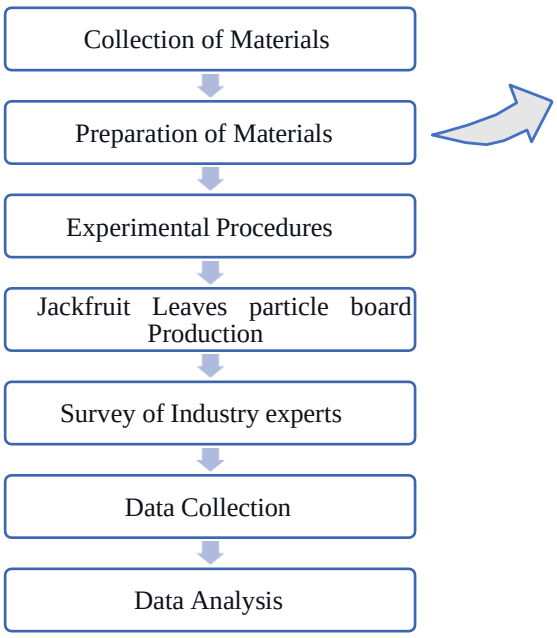
3. Methodology

The research methodology employed to assess the feasibility of utilizing jackfruit leaves (Artocarpus heterophyllus) for particleboard production involves a structured experimental design, incorporating both quantitative and qualitative approaches. The study is divided into several key phases: literature review particleboard production, testing and analysis, surveys, and data analysis. The literature review identified research gaps and informed the experimental procedures, where jackfruit leaves were processed and combined with polyvinyl acetate (PVAC) glue to create particleboard panels under controlled conditions. The physical and mechanical properties of these panels, such as density, moisture content, and water absorption, were tested and compared to conventional wood-based particleboards. Surveys with 30 industry experts provided insights into potential applications and industry acceptance of jackfruit leaf particleboards. Both experimental and survey data were analyzed using statistical methods, ensuring a comprehensive evaluation of the material's performance and feasibility. This mixed-method approach aims to contribute to sustainable construction practices and innovative interior design solutions.

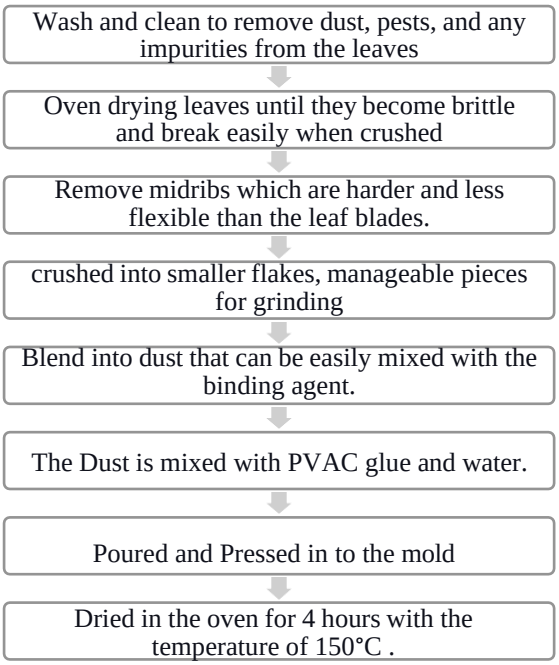
Experimental Sampling: Jackfruit leaves were collected from mature trees in multiple locations within Kelaniya, ensuring a consistent supply and quality. To prepare for production, leaves were oven-dried at 150°C to remove moisture and then ground to a fine dust for uniform mixing with the PVAc adhesive. Each sample followed a fixed ratio to determine the optimal leaf-to-adhesive mix for maximum binding and strength.

Participant Sampling for Survey: The survey employed purposive sampling to involve 30 experts from fields relevant to sustainable materials, particleboard production, and interior design. Participants included designers, industry professionals, and researchers to provide a diverse perspective on market viability and material preferences. Experts were chosen for their potential insight into industry applications, design trends, and environmental considerations for jackfruit leaf-based particleboards.

Flow chart 2 Research Process



Flow chart 3 Experiment Process



4. Results

The selected jackfruit trees for this study are located in Kelaniya, Sri lanka. Kelaniya provides an ideal environment for jackfruit trees, ensuring a consistent and sustainable supply of leaves for particleboard production

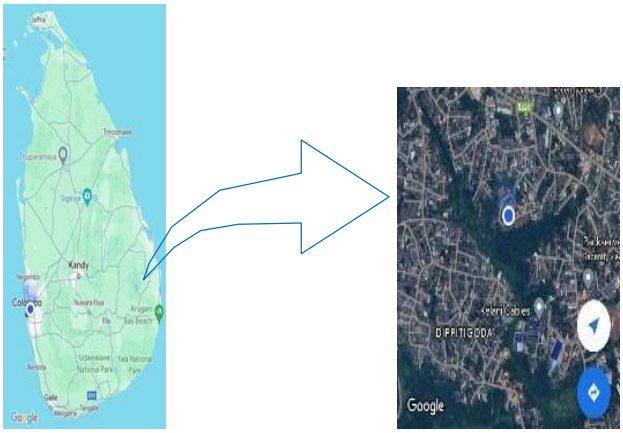


Figure 6 Location of material collected area

Detailed analyses of the leaves' weight, durability, size, and color were conducted, revealing that mature, dry leaves are optimal for particleboard production. Mature leaves, once they have dried, exhibit characteristics that are conducive to binding and structural integrity in particleboard applications.

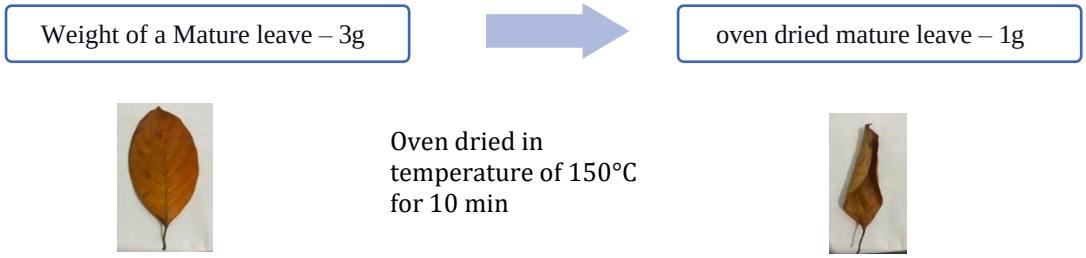


Figure 7 Jackfruit Leave weight difference

Figure 8 Transformation of jackfruit leave

Mature jackfruit leaves vary in size, indicating that the size of the leaves does not significantly impact their usability once they reach maturity. This variability in leaf size provides flexibility in the collection and processing of leaves for particleboard production

Figure 9 Size variation of mature jackfruit leaves

Young leaves are typically bright green. Mature leaves are orange or brownish. Color changes naturally with leaf maturity and drying process.

Figure 10 Color variation of jackfruit leave

Experimental procedures involving various ratios of jackfruit leaf dust, water, and PVAC adhesive determined that a 1:0.5:2.5 ratio yielded the strongest and hardest particleboard. The experimental results demonstrate that jackfruit leaves have potential as a raw material for particleboard production, showing reasonable density and structural integrity (0.613 g/cm^3, within EN 323 standards). However, high water absorption (47.1%) and significant thickness swelling (20%) indicate poor moisture resistance, falling short of ANSI A208.1 standards. indicating that while the density meets industry standards, the water absorption and thickness swelling need improvement. Comparison with industry standards highlights the need for enhancements in moisture resistance for practical applications.

Flow chart 4 Experiment Process that followed

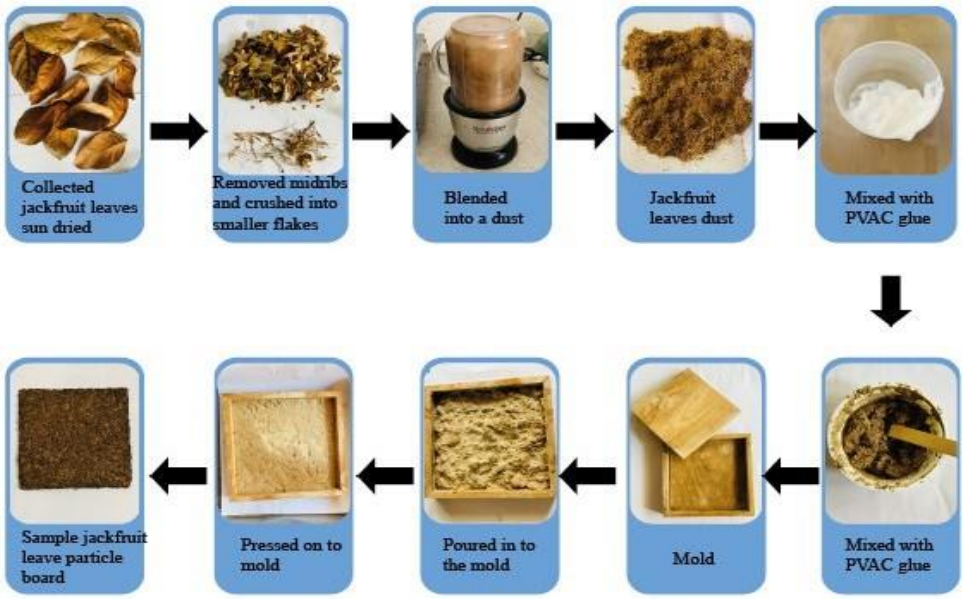
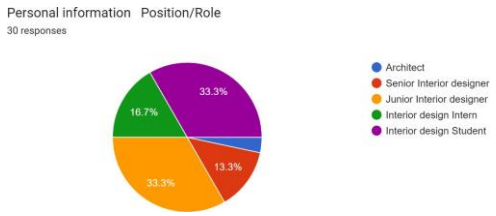


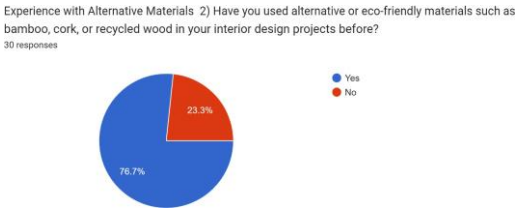
Table 2 Experiment results

Ex.		Jackfruit Leaves (g)	Water (g)	Adhesive (PVAC) (g)	Results	Notes
1.1		20	05	05	Did not bind	Increasing the glue quantity was essential
1.2		20	15	15	Hard, but insufficient thickness	70g of leaf dust is ideal for the mold
1.3		164 (pulp)		15	Somewhat Bind	Moist jackfruit leaves blended into a pulp were ineffective. Molds were creating on the surface
2		70	70	70	Couldn't mix well	Gradually added 5g of glue and water until mixed well
3		70	80	85	Binds well, hard	Glued to mold, hard to remove from mold
4		70	70	105	Binds very well, very hard	Hardness and strength improved. Used aluminum foil to easy demolding

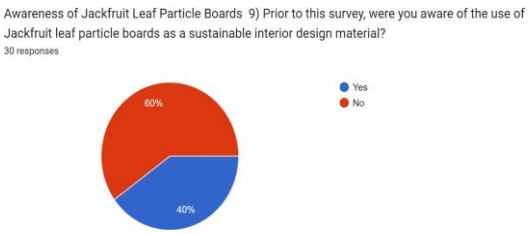
5		70	35	140	Hard, sufficient for particle board	Optimal strength and hardness achieved
6	``	70	35	175	Very hard, suitable for particle board	Increased adhesive content further improved properties

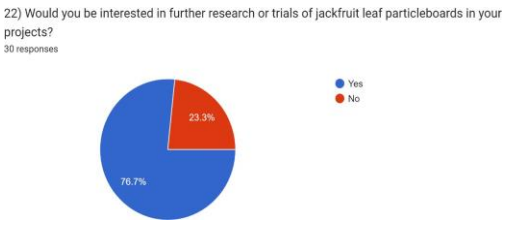
The survey reveals strong awareness and usage of sustainable materials among respondents, with a significant portion experienced in alternative materials. There is a notable openness to innovative materials, though there is still a lack of awareness about jackfruit leaf particleboards specifically. Despite mixed perceptions of their aesthetic appeal, the overall sentiment towards the potential use of jackfruit leaf particleboards is positive, especially regarding their cost-effectiveness and sustainability. Key factors influencing material selection include cost, sustainability, and availability, with strong interest in further exploring jackfruit leaf particleboards for interior design applications. Enhanced durability and resistance to environmental factors are crucial for their appeal.



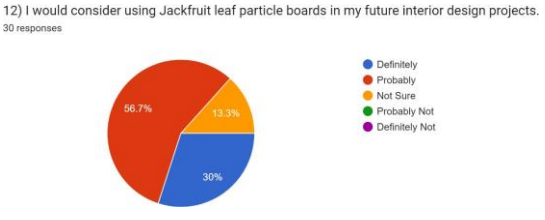


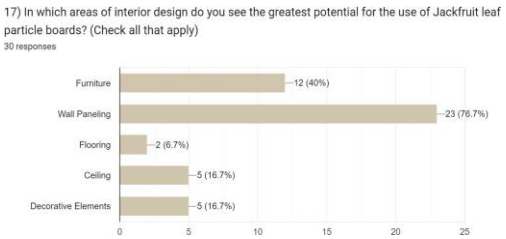
The survey indicates a high level of familiarity and usage of sustainable materials among respondents. Most respondents (40% rated 4, and 30% rated 5) are well-versed in sustainable interior design materials, and a significant majority (76.7%) have experience using alternative materials like bamboo, cork, or recycled wood.





While 60% of respondents were initially unaware of jackfruit leaves as a potential raw material for particleboard production, there is a strong interest in exploring innovative materials. A notable 76.7% are interested in further research or trials of jackfruit leaf particleboards, indicating a willingness to consider new sustainable options in their projects.





A majority of respondents (56.7%) are open to using jackfruit leaf particle boards, with 30% strongly committed. Notably, there were no responses in the "Probably Not" or "Definitely Not" categories, suggesting that no participants were entirely opposed to the idea. This overall positive reception highlights a favorable outlook for the adoption of jackfruit leaf particle boards in interior design. Most see the material's greatest potential in wall paneling (76.7%), followed by furniture (40%). Ceiling and decorative elements were less favored (16.7%), and flooring was the least popular (6.7%). This indicates a preference for using the material in vertical and surface-oriented interior design applications.

4. Conclusion

In conclusion, this research endeavors to explore the feasibility of utilizing jackfruit leaves as a sustainable alternative for particleboard production, alongside analyzing the local particleboard market, investigating binding agents, and exploring innovative applications in interior design. The findings and discussions encapsulated in this study illuminate the potential of jackfruit leaves as a viable material for creating durable and eco-friendly particleboards.

The experiments conducted throughout the study revealed critical insights into the particleboard production process. It was found that utilizing jackfruit leaves as dust, rather than pulp, and adjusting the ratios of water and adhesive were crucial steps in creating a strong, hard material. The identified optimal ratio of 1:0.5:2 (leaves dust: water: PVAc) provided the necessary hardness and strength for a viable particleboard alternative. Further refinements, such as increasing adhesive content, showed potential for yielding even stronger materials.

Additionally, the physical and mechanical properties testing offered valuable insights into the performance characteristics of the particleboards. While exhibiting reasonably high density and structural integrity, the boards demonstrated notable water absorption and thickness swelling properties, highlighting areas for further refinement. These results underscore the importance of continued research and development to address challenges and optimize the performance of jackfruit leaf particleboards.

The survey results provided additional perspectives from industry professionals, indicating a growing awareness and familiarity with sustainable materials in interior design. Despite a significant lack of awareness regarding the innovative use of jackfruit leaves, respondents expressed optimism about the availability and cost-effectiveness of this material. These findings present an opportunity for increased education and information dissemination to foster the adoption of sustainable alternatives in particleboard production.

In conclusion, this research contributes to the ongoing discourse on sustainable materials and presents jackfruit leaves as a promising resource for creating environmentally friendly particleboards. By refining production processes, addressing performance concerns, and raising awareness within the industry, jackfruit leaf particleboards hold the potential to revolutionize the landscape of interior design, offering both aesthetic appeal and ecological benefits.

5. Acknowledgement

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