

The Significance and Applications of Recycled Palm Waste Leaves: Advancing Sustainable Development in Architecture and Interior Design

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Abstract The United Arab Emirates (UAE) is one of the first nations in the Middle East to commit to achieving net-zero carbon emissions by 2050. At the forefront of these efforts is the Emirates Green Building Council, driving initiatives for a more sustainable built environment. This study aims to explore the adoption of PSB as a sustainable architecture material in the UAE by integrating eco-friendly building materials that reflect the nation's cultural identity. Specifically, the research focuses on utilizing Recycled waste of palm leaves as a zero-carbon building material. The Sustainable materials can protect and enhance people, places, and the natural environment while addressing the global climate crisis. Implementing these Alternative solutions will lead to improve quality of life, gradual economic growth, and the development of local skills and job opportunities. Research conducted in the laboratory of the Faculty of Engineering at Abu Dhabi University has demonstrated that Date Palm Waste Blockboard (PSB) possesses superior mechanical properties compared to imported wood species comparing with two more row materials MDF board and particleboard. Additionally, the study confirmed that date palm leaf waste board (PSB) can be effectively utilized as a core layer in the production of blockboards, offering a competitive alternative to traditional wood-based materials. The research involved a multidisciplinary analysis, incorporating chemical, mechanical, civil engineering, and interior design perspectives on wood-based materials. The findings validate PSB as a high-quality, eco-friendly panel material, with proven chemical, mechanical, and physical properties, making it a sustainable alternative in the industry. The students at interior design department explored and applied the PSB material in their Material course project reflecting the united Arab culture and Identity.

Key words: Palm leaves waste, environmental agricultural waste; rediscovery of local resources, Sustainability, Identity, PSB, MDF. Cheap board.

1. Introduction

The date palm leaves were the pivot of cultural social and economic life for long centuries in rural areas in Arab region. The date palm leaves waste also was a direct cause of pollution. Recycling has been a longstanding practice in human history, with roots dating back to the fourth century BC, as seen in the ideas of Plato [1]. In the United Arab Emirates, the Sustainability in construction industry has taken a significant turn after the launch of the Estidama Initiative in 2008, as well as the establishment of NADAF. NADAF has consistently encouraged the recycling of waste materials in the construction projects in the country for both economic and environmental benefits. Essentially, the focus of the initiatives entails the conservation of natural resources, as well as the reduction of the accumulated waste and costs incurred in clearing the wastes. According to, the construction industry in the Arab region should focus on increased recycling [2].

The success of the environmental movements world-wide has led to the decrease of wood availability in the international market. This has led to the soaring of wood prices, which has increased the burden on the balance of

payments in the Arab countries, relying basically on importation to satisfy people's need, of wood for shelter, furniture, etc. Meanwhile, the Arab countries are distinguished with the date palm belt extending from Morocco in the West to Iraq in the East including ~ 102.4 million palms [3].

This observation was the driven force behind the work in this investigation which aim to addressing the problems by proposing innovative recycled palm board as Alternative for the MDF and particleboard in the interior design and Architecture applications. Thus, what is called the rediscovery of renewable materials means: imagining, thinking, designing, carrying out research and producing new product prototypes, conducting market research to apply it in interior and Architecture applications [4].

The research focused on comparison between the Mechanical and chemical properties of three Materials PSB, MDF and Cheap board. The previous Study of Khaled M.Al saud The study revealed a high average response score (3.925) for meeting sustainability criteria in creating art pieces from palm waste, The study recommended further specialized research to generate raw materials from palm waste applicable in designs and decorations beyond tourist destinations and in various settings [1].

The study of H. El Mously, It was proven that the date palm midrib can be used as a core layer for the manufacture of blockboards competing with those manufactured from wood. the study also shows the important result of Fritz Troger -Institute for wood research Munich. Summarizing the result, it can be confirmed that palm leaves Midrib Blockboard can be considered a valuable wood-based material panel, the type of production certificate is eco-friendly product, the research shows limited mechanical and physical results[5].

The study of Johannes Welling (Wood, Bamboo and Palm Wood - Similarities and Differences in Research and Technology Development) shows the following result: research on palm wood and, especially, the processing of palm wood and the utilization of palm products is still at an early stage. Existing knowledge and expertise around wood/bamboo science and technology should be used for speeding-up the development and realization of palm wood utilization options [6].

2.Materials and Methods

Experimental and Descriptive.

Comparison between 3 different type of engineering wood

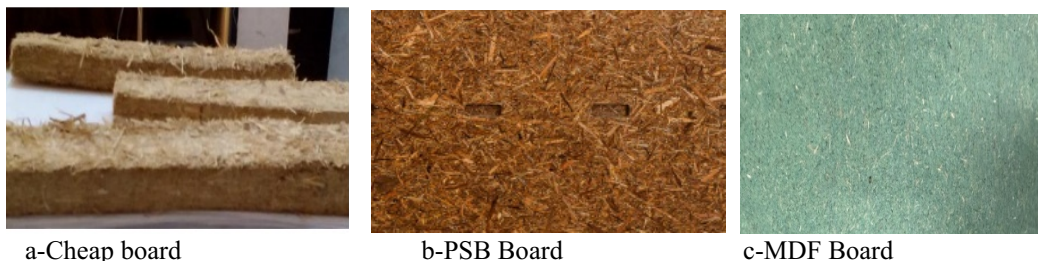


Figure 1. Various surface analysis for 3 different wood structures created, PSB Palm standard board, MDF Board and Cheap board

2.1 Materials

PSB, MDF Board and Particleboard are types of engineered wood[7]. The MDF board is made from fine wood fibers with resin [8]under heat and pressure. PSB is made of upcycled palm Biomass pressed in perpendicular layers and bonded with No Added Formaldehyde resin applied at high pressure and temperature. Where Particleboard is made out of fine wood chips and sawmill shavings, and Formaldehyde-based adhesives pressed into a solid panel of much lighter density than PSB.[9]The research scope of the whole investigation includes the following tests: compression tests using the ELE-3000 Compressive Testing Machine to investigate their mechanical characteristics during axial loading conditions. Deformation of samples under compression were also observed and recorded. Wettability Test Using Krüss Drop Shape Analyzer, sessile drop tests were performed in order to determine the wood surface wettability for four different specimens. This included surfaces fabricated from palm leaves. To analyse and compare the thermal conductivity of three different engineered wood materials: PSB (Palm Strand Board) wood, Cheap board, and Medium-Density Fibreboard (MDF). Understanding their thermal properties is crucial for applications in construction, furniture design, and insulation purposes. Based on the material test results,

the Interior Design students and faculty at Abu Dhabi University conducted an exhibition showcasing their exploration and application of PSB material in interior furniture units.

3.Results and Discussion

3.1 Mechanical Properties of Date Palm leaves (PSB) palm standard board: Compression test comparing with Particle board and MDF& PSB

Three different wood samples underwent compression tests using ELE-3000 Compressive Testing Machine to investigate their mechanical characteristics during axial loading conditions. The experimental analysis demonstrated that Sample A(18mmMDF) received the same overall compression comparing with Sample B (18mm thickness-PSB) and sample C (18mm thickness Particle board) -under the same test conditions. The compression deformation reached [9] mm for Sample A, reached (10) for sample C, while Sample B endured [15] mm of compression as shown in Figures 2. Material properties such as density, grain orientation, and moisture content create different compressive behaviours through their well-documented ability to affect wood mechanical performance. The results offer beneficial understanding about the structural stability and load resistance capabilities of the examined wood materials for engineering applications.

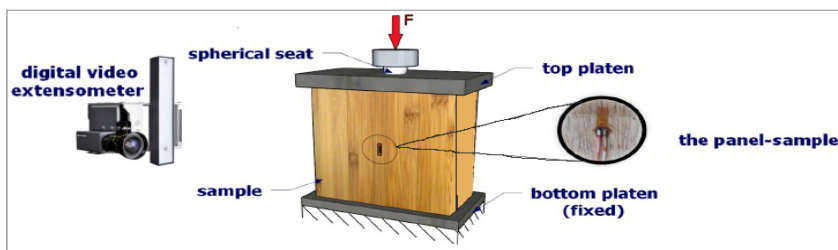
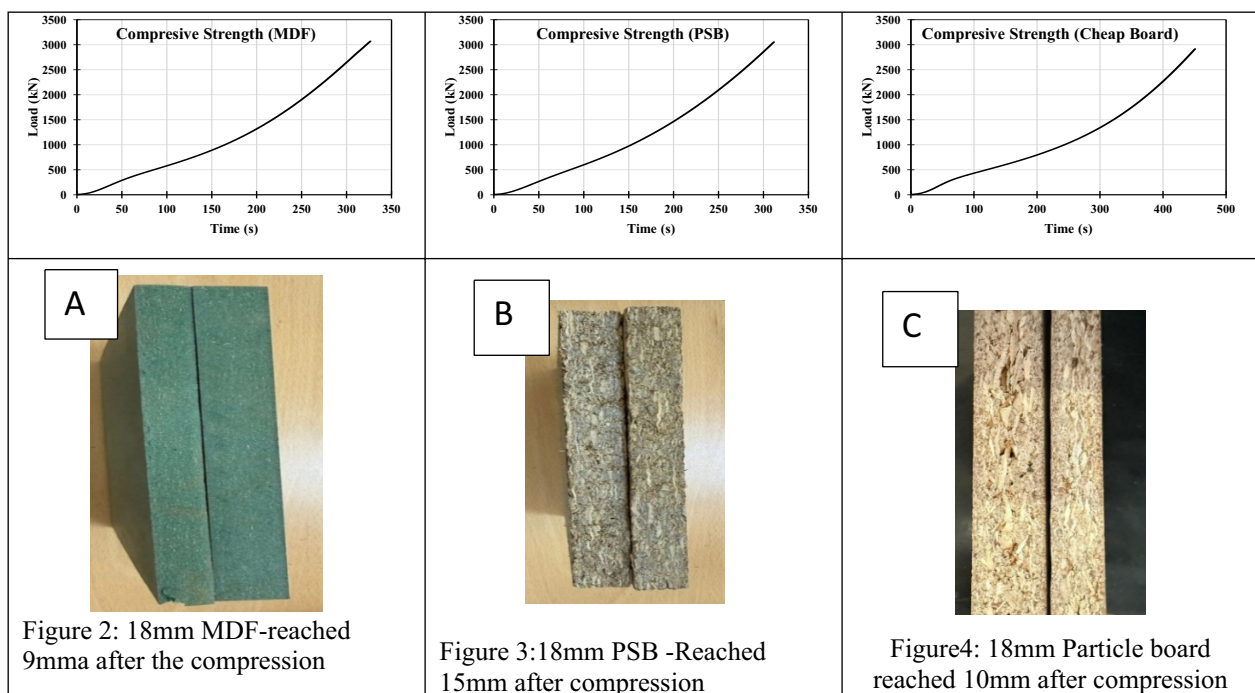


Figure 5 Compressive panel Sample test -Machine

3.2 Mechanical Properties of Date Palm leaves (PSB) palm standard board: The thermal conductivity Test comparing with Particle board and MDF& PSB:

To analyse and compare the thermal conductivity of three different engineered wood materials: PSB (Palm Strand Board) wood, Cheap board, and Medium-Density Fibreboard (MDF). Understanding their thermal properties is crucial for applications in construction, furniture design, and insulation purposes.

Thermal conductivity is a measure of a material’s ability to conduct heat. It plays a critical role in determining the suitability of materials for various applications, especially in construction and furniture manufacturing. Lower thermal conductivity indicates better insulation properties, which is desirable in energy-efficient building designs. This report examines the thermal conductivity of three engineered wood products: PSB wood, Cheap board, and MDF, comparing their effectiveness as insulative materials.

Heat Rate = 550 W

Area =0.1 19*0.18 m^2

Thickness = 0.018 m

PSB wood is a type of engineered wood made from compressed Palm leaves, strands bonded with special adhesives. It is commonly used in construction and furniture applications. Chipboard, also known as particle board, is manufactured by compressing wood chips and resin under heat and pressure, making it a cost-effective alternative for indoor applications. MDF is made by breaking down hardwood and softwood fibres, combining them with wax and resin[7], and forming panels under high pressure. Due to its uniform density and smooth surface, MDF is widely used in furniture and cabinetry.

Table 1: The thermal conductivity of PSB board

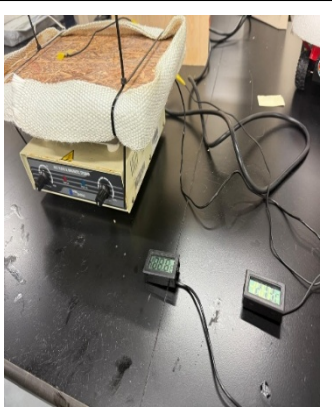
Material used:	PSB	
T1 (Bottom)(°C)	T2 (Top)(°C)	
21	21	
35.2	23	
57.1	24	
71.6	26	
84	28	
90	30	

Table 2: The thermal conductivity of Cheap board


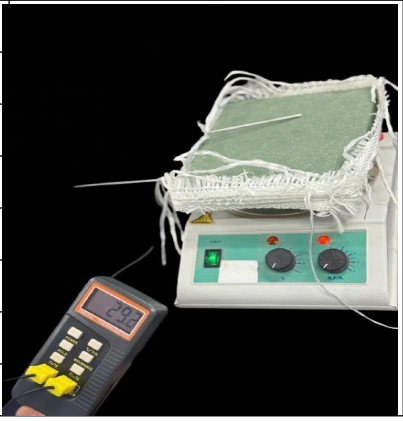
Material used:	Cheap Board	
T1 (Bottom)(°C)	T2 (Top)(°C)	
40	20	
50	22	
58	25	
69	28	
80	30	
100	33	
110	36	

Table 3: The thermal conductivity of MDF board

Material used:	MDF	
T1 (Bottom)(°C)	T2 (Top)(°C)	
21	21	
48	23	
58	26	
80	30	
100	34	
110	38	

The decreasing values of thermal conductivity indicate that as the temperature gradient increases (from T1 to T2), the material's thermal conductivity appears to reduce. This suggests that at higher temperature differences, the material may become less efficient at transferring heat, which could be due to physical changes in the material structure or how heat is distributed through the material.

When it comes to thermal conductivity, PSB is the best at insulating, making it great for energy-efficient buildings. Chipboard offers a good balance between cost and thermal performance, making it a solid choice for everyday furniture and construction. MDF has higher thermal conductivity.

3.3 Chemical Properties of Date Palm leaves (PSB) palm standard board:

Wettability Test with Particle board and MDF& PSB:

Materials used for interior decoration are usually exposed to different environmental conditions such as humidity and water. Thus, protecting the surface from moisture is really important to guarantee both durability and aesthetic appeal. With this in mind, the knowledge of how water is interacting with the material surface is becoming inevitable. The investigation was aimed at scrutinizing the wettability of the material surface because this parameter is mostly responsible for the material's potential to withstand water damage and to maintain good performance in humid conditions. To assess wettability, the study measured the contact angle, here used as the main parameter quantifying how a liquid spreads or beads on a surface. The contact angle, as a basis, is substantial in that it can be used to indicate whether or not both hydrophobicity and/or hydrophilicity are retained, the knowledge of which again allows the selection of a material for an indoor application, rain being an inevitable factor [10]. Using this method, a comprehensive examination was possible, of how well the material would be able to fend off water; thus, both the materials functional and visual integrities were preserved.

Using Krüss Drop Shape Analyzer, sessile drop tests were performed in order to determine the wood surface wettability for four different specimens. This included surfaces fabricated from palm leaves. One of the wood types (MDF Board) had a water contact angle that was chosen as the first type, and was about 50.2°, to be mild hydrophilicity (Figure 1a). The droplet, when in distilled water and on this surface, was characterized by a limited spreading, which was a sign of low attraction of the liquid-wettability to wood. The second wood type (PSB) was having less absorption than the first type as it had less spread and a contact angle of 72.0° (Figure 1b). The third wood type (Plywood) had a contact angle of 65°, exhibiting the overall moderate hydrophilicity, which is more than the first two types (Figure 1c). The fourth sample (Cheap board) was less hydrophilic than the the third wood samples, but with a contact angle of 56°. Thus, the existence of hydrophilic characteristics was confirmed for all of the four samples but with different variations.

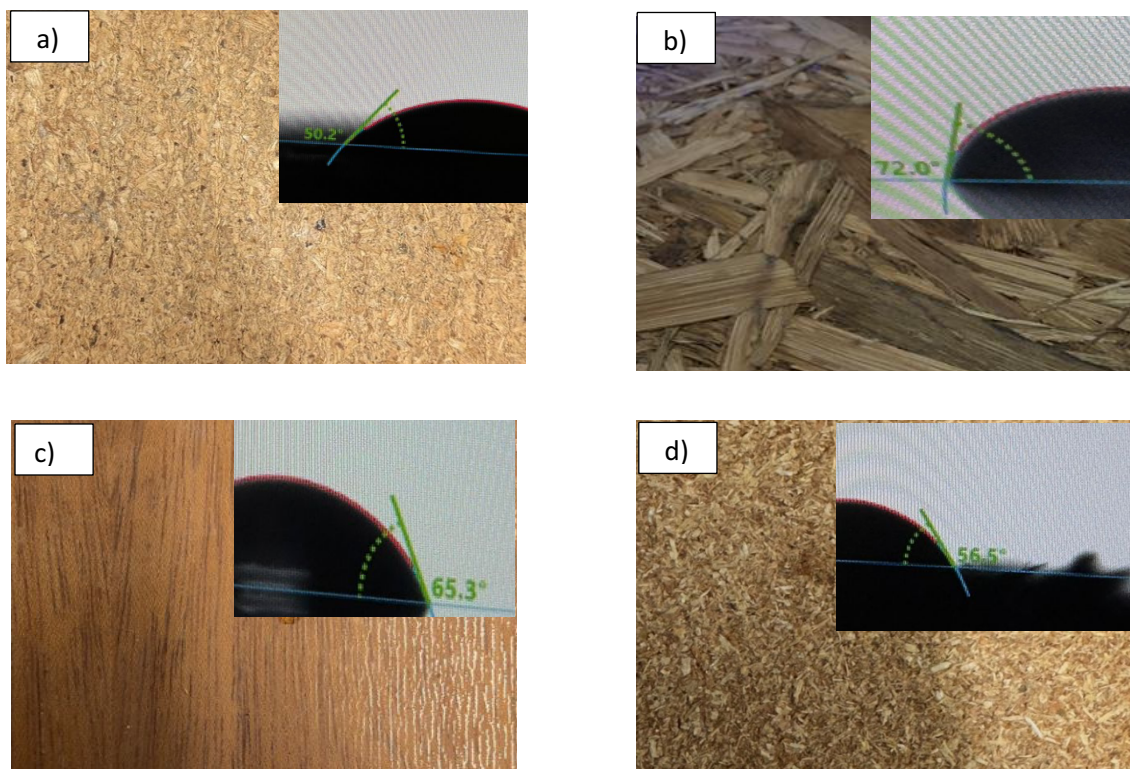


Figure 6. Various surface analysis for 4 different wood structures created, PSB Palm standard board, MDF Board, plywood and Cheap board

A comparison of the contact angle measurements from both this and previous research suggests that all the samples were hydrophilic, as shown by contact angle. All the findings regarding the inherent hydrophilicity of the wood samples are revealed through the measurement of the contact angles. Thus, it becomes clear the origins of wood samples hydrophilicity, this can be mentioned as the chemical formulation of the wood's main components. Wood fibers are made of cellulose, lignin, and extractives, these chemical species predominantly influence the surface chemistry and support the interaction with liquids. Moreover, variances in the measured angles result from random factors like the surface roughness and the existence of structural defects in the wood. The research findings point out the significance of the surface property knowledge to enhance the wood's performance in those applications where the liquid-surface interaction is a key factor.

4.0 Industrial applications and interior design furniture units were explored through experiments conducted at Abu Dhabi University by Interior Design students enrolled in the Materials course. These experiments utilized boards made from Date Palm leaves.

The conduction of tests to determine the physical and mechanical properties of the palm leaves waste to understand the material and apply it on Interior design Applications.

Development of new products from the palm leaves waste board PSB materials proceeding from the knowledge about their physical and mechanical properties, and chemical composition, as well as from the specificity of local, national and international needs.



Figure 7: Interior design furniture units created by ADU Interior Design students. The partition and chair were constructed using PSB Board, demonstrating successful results.



Figure8: Interior design furniture units created by ADU Interior Design students. The partition and chair were constructed using PSB Board, demonstrating successful results.

The Interior Design faculty, along with my students at ADU, explored and experimented with the PSB Palm slandered board material, applying it to create innovative and sustainable products. Our approach aimed to preserve its identity while incorporating a modern touch- The applications shows that the materials can compete the MDF and the Cheap board it is strong enough for a lot of applications and it is economically cheaper than the MDF and the cheap board Implementing these solutions can reduce waste, lower carbon footprints, and promote sustainability in various industries. Environmental benefits of utilizing.

5.Conclusion

The research focuses on the study of Recycled waste of palm leaves, (PSB) Palm Standard board Chemical and Mechanical properties comparing with other wooden recycled wooden boards such as MDF and particle board the research conducted at premises of faculties of engineering and interior Design at Abu Dhabi university has proven that the recycled date palm leaves (PSB)board enjoy Mechanical properties and chemical properties higher than those recycled wooden species (MDF and Particle wood).The proposed PSB (Palm Strand Board) classification falls under OSB (Oriented Strand Board) Type3 of a density average 700-800 kg/m³ (much higher than Particle Board & MDF) .

The chemical wettability test (To assess wettability, the study measured the contact angle, here used as the main parameter quantifying how a liquid spreads or beads on a surface) has Proven that the (PSB) board is the same or higher than the MFD and practical board The PSB wood type was having less absorption than the other type as it had less spread and a contact angle of 72.0°.

More Over, The Mechanical test three wood samples underwent compression tests using the ELE-3000 Compressive Testing Machine to investigate their mechanical characteristics during axial loading conditions. The results offer beneficial understanding about the structural stability and load resistance capabilities of the examined wood materials for engineering applications. Beside other factors cost and sustainability that PSB board is more effective and cheaper than particle board and MDF.

The PSB board through the research and testing were successfully used for the production of partitions and chairs which was made in the interior design department at Abu Dhabi university the result shows that the PSB board is a strong material competing with the beech wood, MDF board and practical board , the production shows the replacement of beech wood in the chairs with the PSB board which was completely strong and successful and reflect the Arab identity and in the partitions it shows the replacement of MDF wooden board with PSB board within the framework of bio economy there are high potentialities for the use of date palm leaves waste board (PSB) and also satisfying the OSB (Oriented Standard board) Type 3 of a density average (700-800 KG/m³) which is much higher than practical board and MDF.

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