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Utilization of coconut hard timber sawdust as particle board using organic binders

Cristhel C. Esmeño
College of Education Graduate Programs
Capiz State University Roxas City Main Campus
Roxas City, Philippines
Email: thelmie04@gmail.com

Abstract: The Panay region in the Philippines is renowned for its vast coconut plantations that produce a plentiful supply of coconut timber. The area also has access to locally sustained organic binders. When coconut timber is processed, sawdust becomes a by-product that can be used as an eco-friendly alternative to wood-based products. This experimental research was conducted to create a particle board product that would benefit the community without posing any health risk. The process of making a particle board involved combining sawdust and binders and then compressing it using heavy pressure. Particle boards with sago and parasol binders were sun-dried, while particle boards with breadnut binders were air-dried. The study assessed the physical characteristics of the particle board and its sensory qualities using testing and evaluation score sheets. The study found that the flexural strength of particle board with sago binder had the highest load-bearing capacity compared to other organic binders. In terms of water absorbency, the particle board with breadnut binder exhibited lesser water absorption. All particle boards using organic binders passed the density range of particle board. For the sensory qualities, the particle board with sago binder got the highest score in terms of appearance, texture, and firmness. The study also found that all three (3) organic binders used in the particle board were acceptable. There was no significant difference in the sensory qualities of coconut hard timber sawdust particle boards using different organic binders. Moreover results showed that coconut timber with organic binder could be used in making particle board.

Keywords: Coconut Timber, Sawdust, Particle Board, Organic Binder, Physical Characteristics, Sensory Qualities

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INTRODUCTION

The demand for wood globally has outstripped forest production capacities, resulting in deforestation and detrimental environmental consequences, such as climate change. In response, researchers have sought sustainable alternatives with similar components to wood, like cellulose, lignin, and hemicellulose, found in other plants (Sunny, 2021). Notably, the coconut tree (Cocos nucifera) has emerged as a viable substitute for rainforest timber, particularly in tropical regions like the Philippines, where various coconut tree varieties thrive in diverse soil conditions. Harnessing the versatility of the coconut tree, its wood residue can be repurposed for artificial wood production, specifically for particle boards (Lima, 2015).

Particle board, a wood composite crafted by grinding wood byproducts into small particles, offers a cost-effective and versatile material for numerous applications, including furniture, flooring underlayment, and decorative wall partitions (Composite Panel Association, 2024). Traditionally, particle board production relies on synthetic binders, such as urea formaldehyde resin, known for its durability but also associated with health risks, especially upon prolonged exposure (Oh, 2020).

In light of these concerns, the exploration of organic binders from tree sap presents a promising alternative. Sourced locally and harmless to human health, tree sap serves as a natural adhesive, forming resilient bonds when dried into resin. This organic approach not only mitigates health risks associated with synthetic binders but also aligns with sustainable manufacturing practices (Eco Bee, 2016).

The utilization of agro-waste further diversifies particle board production, addressing wood scarcity while promoting eco-friendly solutions. By incorporating coconut hard timber sawdust and organic binders from tree sap, researchers aim to reduce waste and offer a sustainable solution to the wood shortage problem. This endeavor, led by an Industrial Arts teacher, underscores the potential of organic binders to mitigate health risks, environmental pollution, and wood scarcity, ushering in a new era of sustainable particle board production.

Research objective

The primary purpose of this study was to utilize and evaluate the coconut hard timber sawdust particle board using different organic binders. Specifically, it aimed to determine the acceptability of the particle board from coconut hard timber sawdust with varying amounts of organic binders in terms of appearance, texture, and firmness.

LITERATURE REVIEW

Raw materials and additives

One significant area of focus is the influence of particle size on mechanical properties, as demonstrated in studies such as that by Harshavardhan et al. (2017) regarding coconut frond powder. This research underscores the critical role of particle size optimization in enhancing board performance, highlighting the need for precise control and understanding of particle characteristics during manufacturing processes. By tailoring particle size, manufacturers can achieve improved mechanical strength, dimensional stability, and overall durability in particleboard products.

Moreover, the exploration of alternative raw materials has opened new avenues for sustainable particleboard manufacturing. Studies by Kibet (2022) and Odeyemi et al. (2020) have identified leather shavings, waste papers, and periwinkle shells as viable substitutes for traditional wood fibers. These findings not only offer environmental benefits by utilizing waste materials but also diversify the raw material base, reducing dependence on finite wood resources. Incorporating these alternative materials into particleboard production not only reduces waste but also enhances the sustainability profile of particleboard manufacturing.

Advancements in manufacturing technologies, such as extrusion technology and ionic liquid-based fusion, have further contributed to improving particleboard properties. Orelma's (2021) research on sawdust particle fusion exemplifies how innovative processing techniques can enhance particle bonding and overall board strength. By leveraging extrusion technology and ionic liquid-based fusion, manufacturers can achieve superior tensile strength and structural integrity in particleboard products, paving the way for higher performance and broader application possibilities.

Manufacturing processes

Studies such as that by Massons et al. (2024) emphasize the impact of manufacturing processes on particleboard properties. Fine particles and optimized resin impregnation techniques have been shown to result in stronger boards with lower water absorption rates. These findings highlight the importance of precise control over particle size distribution and resin application methods to achieve desired performance characteristics in particleboard products.

Furthermore, research by Maraghi et al. (2018) underscores the role of resin content in influencing dimensional stability during manufacturing. While increased resin content can enhance dimensional stability to a certain extent, there is a critical need to optimize resin levels to avoid diminishing returns and potential negative impacts on other properties. This highlights the intricate balance that manufacturers must strike between resin content and overall board performance.

Structural analysis during cycling, as explored by Melichar (2022), offers valuable insights into the dynamic behavior of particleboard under varying environmental conditions. By examining parameters such as ultrasonic pulse velocity and crack width during cyclic loading, researchers can better understand the relationship between structural integrity and durability in particleboard products. These insights inform strategies for enhancing board resilience and longevity, ultimately contributing to improved product quality and customer satisfaction.

Mechanical and thermal properties

Dukarska (2022) underscores the critical influence of wood particle characteristics on particleboard properties. Factors such as particle fineness, geometry, and moisture content play pivotal roles in determining the mechanical strength and durability of the final product. By optimizing these parameters during the manufacturing process, manufacturers can achieve superior board performance and meet stringent quality standards.

Furthermore, studies exploring the use of additives have yielded promising results in enhancing mechanical properties. Hartono's research (2022) highlights the positive impact of incorporating wood shavings into particleboard production. By blending wood shavings with traditional wood particles, manufacturers can improve mechanical parameters such as modulus of elasticity and rupture, thereby enhancing overall board strength and stability. These findings offer valuable insights into alternative raw material sources and innovative manufacturing techniques aimed at elevating particleboard performance.

The emergence of particleboard oil as a thermal insulation material presents exciting opportunities for energy-efficient building construction. Research by Hasibuan (2022) suggests that particleboard oil exhibits favorable thermal conductivity properties, making it a viable option for improving building insulation and reducing energy consumption. By leveraging particleboard oil as a sustainable insulation material, builders and architects can enhance the thermal efficiency of structures while minimizing environmental impact.

Environmental and policy observations

The environmental impact of particleboard production has emerged as a critical consideration in both industry practices and policy development. Researchers have employed advanced analytical techniques such as Fourier Transform Infrared Spectroscopy (FTIR) to gain insights into the chemical composition and environmental implications of particleboard manufacturing processes (Hakim MohdAzman et al., 2021). By elucidating the molecular structure and vibrational modes of particleboard components, FTIR analysis informs policymakers about potential environmental risks associated with particleboard production, thereby facilitating the formulation of regulations aimed at minimizing adverse environmental effects.

The quest for sustainable alternatives has prompted investigations into natural-based adhesives as substitutes for formaldehyde-based adhesives commonly used in particleboard manufacturing. However, ensuring the safety and efficacy of these alternatives necessitates comprehensive toxicological assessments (Baharuddin, 2023). By evaluating the potential health hazards and environmental impacts of natural-based adhesives, policymakers can make informed decisions regarding their regulatory approval and widespread adoption within the industry.

METHODOLOGY

Research design

The study adopted an experimental research method employing Completely Randomized Design (CRD), where each treatment was assigned randomly to ensure that every experimental unit had an equal chance of receiving the treatment. The experiment involved three (3) treatments, labeled as A, B, and C. The researcher used the same amount of coconut sawdust. The tree binders varied across the treatments as the main ingredients. Three (3) product formulations were used in the experiment, each containing three (3) Treatments. Treatment A consisted of 235g of coconut sawdust with 300 ml of tree binders, Treatment B consisted of 235g coconut sawdust and 275g of tree binders, and Treatment C consisted of 235g of coconut sawdust and 250g of tree binders. Particle boards made with Parasol leaf tree and Sago binders were left out to dry under the sun for at least two (2) days. However, boards made with Breadnut binder were dried at room temperature for at least five (5) days as exposing them to high temperatures caused the Breadnut binder to melt. All boards were then stored to cure for 30 days.

Tools, equipment and materials used in the study

The tools and equipment used in the study were a working table, mixing container, sieving screen, particle board molder, grinding machine, putty trowel, digital scale for grams, measurement cup for milliliters, ladle, and a set of Personal Protective Equipment (PPE). The materials, tools, and equipment used in this study were coconut sawdustand organic binder (parasol sap, sago sap, and breadnutsap).

Experimental treatments

Three experimental treatments were made in this study. Treatments, A, B, and C had the same measurements of other ingredients, but varied only in the organic binder. The organic binder was made up of sago tree sap, parasol leaf tree sap, and breadnut tree sap, and served as the binder of particle board. The experiment was carried out in three product formulations, with each formulation having three treatments.

Experimental treatments in making particle board with Sago,Parasol, and Breadnut as binders.

Ingredients	Treatment A	Treatment B	Treatment C
Coconut saw dust	235g	235g	235g
Sagu Tree Sap	300ml	275ml	250ml
BinungaTree Sap	300ml	275ml	250ml
Kamansi Tree Sap	300ml	275ml	250ml

Procedures

Coconut hard timber sawdust

Sawdust from coconut trees is collected by sawing the trees. It is then placed in a sack and transferred to a circular winnower called a bilao. The sawdust is left to dry in the sun until it becomes lightweight and free of moisture. For best results, it is recommended to leave the sawdust for at least three (3) weeks at 40°C if the trees were freshly cut. Once the sawdust has dried, a medium-hole strainer is used to separate the hard timber from the soft parts of the coconut tree, and the particles are ground into a powdery substance with the help of an electric grinder. Finally, the substance is weighed using a digital scale to ensure the desired amount is obtained. Sawdust must be stored in a clean dry container for the preparation of particle board making.

Organic binder

The process of collecting tree sap involved gathering sap from various tree species. To obtain sago tree sap, the leaf sheath and petioles were cut into 1-foot-long pieces. The sap was then scraped out and placed in a clean container. Parasol leaf tree sap, on the other hand, was collected from the twigs or the terminal part of the tree. It was then scraped out and placed in a container. In order to extract sap from a breadnut tree, it was necessary to make slanted grooves on the bark that lead into the wood. Initially, watery sap would flow out immediately after the branch had been cut. However, to get more sap, one must wait for several minutes to an hour, as the sticky sap would stay in the cut portion of the trunk. The quantity of sap collected was determined based on the treatment applied during the particle board manufacturing process. It was essential to use the sap immediately, as they tend to dry quickly. The collection of sap requires patience, precision, and expertise to obtain the best results.

Particle board preparation

The production of particle board involves a multi-stage process. Initially, precise quantities of sawdust and sago binder are mixed according to specific treatment requirements. This process is repeated with the Parasol binder and Breadnut binder. The mixture is then manually stirred to ensure even distribution of the sawdust and binder throughout. After preparing the mixture, it is poured into a molder, ensuring no gaps or spaces in the corners. Once poured, the mixture is pressed into a solid panel with a threaded lock to tightly compress it. The molded panel is left to rest for approximately an hour before being removed from the molder.

For boards using Parasol and Sago binder, they are dried for 48 hours under direct sunlight at 40°C to evaporate any excess moisture. However, for boards using a Breadnut binder, they are placed in an airy area not directly exposed to the sun to prevent melting and deformation. After drying, the boards are stored in a cool, dry place to cure for at least one month. During this curing process, which lasts a minimum of one month, the board's fibers fully adapt to their environment, ensuring sturdiness and longevity.

Drying time frame

The researcher utilized a microwave oven to dry particle board with Sago and Parasol binder and recorded the drying time in the table. This method of drying was highly effective and hastens the drying process. However, for the particle board with Breadnut binder, the researcher opted for an air blower to dry the product. The sap present in the material was unable to resist heat, so the researcher chose to employ a blower instead. This method of drying takes longer, but it ensures that the material did not get damaged in the process.

Instrumentation

The researcher evaluated the different qualities of particle board as to physical property and strength which conformed to a standard of good quality particle board. The product was subjected to a battery of tests to evaluate its flexural strength, water absorbency, and density. For the composition of the particle board, the research instrument used was an evaluation sheet prepared by the researcher with five (5) point Likert Scale for the sensory qualities of the product. The content of the evaluation sheet was subjected to content validation.

Observation and evaluation procedure

The observation and evaluation processes were conducted separately and labeled as Phase 1 for observation and Phase 2 for evaluation. In Phase 1, the flexural strength testing was done by a universal testing machine (UTM) at Central Philippine University, Iloilo City. The absorbency and density testing were conducted by the researcher at their place in Hemming St., TizaRoxas City. In Phase 2, an evaluation sheet was used by the researcher and distributed to 30 evaluators, consisting of 5 furniture makers, 10 students, and 15 professors. The evaluators assessed the particle board's appearance, texture, and firmness. The evaluation was conducted in the presence of two panel experts and members.

Data analysis

The products and the treatments with means were evaluated by the students, furniture makers, and teachers for the general acceptabilityof the product. The data were tabulated and statistically analyzed using the mean to determine the average responses on the qualities of the particleboards from coconut hard timber sawdust with varying amounts of organic binders in terms of appearance, texture, and firmness.The collected data were tabulated and analyzed using the mean. The one-way analysis of variance (ANOVA) and Levene's test were used to determine the homogeneity of variance in the study. To generate the result, computer process (SPSS) was employed. Further, inferential tests were set at 0.05 level of significance.

FINDINGS AND DISCUSSION

Data based on the evaluation showed that particle board with Parasol binder had a mean score of 4.02 with a verbal interpretation of acceptable. On the other hand, particle board with Breadnut binder had a mean score of 4.13 interpreted as acceptable. Furthermore, particle board with sago binder had a mean score of 4.60, which was indicated as very acceptable.

The results imply that particle boards with Sago binder were the most acceptable among the three binders in particle board in terms of appearance. This preference maybe due to its superior visual appeal, which sets it apart from the other alternatives. The Sago binder stands out because of its pronounced effectiveness in blending seamlessly with sawdust, producing a particle board that is not only visually pleasing, but also exhibits superior physical properties. Additionally, particle boardsmanufactured from sawdust with uniform particle size have a more consistent appearance, contributingtotheoverall quality of the product.

The level of acceptability of organic binder in terms of texture showed that particle board with Parasol binder got a mean score of 3. 81 with a verbal interpretation of acceptable. In like manner, particle board with Breadnut binder had a mean score of 3.62 interpreted as acceptable. However, particle board with Sago binder had a mean score of 4.22 verbally interpreted as very acceptable.

The results imply that particle board with sago binder are the most acceptable among the three (3) binders in particle board in terms of texture. The findings of the study indicate that the Ambulong binder received favorable evaluations from the assessors. When evaluating the integrity and strength of particleboards, it's important to consider their texture, as it has a significant impact on their mechanical properties.

The result of this study conforms with Martins et al. (2022), which stated that the characterization of wood sawdust exposed the differences in the size and shapes of wood particles from fine particles to coarser particles.

The level of acceptability of organic binder in terms of firmness showed that particle board with Parasol binder has a mean score as a whole of 3.96 as a whole with a verbal interpretation of "acceptable". On the other hand, particle board with Breadnut binder had a mean score of 3.90 interpreted as acceptable. Furthermore, particle board with Sago binder had a mean score of 4.21 interpreted as very acceptable.

The results imply that particle board with sago binder are the most acceptable among the three (3) binders in particle board in terms of firmness. Particle board bonded with Sago binder exhibited superior mechanical properties when compared to other organic binders. This improved performance is highly desirable in various industrial and commercial applications where maintaining the durability and long-term stability of bonded surfaces is critical. This study conforms with Baini et al. (2021),which discloses the thegood wetting properties of the adhesive contribute to a strong adhesion force between the starch adhesive molecules and the wood surface.

The results imply that particle board with Sago binder was the most acceptable among the three (3) binders in particle board in terms of firmness. Particle board bonded with Sago binder exhibited superior mechanical properties when compared to other organic binders. Sago sap contains starch which improves the adhesive ability to stretch before breaking and also provides better resistance against the substrate peel-off. This improved performance is highly desirable in different industrial and commercial applications where it is critical to maintain the durability and long-term stability of the bonded surfaces.

CONCLUSIONS AND RECOMMENDATION

End users preferred the particle board with Sago binder due to its sensory quality in regard to appearance, texture, and firmness. As such, coconut sawdust can be used to make particle boards, which is a sustainable material. Furthermore, organic binders derived from various trees in the area can be utilized for different purposes. This not only encourages the use of sustainable materials but also promotes economic growth through innovative ideas and resourcefulness of every individual with the intervention of local government units and higher education institutions.

According to this study, particleboards utilizing Breadnut binders exhibit remarkable resistance to moisture, making them suitable for a range of wood-based products, including tables, false ceilings, and floorings underlayment. While these particleboards are not recommended for outdoor use, the application of water-resistant coatings can enhance their water-resistance properties.

For further development of the study on the utilization of coconut hard timber sawdust for particle board production, this study employed organic binders including Parasol sap, Breadnut sap, and Sago sap. However, the study did not account for other waste products such as different types of biowastes and tree sap. Thus, further investigation of these materials may be warranted given their potential as organic binders in manufacturing of particle boards.

The particle board industry may explore into the possibility of developing a specialized pressing machine with the capacity to produce a wide range of particle board products. This innovation is expected to enhance production efficiency and facilitate the creation of diverse particle board products to meet the ever-growing demand.

Further studies and observations are recommended to discover more approaches suited to advanced studies conducted in experimental or developmental research. Thus, it is also recommended to submit the product for (IPR) Intellectual Property Rights for the protection of the researcher's innovative ideas and routine purpose.

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