Coconana Fiberboard: Minimizing Banana Fiber and Coconut Husk Biomass Through Sustainable Product Development

Jeffrey B. Dionisio[1], Kian Christian M. Mendoza[1], Kyla Mae S.M. Artiaga[1], Patricia Gayle F. Cardeño[1], Erwin Ronald D. Calma[2], June C. Musngi[2]

[1]*Student, College of Engineering and Architecture – Industrial Engineering Department, University of the Assumption, City of San Fernando, Pampanga, Philippines*

[2]*Professor, College of Engineering and Architecture – Industrial and Civil Engineering Department, University of the Assumption, City of San Fernando, Pampanga, Philippines*

Corresponding Author: patricia.gayle.cardeno@gmail.com

Abstract— **This study aims to integrate sustainability into furniture production by using alternative raw materials like coconut husk and banana fiber. This strategy, known as "Greening the Supply Chain," focuses on efficient resource use, waste reduction, and eco-friendly manufacturing. The industry that this study focuses on is the furniture industry. It aims to develop an alternative raw material for wood as these finite resources have become much less accessible because of too much deforestation. To address these concerns, innovative approaches utilizing wastes from the agricultural by-products of the Philippines, such as banana fibers and coconut husks, have been explored in this study. These agricultural wastes are repurposed into a fiberboard in order to help minimize wastes and reduce the cutting down of trees. This study has made the three samples of fiberboard namely the Pure Coconut Husks, Pure Banana Fiber, and the Coconana Fiberboard using epoxy resin as the binding agent. As this is experimental research, the samples have gone through three (3) tests to determine the capabilities of each fiberboard sample. The water absorption rate, compressive strength, and the drop test by using the American Society for Testing Materials ASTM D3501-05a and ASTM D1037-12(2020). Among the three (3) tests the Coconana Fiberboard have produced successful results. These findings indicate that Coconana fiberboard holds promise as a sustainable alternative to wood in furniture production**.

Index Terms— **Sustainability, furniture production, alternative raw materials, coconut husk, banana fiber, greening the supply chain, fiberboard.**

1. Introduction

The urgent requirement for solving environmental concerns is driving an innovative trend in the furniture business towards eco-friendly and sustainable materials. The incorporation of alternative materials specifically, banana fiber and coconut husk into furniture design is the primary objective of this capstone project. There is an increasing need for sustainable alternatives that maintain a balance between practicality, elegance, and ecological responsibility as traditional resources become less accessible and awareness of the environment increases.

Usually considered to be agricultural waste, coconut husk and banana fiber give an unusual opportunity to make strong and eco-friendly furniture. We can lessen the negative effects of furniture developing and waste on the environment by recycling these available natural resources. The purpose of this capstone project is to examine if it is possible to use banana fiber and coconut husk as the main materials in furniture design and production, with a focus on the structural quality and reliability, visual attractiveness, and environmental advantages of these materials.

Utilizing existing waste is a significant concept when conducting research on environmental conservation. We can lessen waste and the damaging consequences of human activities on the environment by converting waste into usable items (Yang, 2022). Recycling waste products is crucial, according to (Maddodi, 2022), since it reduces greenhouse gas emissions, conserves natural resources, and reduces the quantity of waste that ends up in landfills and ecosystems. This is a practical way of minimizing production costs and energy use. In general, recycling waste is a vital strategy to create a more sustainable future. To address these concerns, innovative approaches utilizing wastes from the agricultural by-products, such as banana fibers and coconut husks, have been explored.

Drawing inspiration from the rich agricultural landscape of the Philippines, researchers identified banana fibers and coconut husks as abundant waste materials. Typically discarded after harvest and processing, these fibers and husks hold untapped potential for transforming into composite materials.

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In recent years, composite material has replaced conventional material like metal, wood etc. due to its lightweight, high strength to weight ratio and stiffness characteristics. Natural fibers such as coconut fiber, bamboo and banana plant fiber etc. It is low cost, easy availability and less harmful to human beings. (Kumar, S., Deka, K., & Suresh, P., 2016).

The concept of utilizing banana fibers and coconut husks to create fiberboard emerged as an innovative approach. By combining these natural fibers with appropriate binding agents, such as resin, researchers aimed to develop a sustainable alternative to traditional wood-based materials.

The concept revolves around repurposing agricultural waste into fiberboard—a versatile material suitable for various applications, including construction, furniture, and interior design. Banana fibers, known for their strength and flexibility, complement the structural integrity of coconut husks, resulting in a composite material with desirable properties.

Through this innovative approach, researchers sought to address environmental challenges while promoting economic opportunities for local communities. By creating value from agricultural waste, the study aims to contribute to sustainable development initiatives and reduce reliance on finite natural resources.

The vision of utilizing banana fibers and coconut husks for fiberboard production represents a paradigm shift in material sourcing and manufacturing processes. By harnessing the abundant resources available in the Philippines, researchers aspire to pave the way for a greener, more sustainable future in the construction and manufacturing industries.

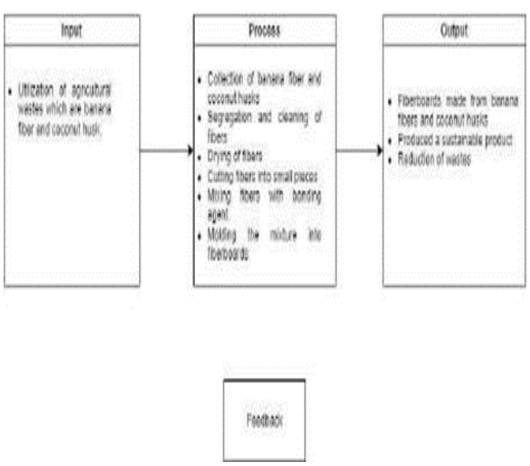

Fig.1. Conceptual Framework

Fiberboard, derived from innovative combinations of materials like coconut husk and banana fiber, offers numerous benefits across various industries, including furniture production. Its utilization presents a sustainable alternative to traditional wood-based products, significantly reducing reliance on deforestation and promoting environmental conservation.

2. Methodology

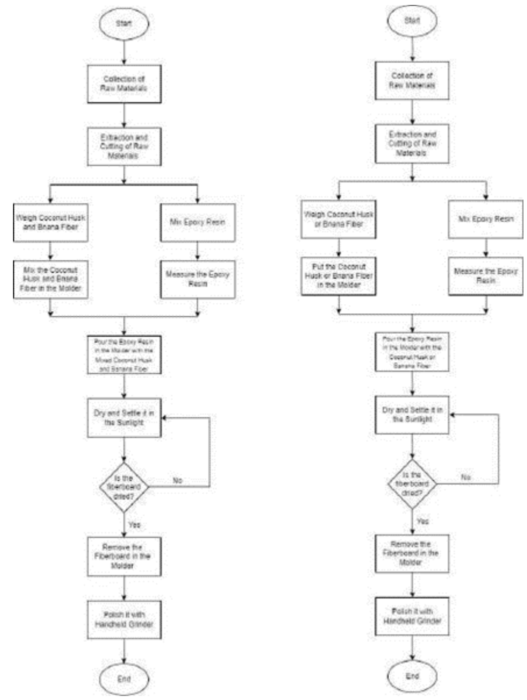

Fig.2. Process Flowchart

A. Formulation of Samples

In creating the sample product, coconut husks, banana fibers, and epoxy are the raw materials used. The table below shows the amount input for each sample.

Table.1.
Sample Ratio

Sample	Coconut Husk	Banana Fiber	Epoxy Resin
Mixed	10g	10g	313mL
Pure Coconut Husk	20g	-	313mL
Pure Banana Fiber	-	25g	313mL

B. Collection of Raw Materials

Collecting coconut husk and banana fiber, the coconut husks were obtained through a request from a friend, and banana fibers were obtained by cutting banana trees, as well as through a request from a friend.

Fig.3. Coconut husk and Banana pseudo-stem

C. Extraction and Cutting of Raw Materials

Using bare hands, the coconut husk is extracted to produce more fibrous. After the coconut husk is extracted, the fibers are then finely cut using scissors. Cut the banana pseudo-stem into chunks. Peel away each banana sheath. Then smash it with a mallet to break down the fibers. Soak it with water to remove the impurities. Lay them out to dry in the sun. After the banana pseudo-stem is extracted and dried, the fibers are then finely cut using scissors.

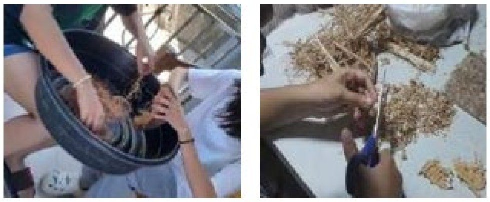

Fig.4. Extraction and cutting of coconut husk and banana pseudo-stem

D. Preparation of weighing and mixing

After the coconut husks and banana fiber has been prepared from extracting and cutting the fibers into small pieces. It was then put on a weighing scale to measure the amount of coconut husks and banana fibers needed in each sample. Once done with the fibers the next step is to mix the two solutions thoroughly which is the Epoxy Resin and the Epoxy hardener.

Fig.5. Weighing Raw Materials and Mixing Epoxy Resin and Hardener

E. Setting up of Raw materials

As this involves the creation of three (3) sample products, coconut husks and banana fibers are being placed in the three (3) molds. Two samples consist of Pure coconut husk and Banana fiber, while the third sample is a combination of the two, referred to as the Coconana fiberboard. Afterwards measure the mixed epoxy resin by using a measuring cup with an amount of 313 mL.

Fig.6. Putting the fibers into the molder

F. Pouring the mixed solution of resin epoxy in the molder

Pour the bonding agent into the molder after incorporating the coconut husk and banana fiber. Pour it around to ensure an even distribution.

Fig.7. Pouring the epoxy resin

G. Drying and Settling under the Sunlight

Leave the samples for about 48 hours and allow the fibers to absorb the epoxy resin. Let it dry under the sunlight.

Fig.8. Curing of Sample

H. Demolding the Fiberboard

The edges of the molder will be unfolded first by using the cutter. Using a flat screw and hammer, remove the fiberboard from the bottom of the molder.

Fig.9. Removing of fiberboard from the molder

I. Finishing Process

Using a hand-held grinder, polish the fiberboard so that the surface is smooth and even and the fiberboard is more pleasing to look at.

Fig.10. Polished Fiberboard Samples

3. Results And Discussions

A. Water Absorption Test

Table.2.
Results of Water Absorption Test

WATER ABSORPTION TEST			
Sample Identification	Pure Coconut Husk	Pure Banana Fiber	Mixed
Mass of Dry Sample (g.)	223.70	196.90	237.20
Mass after Immersion (g.)	235.10	200.60	238.80
Water Absorption %	5.1	1.9	0.7

The water absorption test gives an insight into the material's resistance to moisture, which is a major factor determining its durability and suitability for long term use in various environment.

This table shows the results of water absorption tests for Coconana Fiberboard components reveal promising properties in terms of water resistance. Pure coconut husk showed a water absorption rate of 5.1%, indicating low absorption and demonstrating good water resistance. Similarly, pure banana fiber exhibited very low absorption at 1.9%, showcasing excellent water resistance properties. For the mixed coconut husk and banana fiber fiberboard, the material also demonstrated very low absorption, indicating excellent water resistance overall. These findings suggest that Coconana Fiberboard has the potential to withstand exposure to moisture and humidity effectively, making it suitable for various indoor and outdoor applications where water resistance is needed.

B. Compressive Strength Test

Table.3.
Results of Compressive Strength Test

COMPRESSIVE STRENGTH TEST	
Fiberboard Type	
Coconut Husk	19.69 N/mm^2
Banana Fiber	14.32 N/mm^2
Mixed	25.08 N/mm^2

Compressive testing demonstrates how the material reacts when compressed. Compression testing can determine a material's behavior or response to crushing pressure.

This table shows the results of the compressive strength tests, which reveal the strength of Cococnana Fiberboard components under pressure.

Coconut husk exhibited a commendable compressive strength of 19.69 N/mm2.

Similarly, banana fiber demonstrated a respectable compressive strength of 14.32 N/mm2, showcasing its resilience to compression. Notably, the mixed Coconana Fiberboard, combining both coconut husk and banana fiber, displayed an impressive compressive strength of 25.08 N/mm2, surpassing the other strengths of pure coconut husk or banana fiber in its components.

The researchers had nine (9) sample fiberboards that underwent a compressive strength test at the University of Assumption. To establish the average compressive strength of the material, multiple trials were conducted. The sample that has the highest average compressive strength which can withstand greater compressive forces is the Mixed Sample (25.08 N/mm2). Followed by the Pure Coconut Husk (19.96 N/mm2), while the Pure Banana fiber (14.32 N/mm2) has the least average compressive strength. The compressive strength results inform material choices for the furniture industry, ensuring durable and reliable in the furniture industry.

C. Drop Test

Fig.11.Image of the Coconana Fiberboard after subjecting to drop test

Conducting a drop test involves subjecting a product or material to controlled impacts from varying heights to assess its resilience and durability. This test helps evaluate how well the fiberboard withstands impact forces and whether it can endure accidental drops or shocks during normal use. The researchers have conducted three (3) trials of drop tests per fiberboard sample from a 1.5 meters height. The three (3) samples which are the Pure Coconut Husk, Pure Banana Fiber, and Mixed all have successfully passed and withstood the certain height without breaking or getting damaged.

The successful outcome of the three (3) conducted tests indicate the feasibility of utilizing agricultural wastes, specifically coconut husk and banana fibers to produce valuable products like Coconana Fiberboard. This innovative approach promotes the use of sustainable alternative raw materials in furniture manufacturing, contributing to resource conservation and environmental protection. Additionally, the production of fiberboard helps reduce agricultural wastes and mitigates deforestation, further emphasizing its positive impact on sustainability and ecosystem preservation.

4. Estimated Costs in The Coconana Fiberboard Production

In this section, the researchers have provided computation on the estimated pricing for the Coconana Fiberboard. The various factors considered are the material costs, equipment costs, labor costs, and overhead costs of the Coconana Fiberboard production. By thoroughly examining these factors, manufacturers can develop a pricing plan that highlights the benefits of Coconana Fiberboard and ensures it stays profitable and appealing in the market.

Computation:

Given that Resin Epoxy (1.5 Liter) = ₱960

$$\textit{Cost of Epoxy Resin per mL} = \frac{₱960}{1.5\,L} \times \frac{1\,L}{1000\,mL} = ₱\,0.64/mL$$

Volume = Length x Width x Thickness

Volume = 10 cm x 10 cm x 2 cm = 200 cm^3 requires 313mL of Epoxy Resin

Volume = 10 cm x 10 cm x 1 cm = 100 cm^3 requires 156.5mL of Epoxy Resin

Volume = 10 cm x 10 cm x 0.5 cm = 50 cm^3 requires 78.25mL of Epoxy Resin

Table.4.
Estimated Prices of Coconana Fiberboard by Dimensions

Dimension			Volume	Output	Price per piece
Length (cm)	Width (cm)	Thickness (cm)			
10	10	2	200 cm^3	6 pieces/bottle	₱ 200.32/piece
10	10	1	100 cm^3	12 pieces/bottle	₱ 100.16 /piece
10	10	0.5	50 cm^3	24 pieces/bottle	₱ 50.08 /piece

The list above are the following estimated prices of Coconana Fiberboard that are according to their dimensions. The final product that the researchers have produced are in the first row which is the (10cm x 10cm x 2cm) that costs 200.32 pesos per piece. The corresponding rows below it have a decrease in thickness which means the output is thinner than the previous one and along with it costs more cheaper than the previous and can generate more pieces of samples or product.

Table.5.
Material Costs

Material Cost			
Item	Unit Cost	Quantity	Amount
Coconut Husk	-	60 grams	-
Banana Fiber	-	70 grams	-
Epoxy Resin	₱ 960	1.5 Liter	₱960
		Total Cost	₱960

In material costs shown above, are the following raw materials that have been used in the production to be able to produce 6 samples with a dimension of (10cm x 10cm x 2cm). The coconut husks and banana fibers don't have a cost as these are wastes that are abandoned or discarded agriculture.

Table.6.
Equipment Costs

Equipment Cost			
Item	Unit Cost	Quantity	Amount
Cutter	₱ 34	1	₱34
Flat Screw	₱ 24	1	₱24
Hammer	₱ 75	1	₱ 75
Handheld Grinder	₱ 384	1	₱384
Kitchen Scale	₱ 105	1	₱105
Measuring Cups	₱ 35	1	₱35
Molder (CORRUGATED SHEET)	₱ 80	1	₱80
Scissors	₱ 19	2	₱38
		Total Cost	₱ 775

The following equipment listed above that has been used in the Coconana Fiberboard production are all available at the researchers' homes. But here is the list of prices per equipment if there is a need for purchase or as a start-up of the business.

Table.7.
Labor Costs

Labor Cost				
Position	Rate	Manpower	Working days	Amount
Banana Fiber cutter	₱400	1	20	₱8,000
Coconut Husk cutter	₱400	1	20	₱8,000
Fiber and Epoxy Mixer	₱400	1	20	₱8,000
Molding Operator	₱400	1	20	₱8,000
			Total Cost	₱32,000

In the labor cost analysis, the researchers estimated the salary for production workers to be 400 pesos. The following workers in the fiberboard production work eight (8) hours a day on weekdays.

Table.8.
Overhead Costs

Overhead Cost		
Estimated Utility Expenses		
Utilities	Monthly (20 days)	Yearly (12 Months)
Electricity Bill	₱ 4, 000.00 ₱200/day	₱ 48, 000.00
	Total Cost	₱ 48, 000.00

In the overhead cost, the researchers only acquired expenses for electricity when using a hand-held grinder. By using a grinder, it improves the appearance and smoothens the surface of the fiberboard.

5. Conclusion

In conclusion, this study aimed to investigate the properties and potential applications of Coconana Fiberboard. Through experimentation and analysis, the researchers have identified promising results for the Coconana Fiberboard, specifically by conducting three tests: the water absorption test, compressive strength test, and drop test. These findings suggest the potential of Coconana Fiberboard for use in the furniture industry.

Among the three samples tested: Pure Coconut Husk, Pure Banana Fiber, and Mixed Coconana Fiberboard—the last showed superior results in both the water absorption test, compressive strength test and drop test. Water absorption test with a percentage of 0.7 which falls within the range of 0% to 5%. This indicates that it has a very low absorption demonstrating excellent water resistance. The compressive strength test yielded the highest average compressive strength of 25.08 N/mm^2. Lastly, the drop tests which along with the two more samples have successfully passed and withstood the 1.5 meters height without breaking or getting damaged. These findings offer valuable insights into the product's suitability for various furniture manufacturing processes.

In addition to exploring the capabilities of Coconana Fiberboard through three (3) tests in the study. The researchers have conducted a survey to assess the perception and acceptance of making fiberboard using alternative raw materials in the local community. They employed structured surveys and feedback methods.

The survey provides valuable insights into the demographics, awareness, and perceptions regarding Coconana Fiberboard among respondents. The majority of respondents are young professionals, predominantly male, with varying degrees of experience in the furniture industry. While there is a notable level of unfamiliarity with Coconana Fiberboard, there is also significant support for its environmental sustainability benefits and recognition of its potential in fiberboard production.

The survey underscores the importance of raising awareness and educating individuals about Coconana Fiberboard and its production process. Despite some concerns about quality and durability, there is an overall interest in using Coconana Fiberboard for construction or furniture purposes, with a willingness to pay a premium for sustainable products. Respondents highlighted areas for improvement in Coconana Fiberboard, including enhancing strength, durability, quality assurance, aesthetics, and cost competitiveness. They recommended exploring alternative fibers and refining production techniques to address these concerns and leverage the potential of Coconana Fiberboard as a sustainable alternative to traditional wood-based fiberboards.

Despite concerns, respondents recognized its potential to promote livelihoods and viewed it as an innovative and sustainable material. They provided valuable feedback for further research and development, emphasizing the importance of durability, aesthetics, and cost-effectiveness. Overall, respondents praised Coconana Fiberboard and anticipated its future developments in its utilization and production.

On the other hand of the contributed valuable insights, it is essential to acknowledge its limitations, including constraints on time and budget for further research and testing.

Moving forward, future research should focus on extending the testing period to explore the full potential of Coconana Fiberboard, experimenting with alternative binding agents, fibers, and additives to enhance its quality.

In summary, this study highlights the potential of Coconana Fiberboard as an environmentally friendly alternative to wood in furniture manufacturing. With further research and improvements, Coconana Fiberboard could significantly reduce the environmental impact of furniture production by repurposing agricultural waste materials such as coconut husks and banana fibers.

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