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Development of Pinboard Using Eggshells and Ricebran

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Index Terms:

eggshells, rice bran, pinboard fabrication, recycled composite materials, solid waste utilization

Abstract. The growing demand for sustainable waste management practices has prompted researchers to explore alternative uses for agricultural and food processing wastes. This study aimed to develop and evaluate an eco-friendly pinboard fabricated from eggshells and rice bran bonded with cornstarch adhesive. Specifically, the study investigated the physical and mechanical properties of the fabricated pinboards with different proportions of eggshells, rice bran, and adhesive. The study employed an experimental research design with a 3 × 3 factorial arrangement, yielding 9 treatment combinations with 4 replications each. Eggshells were cleaned, dried, pulverized, and mixed with rice bran and cornstarch adhesive according to the designated treatment ratios. The mixtures were molded and cured under sunlight before undergoing 1 physical and mechanical testing. Physical characteristics such as texture and hardness were evaluated using a modi ed hedonic rating scale. At the same time, the mechanical property, Modulus of Rupture (MOR), was tested using a Universal Testing Machine (UTM). Results revealed that treatment 9, consisting of 25% eggshells, 75% rice bran, and 40% cornstarch adhesive, produced the most acceptable pinboard in terms of texture, hardness, and bending strength. Analysis of Variance (ANOVA) showed a signi cant difference among treatments ($p = 0.001$), indicating that the treatment combinations signicantly influenced the mechanical properties of the fabricated pinboards. The findings demonstrate that eggshells and rice bran can serve as sustainable alternatives for producing affordable, environmentally friendly pinboards.

Introduction

The pinboard is very useful in many ways. It is used in offices, schools, and even in public places. Pinboards are also helpful as bulletin boards for posting reminders or notifications. The corkboard, also called a pinboard, is a framed section backed with wood or plastic. They are typically used in facilities where information needs to be visible to everyone. These useful products were first commercialized in 1924 by none other than George Brooks of Topeka, Kansas. Because of its durability and resilience, cork is a common raw material for making pinboards. It comes in a variety of sizes, and if it is well cared for, it may last for several years. A simple yet very purposeful object: layer and mold it into its subtle form, then mix it with wood glue. For instance, the pinboard or bulletin boards proved to be a valuable forum for personal opinions, actionable suggestions, concrete information, and emotional support. (Suzuki & Calzo, 2004). Eggs have always been part of our everyday lives, most notably at mealtime. People often ignore what remains in their eggs after eating them, unaware of the materials that can be obtained from discarded eggshells. The food processing industry, in particular, generates large amounts of eggshell waste worldwide. Eggshells are waste products from hatcheries, homes, and fast food industries (Phil & Zhihong, 2009) that can be readily collected in abundance. Eggshells are known to have excellent strength characteristics when mixed with concrete. Calcium-rich eggshell is a poultry waste with 55 chemical composition nearly the same as limestone (Amu., Fajobi, & Oke, B 2005). Besides, its chemical composition is almost similar to that of ordinary Portland types of cement (Gajjar & Zala,2018) Rice is an essential cereal product in Asia and is an overwhelming staple food in most populations of this region. They have spread across more than 100 countries, and around 18,000 varieties account for about 25% of the grain production. The prominent rice-producing continents are Asia, Africa, and America. Milling of paddy yields 70% of rice (endosperm) as the primary product and by-products consisting of 20% rice husk, 8% rice bran, and 2% rice germ. The brownish portion of rice, which is removed in ne grain form during de-husking

and milling of paddy, is rice bran. The bran is usually the hard outer layer of rice, consisting of aleurone and pericarp (Nagendra Prasad, Sanjay, Shravya, Vismaya, & Nanjunda, 2011). Rice bran, or the brown outer layer of the rice kernel, is mainly comprised of the pericarp, aleuron, subaleuron layer, and germ. It contains substantial amounts of nutrients, such as protein, fat, and dietary ber. Furthermore, it provides a substantial amount of minerals like K, Ca, Mg, and Fe. The presence of antioxidants like tocopherols, tocotrienols, and γ- oryzanol also brightens prospects of rice bran utilization for humans (Gong et al., 2001) These waste materials can be used to produce other products that will be beneficial in various areas. Several types of research are being conducted to achieve the objective of using eggshells and rice bran, thereby minimizing their disposal to garbage sites. It also has a significant impact on solid waste management, as it can reduce waste by promoting its use. However, the fabrication of pinboards made from eggshells and rice bran has not yet been realized.

Specifically, this alternative pinboard will also have the same purpose as the commercialized one. This study aims to conceptualize technology development on the pinboard using waste materials such as eggshells and rice bran. Similar to eggshells, rice bran, and many other waste materials, these can be recycled and reused to create a sustainable environment. The reformation of eggshells and rice bran from industries is an efficient and cost-effective way to reduce waste disposal and prevent severe environmental pollution. Speci cally, this study addresses the following research questions: This study aims to develop the process of making pinboards using the combination of eggshells and rice bran mixture. For a complete understanding of the study, this specifically aims to:

1. Design and fabricate a pinboard made from eggshells and rice bran;
2. Determine the physical characteristics of the pinboard of the different treatments of eggshells and rice bran added with adhesive materials in terms 1 of texture and hardness;
3. Determine the mechanical characteristics of the pinboard of the different treatments of eggshells and rice bran added with adhesive materials in terms of modulus of rupture.
4. Determine if there is a significant effect on the physical and mechanical characteristics of the pinboard of the different treatment properties of the eggshells and rice bran.

Framework of the Study

This is the study's framework: the input is eggshells, and the material is rice bran collected from rice mills and bakery shops. The process of developing the fabricated pinboards will involve different treatments/proportions of eggshells, rice bran, and the adhesive material. The output will be the products fabricated on the pin board, which will be evaluated for their physical and mechanical characteristics.

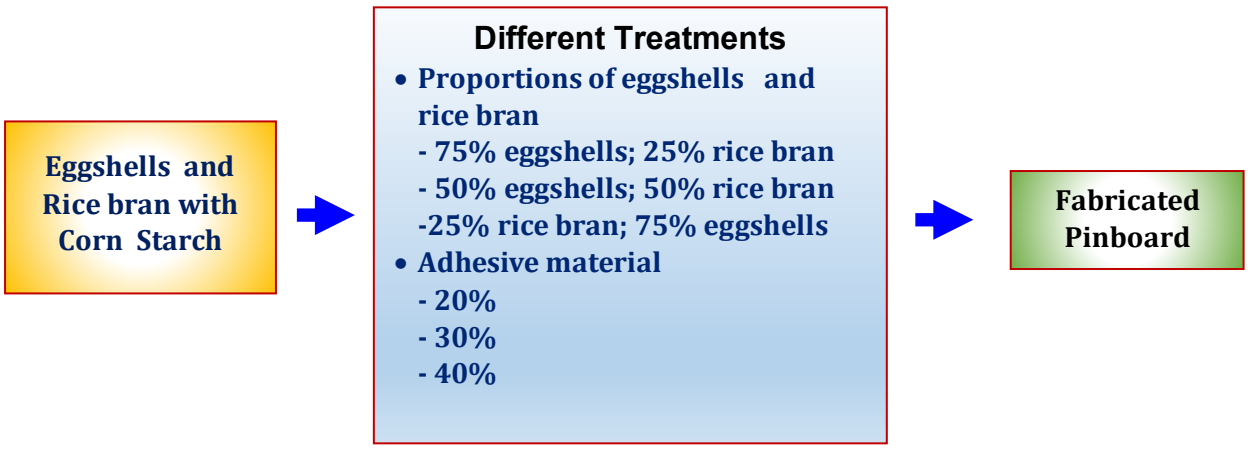

Figure 1. Integrated Framework for Pinboard

Methodology

Research Design

The study used an experimental research design. It was used to assess the 10 effectiveness of eggshells and rice bran with cornstarch adhesive in fabricating commercialized pinboards. There are several methods for testing the physical and mechanical properties of the fabricated pinboards.

Research Locale

The research was conducted at Maria Soccoro, San Isidro, Saint Bernard, Southern Leyte, in the vacant area of Catindoy's Residence. There are nine treatments in this study to select the best treatment. The research target duration is until the pinboards are cured and ready to be tested by their mechanical and physical characteristics. The physical characteristics were tested at Liloan TechVoch school while for the mechanical testing accurately to test its bending strength using the Universal Testing Machine (UTM) is at Maasin City, particularly the Department of Public Works and Highways (DPWH)

Experimental Treatments

The experimental designed used in the study is a 3x3 factorial design because there are three eggshells, a rice bran ratio, and three proportion of adhesive materials.

Adhesive Materials (%)	***Eggshells and Rice Bran Ratio***			
		75:25	*50:50*	*25:75*
	20	T_1	T_4	T_7
	30	T_2	T_5	T_8
	40	T_3	T_6	T_9

Legend: T1 = 75% egg shells; 25% rice bran; 20% corn starch ,T2 = 75% egg shells; 25% rice bran; 30% corn starch ,T3 = 75% egg shells; 25% rice bran; 40% corn starch ,T4 = 50% egg shells; 50% rice bran; 20% corn starch ,T5 = 50% egg shells; 50% rice bran; 30% corn starch,T6 = 50% egg shells; 50% rice bran; 40% corn starch ,T7 = 25% egg shells; 75% rice bran; 20% corn starch ,T8 = 25% egg shells; 75% rice bran; 30% corn starch ,T9 = 25% egg shells; 75% rice bran; 40% cornstarch

Table 1. Experimental design of the different treatments.

The experimental design and layout of the experiments is shown in Table 1. There will be nine treatments with four replications in each treatment with a total of 36 specimens.

Research Respondents

The target respondents of the study were the teachers of Liloan Technical Vocation High School from the Industrial Arts department, which primarily teaches this to help them produce eco-friendly materials without paying a large amount of money. The sampling procedure used a Complete Randomized Design (CRD) to enable random placement of the several replications of the different treatments. The different treatments were randomly assigned to ensure that the effects of factors that may affect the physical and mechanical characteristics of the pinboard are controlled

Data Gathering Procedure

Eggshells were collected, washed thoroughly, dried in the sunlight, and crushed into powder form. Rice bran was collected from local rice mills and dried before utilization. The adhesive material was prepared and mixed with the powdered eggshells and rice bran according to the designated treatment proportions. The mixtures were molded using a custom

wooden mold and cured in sunlight until fully hardened. After curing, the fabricated pinboards were subjected to physical and mechanical testing

Research Instrument

The data-gathering procedure in this study is the level of acceptability, using the modified hedonic rating scale. The respondents have been given an evaluation form to indicate their preferences for physical parameters such as 1 hardness and texture. At the same time, rupture testing was conducted using a Universal Testing Machine (UTM) to determine the rupture modulus and rupture strength of the fabricated pinboards and to determine the best treatment during pinboard fabrication. In gathering the crucial data for this study, there are different ways to obtain tangible results using the chosen instrument. The teachers who are the respondents in this study assess the physical parameters of the pinboard by touching and feeling it, and choosing between the two indicators, texture and hardness, and randomly choosing their preference based on the given description and acceptability of the particular treatment of the fabricated pinboard. While the mechanical strength results from the Universal Testing Machine (UTM), this test was performed; moreover, the Modulus of Rupture (MOR) test determines the degree of rupture or tearing strength of the fabricated pinboard.

Statistical Analysis Procedure

The study focuses on the development of the Pinboard using Eggshells and Rice Bran. There are 9 treatments with 4 replications, for a total of 36 specimens. They are divided into three proportions of the materials. The collected data were analyzed using a two-way ANOVA to test the physical 1 characteristic, specifically the texture and hardness. In contrast, the mode was used to measure the mechanical characteristics, specifically the rupture test or the modulus rupture of the pinboard. On the other hand, it was used to evaluate whether there is a significant difference in the mechanical properties of the pinboard across the different treatments.

Ethical Consideration

This study was conducted in strict adherence to the ethical principles governing research involving human participants. Before data collection, informed consent was obtained from all respondents, who were clearly informed of the study's purpose, their voluntary participation, and their right to withdraw at any time without consequences. To protect participants' privacy and confidentiality, no personally identifiable information was collected; all data were recorded and reported in aggregate to ensure anonymity.

Results and Discussion

The fabricated pinboard with the different treatments is shown in Figure 2. Eggshell powder can replace cement in concrete, according to Gowsika, Sarankokila, and Sargunan (2014). This study uses eggshells to identify specifically physical characteristics, such as texture

Physical Properties of the fabricated Pin board

Figure 2: Different treatments of the fabricated Pinboard

Figure 2 shows the different fabricated pinboards with different proportions of rice bran, eggshells, and adhesive materials. Through keen observation during and after the fabrication process, from the collection of materials to the final curing, the researcher found that different ratios or proportions of materials and adhesive had a significant impact on the finished boards. Treatments 1, 2, and 3 in the texture mode had a rough texture and good acceptability, whereas in the hardness mode, they were very hard and also had good acceptability. In contrast, treatments 4, 5, and 6 had a smooth texture and good acceptability in the texture mode, while in the hardness mode, they had slightly hard 1,14 characteristics. Lastly, in treatments 7, 8, and 9, in the mode of texture, the 1 14 texture is smooth and very good, while in the mode of hardness, the treatments are slightly hard and have very good acceptability. Thus, treatments 7, 8, and 9 were selected as the best pin boards among the other treatments. From the 15 1 respondent's perspective, the modal result showed that Texture described the 2 pinboard in treatments 4, 6, 7, 8, and 9 as smooth, and in treatments 2, 3, and 5 as rough, and only one teacher described treatment 1 as spongy. At the same 2 time, the acceptability measures for the pinboard showed that respondents' 16 treatment was 8, meaning 9 as very good. Furthermore, the majority of the 17 respondents chose treatments 1, 3, 4, 5, 6, and 7 as good, and only two teachers chose treatments 7 and 8 as fair. In the hardness mode, most respondents describe the pinboard in treatments 3, 4, 5, 8, and 9 as slightly hard. Three of the teachers describe treatments 1, 2, and 3 as very hard, and two describe treatments 7 and 8 as soft. While in acceptability measures of the pinboard, the majority of the teachers chose treatment 1, treatment 2, treatment 3, treatment 4, treatment 6, and treatment 9 as very good, and treatment 3, treatment 4, treatment 5, and treatment 6 as good, and treatment 3, treatment 5, treatment 7, and treatment 8 as fair. Among the treatments of the pinboard for its physical characteristics, treatment 9, consisting of 25% eggshells, 75% rice bran, and 40% cornstarch, has smooth and very good texture acceptability, as described by Barber and Benedito de Barber (1981). The texture of rice bran varies from ne, powdery to flaky, depending on the stabilization process. Moreover, because most of the rice bran was added to the treatment, the pinboard had a fine, smooth texture.

Treatment	Texture (Mode)		Hardness (Mode)	
	Description	Acceptability	Description	Acceptability
1	Spongy	Good	Very Hard	Very Good
2	Rough	Fair	Very Hard	Very Good Fair
3	Rough	Good	Slightly Hard Very Hard	Good Very Good
4	Smooth	Good Very Good	Slightly Hard	Good Very Good
5	Rough	Good	Slightly Hard	Good Fair
6	Smooth	Good	Slightly Hard	Good Very Good
7	Smooth	Good Fair	Soft	Fair
8	Smooth	Very Good Fair	Soft	Fair
9	Smooth	Very Good	Slightly Hard	Very Good

Table 3 Tabulated results of the Physical characteristics of the Pinboard

Mechanical Properties of the Fabricated Pinboard

Table 3 shows the tabulated data of the mechanical properties of the 2 fabricated pinboard based on the Modulus of Rupture. Mechanical testing using a Universal Testing Machine (UTM) clearly shows that the different treatments, with their replications, yield different MOR results. In treatment 1, the minimum value is 300 MPa, while the maximum is 400 MPa. For treatment 2, the minimum and maximum values are 300 MPa and 9150 MPa, respectively. For treatment 3, the minimum and maximum values are 280 MPa and 9000 MPa, respectively. For treatment 4, the minimum and maximum values are 280 MPa and 9000 MPa, respectively. For treatments 5 to 9, the minimum and maximum values are too close. For Treatment 5, the minimum and maximum values are 8,450 MPa and 9,150 MPa, respectively. For treatment 6, the minimum and maximum values are 9,050 MPa and 9,150 MPa, respectively. For treatment 7, the minimum and maximum values are 8,900 MPa and 9,200 MPa, respectively. For treatment 8, the minimum and maximum values are 9,000 MPa and 10,100 MPa, respectively. Finally, for treatment 9, the minimum and maximum values are 8,900 MPa and 9,100 MPa, respectively.

Treatments	Replications	Modulus Rupture	
		Average Value of MPa	
1	1	350	350.0000
	2	300	
	3	350	
	4	400	
2	1	9150	2662.5000
	2	300	
	3	900	
	4	300	
3	1	8400	6507.5000
	2	8350	
	3	9000	
	4	280	
4	1	9000	6807.5000
	2	9000	
	3	280	
	4	8950	
5	1	9050	8950.0000
	2	8450	
	3	9150	
	4	9150	
6	1	9100	9075.0000
	2	9050	
	3	9050	
	4	9100	
7	1	9150	9087.5000
	2	9200	
	3	8900	
	4	9100	
8	1	9000	7062.5000
	2	9150	
	3	NO RESULT	
	4	10100	
9	1	8900	9037.5000
	2	9100	
	3	9100	
	4	9050	

Table 4. Consolidated Result of the different treatments' modulus rupture tested by the Universal Testing Machine

Table 4 shows that group A treatments consisting of treatments 1, 2,3, 4, and 8 have almost the same MOR values, while group B treatments consisting of treatments 2, 3,4,6,7,8, and 9 also have almost same MOR values. Therefore, the MOR

values of Group A treatments and Group B treatments differs significantly. It shows that the presence of the eggshell powder gave more strength which has higher MOR values of the fabricated pinboard as also emphasized in the study of Yerramala et al. (2010). It showed that at 5% eggshell powder replacement, the strength was higher than control concretes and indicated that 5% eggshell powder is an optimum content for full strength.

Treatment	N	Subset for alpha = 0.05	
		1*	2**
1	4	350.0000	
2	4	2662.5000	2662.5000
3	4	6507.5000	6507.5000
4	4	6807.5000	6807.5000
8	4	7062.5000	7062.5000
5	4		8950.0000
9	**4**		**9037.5000**
6	4		9075.0000
7	4		9087.5000
Sig.		.067	.090

**Group A; **Group B*

Table 5: Tabulated results on the Mechanical Characteristics (rupture values) of the fabricated Pin Boards

Based on the Analysis of Variance (ANOVA) between treatments, the computed p-value is 0.001 which is lower than the acceptance level of 0.05. (Table 6). This means that there is significant difference of the Modulus of Rupture (MOR) between the different treatments. Thus, the null hypothesis is rejected.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	314427738.889	8	39303467.361	4.559	.001
Within Groups	232783350.000	27	8621605.556		
Total	**547211088.889**	**35**			

Table 6: The Analysis of Variance between treatments

Findings of the Study

Based on the results gathered and analyzed in the study, the following findings were obtained:
1. The fabricated pinboards made from eggshells, rice bran, and cornstarch adhesive were successfully developed using different treatment combinations.
2. The different proportions of eggshells, rice bran, and adhesive materials signifiantly affected the physical characteristics of the fabricated pinboards, including texture and hardness.
3. Treatments 7, 8, and 9, which contained higher proportions of rice bran, exhibited smoother textures and higher acceptability ratings than the other treatments.
4. Treatments 1, 2, and 3, which contained higher proportions of eggshells, were observed to have harder surfaces and greater rigidity.
5. Treatment 9, consisting of 25% eggshells, 75% rice bran, and 40% adhesive material, had the highest acceptability for texture and hardness among all treatments.
6. Mechanical testing using a Universal Testing Machine (UTM) revealed that the fabricated pinboards exhibited varying Modulus of Rupture (MOR) values depending on the treatment combinations.

7. Treatment 9 produced one of the highest Modulus of Rupture (MOR) values, indicating better bending strength and durability compared to the other treatments.
8. The Analysis of Variance (ANOVA) showed a p-value of 0.001, which is lower than the 0.05 level of signi cance, indicating a significant difference among treatments in mechanical characteristics.
9. The study established that eggshells and rice bran can be used as alternative raw materials for the fabrication of eco-friendly, affordable pinboards.
10. The use of eggshells and rice bran contributed to waste reduction and promoted environmental

Conclusion and Recommendations

Based on the study's ndings, the fabricated pinboard made from eggshells and rice bran, bonded with a cornstarch adhesive, was successfully developed and evaluated for its physical and mechanical characteristics. The results revealed that the different treatment combinations signi cantly affected the 1 texture, hardness, and Modulus of Rupture (MOR) of the fabricated pinboards. Among all treatments, Treatment 9, consisting of 25% eggshells, 75% rice bran, 15 and 40% adhesive material, produced the most acceptable result in terms of 1 texture, hardness, and mechanical strength. The study con rmed that eggshells and rice bran can be effectively utilized as alternative materials in the fabrication of environmentally friendly and affordable pinboards. The findings imply that agricultural and food-processing waste materials possess significant potential for technology development and sustainable product innovation. Furthermore, the utilization of these waste materials contributes to proper solid waste management, environmental conservation, and resource sustainability through recycling and reuse practices. The study also suggests that schools, of offices, and communities may benefit from the development of low-cost, eco-friendly materials that serve practical purposes while minimizing environmental pollution. Moreover, the findings may encourage future researchers and product developers to explore further the use of waste materials in creating sustainable, commercially viable products.

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Competing Interests Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study; all data used were obtained from previously published sources as cited in the reference list.

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Appendices

No appendices are attached to this study.