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Valorization of Cabbage Waste *(Brassica oleracea)* Waste and Discarded Molded Pulp Egg Trays into Eco-Fiberboards Enhanced with Banana *(Musa acuminata x balbasiana)* Peel Waste as Bio-Coating

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Abstract— *This study explores the valorization of agricultural and paper-based wastes into eco-friendly fiberboards by utilizing cabbage (Brassica oleracea) residues, discarded molded pulp egg trays and banana (Musa acuminata x balbasiana) peel waste as bio-coating. Four experimental treatments (FB1, FB2, FB3 and FBc) with (FB1- 60% pulp egg trays, FB2- 40% cabbage fibers, FB3- 70% pulp egg trays, 30% cabbage fibers, 80% pulp egg trays, 20% cabbage fibers and FBc- 100% pulp egg trays), were fabricated and evaluated in terms of physical, mechanical and durability properties. In physical testing, significant differences were observed in density (Kruskal–Wallis,* $p < 0.001$*), where FB1 exhibited the highest mean density of 740 kg/m³. Water absorption also showed significant variation (Kruskal Walis,* $p < 0.001$*), with FB1 having the lowest absorption at 146% exceeding standard limits. However, thickness swelling showed no significant difference (ANOVA,* $p = 0.058$*), all treatments with values ranging from 6.57% to 10.28%, remaining within acceptable limits. In mechanical testing, FB1 demonstrated the highest modulus of rupture (MOR) of 2.35 MPa with statistical analysis confirming significant differences among treatments (ANOVA,* $p < 0.001$*). Despite this, all treatments fell below the standard requirement for commercial boards. In durability and safety evaluation, FB1 exhibited better fire resistance, characterized by slower flame spread and reduced ignition intensity, while also showing higher biodegradability compared to other treatments. Compared to commercial MDF, the developed boards showed improved environmental performance but lower mechanical strength and moisture resistance. Overall, FB1 showed the best balance of stability, strength and durability. To further improve the performance and reliability of the eco-fiberboards, optimization of fiber composition, pressing methods, and thermal treatment is recommended to enhance their mechanical, dimensional, and durability properties.*

Keywords—*Biodegradable fiberboard, commercial medium-density fiberboard (MDF), FB1, FB2, FB3, FBc, Cabbage waste, Molded pulp egg trays, Banana peel biocoating, Agro-waste utilization, Green composites, Sustainable materials, Fiberboard fabrication, Density, Water Absorption, Thickness swelling, Modulus of rupture, Fire Resistance and biodegradability.*

I. INTRODUCTION

The increasing generation of agricultural waste poses significant environmental and sustainability challenges worldwide. Agricultural residues are often burned, dumped, or landfilled, contributing to pollution and resource loss (Iqbal et al., 2019). Among these wastes, cabbage residues are rich in cellulose, hemicellulose, lignin, and pectin, making them suitable raw materials for sustainable composite materials (Manzano et al., 2024; Rani & Kawatra, 2020).

Similarly, discarded molded pulp egg trays contribute to municipal solid waste but possess valuable cellulosic fibers that can be repurposed into eco-friendly products. Advances in molded pulp technology have further improved the quality and efficiency of recycled fiber materials, supporting their use as sustainable alternatives to conventional wood-based products (Semple et al., 2022). Banana peels, another abundant agricultural waste, contain starch and pectin that provide excellent film-forming properties, making them suitable as natural biocoatings for biodegradable materials (Athanasopoulou et al., 2025).

This study evaluates the physical properties (density, water absorption, thickness swelling), mechanical strength (modulus of rupture), and durability (fire resistance and biodegradability) of the fiberboards and use varying proportions of cabbage waste and molded pulp egg trays, apply banana peel-based biocoating, and assess their potential as sustainable alternatives to conventional fiberboards. By converting agricultural and household wastes into value-added products, this research promotes waste valorization, reduces environmental impacts, and supports the development of affordable, biodegradable materials for applications in packaging, crafts, and lightweight construction. The investigation is limited to laboratory-scale production using locally available materials and excludes large-scale manufacturing, cost analysis, and long-term industrial performance.

II. METHODOLOGY

2.1 Data Gathering

The data were be obtained through peer-reviewed journals, scientific articles, and technical reports accessed from online databases, which discussed the recycling and valorization of cabbage waste, recycled paper products such as egg trays, and the application of natural binders and coatings. Additional information was obtained through observations of local waste management and fiberboard production practices.

2.2 Research Design

This study employed a mixed-method experimental design to evaluate the effects of fiber composition and banana peel biocoating on the physical and mechanical properties of eco-fiberboards. Fiberboards with a total weight of 80 g were fabricated using different ratios of cabbage waste and egg tray pulp: FB1 (32:48 g), FB2 (24:56 g), FB3 (16:64 g), and FBc (0:80 g). The formulations were based on previous studies demonstrating that egg tray fibers provide effective bonding, while cabbage waste enhances cellulose content as a supplementary fiber source (MDPI, 2023; E3S Conference, 2018). These fiberboards were then prepared for subsequent physical and mechanical testing.

TABLE I. Number of Experimental Setups to Be Produced

Testing Methods	Treatment 1 (40%, 60%)	Treatment 2 (30%, 70%)	Treatment 3 (20%, 80%)	Control Treatment (0%,100%)
I.Physical Test				
Density	10 replicates	10 replicates	10 replicates	10 replicates
Water Absorption	10 replicates	10 replicates	10 replicates	10 replicates
Thickness Swelling	10 replicates	10 replicates	10 replicates	10 replicates
II. Mechanical Test				
Modulus of Rupture	10 replicates	10 replicates	10 replicates	10 replicates
III. Durability and Safety Properties				
Fire Resistance	10 replicates	10 replicates	10 replicates	10 replicates
Biodegradability	10 replicates	10 replicates	10 replicates	10 replicates

The fiberboard production process was repeated for four treatment groups—FB1, FB2, FB3, and the control (FBc)—with each specimen weighing 80 g. Each treatment was replicated ten (10) times to ensure the reliability and consistency of the results, while the banana peel biocoating was applied uniformly to all designated samples. The fabricated fiberboards were then evaluated for physical properties (dimensions, density, water absorption, and thickness swelling), mechanical properties, and durability and safety properties, including fire resistance and biodegradability.

2.3 Research Locale

The DIY tests were conducted at the researcher's residence on Barangay Zone 1, Varela Street, Zamboanga City as well as the flexural strength performed by DIY set ups that still ensured accuracy and reliability in results.

2.4 Fabrication of Mold

The testing molds were constructed with standard dimensions of 150 mm × 150 mm and a thickness of 10 mm, suitable for fiberboard evaluation. 20 Molders were fabricated at Telompros Welding Services, Putik, Zamboanga City. Figure 3.1 presents the detailed representation (150 mm x 150 mm x 10 mm) of the steel mold to be used for specimen testing. Figure 3.2 shows the actual steel mold (150 mm x 150 mm x 10 mm) utilized for fiberboards fabrication.

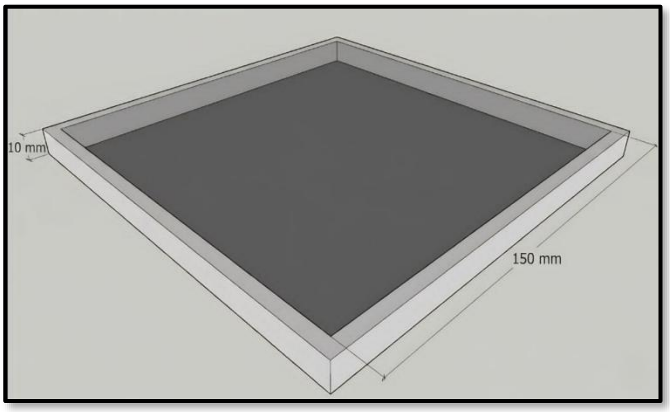

Fig. 1. Dimension of Steel Mold Utilized for Fiberboards Fabrication.

Fig. 2. Actual Steel Mold Utilized for Fiberboards Fabrication.

2.5 Mixing Procedures

The prepared fibers derived from waste egg trays and cabbage waste were combined according to predetermined weight ratios: FB1: 40% cabbage: 60% egg tray, FB2: 30% cabbage: 70% egg tray, FB3: 20% cabbage: 80% egg tray, and FBc (Control): 0% cabbage: 100% egg tray. The fabricated fiberboards were prepared using varying weight ratios of cabbage waste and molded pulp egg trays, with each fiberboard specimen having a total weight of 80 g. The mixtures were proportioned according to the formulations shown below:

TABLE II. Eco-Fiberboards Treatments Proportion.

Treatment	Cabbage fiber waste volume *(m^3)*	Discarded Pulp egg trays volume *(m^3)*	Cabbage fiber waste mass *(g)*	Discarded Pulp egg trays mass *(g)*
FB1 (40%:60%)	0.000090 m^3	0.000135 m^3	32 g	48 g
FB2 (30%:70%)	0.0000675 m^3	0.0001575 m^3	24 g	56 g
FB3 (20%:80%)	0.000045 m^3	0.000180 m^3	16 g	64 g

These proportions were homogenized thoroughly to ensure consistent fiber distribution. The cassava starch binder, prepared as a 10% (w/v) gelatinized solution with citric acid incorporated at 3% of starch weight, was then added to the fiber mixtures. Blending continued until the binder is uniformly distributed, ensuring complete fiber wetting and adequate coating. The binder concentration was kept constant across all

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formulations, equivalent to 10% of the total fiber weight (80 g) per fiberboard sample, to maintain consistency during comparative testing.

2.6 Data Gathering Procedure

The raw materials used in the study—cabbage waste, discarded molded pulp egg trays, and banana peels were collected from local sources in Zamboanga City. The materials were cleaned and prepared by dehydrating, grinding, and re-drying the cabbage waste; tearing, soaking, and hand-pulping the egg trays; and drying, grinding, sieving, and gelatinizing the banana peels into a bio-based coating slurry. A cassava starch–citric acid binder was prepared by gelatinizing a 10% (w/v) cassava starch solution with 3% citric acid as a natural crosslinking agent. The processed cabbage fibers, egg tray pulp, and binder were mixed according to the designated treatment ratios, molded into 150 mm × 150 mm × 10 mm fiberboards, manually pressed, and dried. A banana peel bio-based coating, formulated from 50 g banana peel powder, 400 mL water, and 10 g cassava starch, was applied uniformly in two successive layers to improve surface quality and durability. The coated fiberboards were conditioned at room temperature for 3–4 days before testing. The entire fabrication procedure was repeated for four treatments with ten replications each to ensure consistency and reliability. Finally, the fabricated fiberboards were evaluated for their physical, mechanical, durability, and safety properties, and the resulting data were subjected to statistical analysis.

2.7 Physical Properties Testings

The physical properties of the fabricated fiberboards were evaluated in accordance with EN 622-5 to assess their dimensional stability, density, and water resistance. Density was determined by measuring the mass and dimensions of 50 mm × 50 mm × 10 mm specimens and calculating the mass-to-volume ratio (kg/m³). Water absorption was measured by oven-drying the specimens, immersing them in water for 24 hours, and determining the percentage increase in weight. Thickness swelling was evaluated by measuring the specimens' thickness before and after 24 hours of water immersion, with the percentage increase indicating the fiberboards' dimensional stability under moisture exposure. At least 10 specimens per treatment were tested to ensure reliable results.

2.8 Mechanical Properties Testings

The mechanical performance of the eco-fiberboards was evaluated by determining the Modulus of Rupture (MOR) through a DIY three-point bending test based on the principles of ANSI A208.2. Rectangular specimens measuring 150 mm × 150 mm × 10 mm were placed across two supports, and a container suspended at the midpoint was gradually loaded with sand until the specimen fractured. The maximum load at failure was measured using a digital weighing scale, and the MOR was calculated using the standard flexural strength equation. This test assessed the maximum bending stress the fiberboards could withstand before failure.

2.9 Durability and Safety Properties

The durability and safety of the fabricated eco-fiberboards were evaluated through fire resistance and biodegradability tests. Fire resistance was assessed using a DIY flame test, in which 150 mm × 150 mm specimens were exposed to a butane torch for 10 seconds while observations were made on ignition behavior, flame spread, smoke production, charring, deformation, and self-extinguishing characteristics. Biodegradability was evaluated using a 14-day soil burial test, where 150 mm × 150 mm × 10 mm specimens were buried at a depth of 10 cm with 10 replicates per formulation. Samples were retrieved on Days 7 and 14 to determine mass loss and document visible signs of degradation, including changes in color, texture, fungal growth, softening, and structural deterioration. Ambient and soil conditions were also recorded throughout the testing period.

2.10 Data Analysis and Interpretation

Ten trials were conducted for each parameter to ensure the reliability of the results. The study evaluated the physical, mechanical, durability, and safety properties of eco-fiberboards fabricated from cabbage waste, discarded molded pulp egg trays, and banana peel biocoating to determine their feasibility. Descriptive and inferential statistics were employed, with the Shapiro–Wilk Test and Levene's Test used to assess normality and homogeneity of variances, respectively. One-way ANOVA was applied when parametric assumptions were satisfied, while the Kruskal–Wallis H test was used for non-parametric data, with all analyses performed in Jamovi at a 5% significance level ($\alpha = 0.05$). Additionally, treatment performance was evaluated using a Likert-based ranking system, allowing comparison of the overall effectiveness of each fiberboard formulation across the measured properties.

TABLE III. Scoring Systems for Physical Properties, Mechanical Property and Durability and Safety Properties of the Fabricated Eco-Fiberboards.

Rank	Equivalent Points
Rank 1	4 points
Rank 2	3 points
Rank 3	2 points
Rank 4	1 point

III. Results and Discussion

3.1 Physical Testing of Fabricated Eco- fiberboards

The physical properties of the fabricated fiberboards were evaluated based on density, water absorption, and thickness swelling in accordance with EN 622-5 standards for medium-density fiberboard (MDF).

For density, FB1 (740 kg/m³) and FB2 (692 kg/m³) met the EN 622-5 MDF requirement of 600–800 kg/m³, indicating effective compaction and adequate structural quality. In contrast, FB3 (532 kg/m³) and the control treatment FBc (492 kg/m³) fell below the required range, suggesting insufficient densification due to their higher egg tray fiber content.

For water absorption, all treatments exceeded the EN 622-5 maximum limit of 35%, indicating poor moisture resistance. FBc exhibited the highest water absorption (270.5%), followed by FB3 (211%), FB2 (157%), and FB1 (146%). The higher moisture uptake was attributed to the hydrophilic and porous nature of recycled egg tray fibers and the banana peel

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biocoating, while the denser structure of FB1 contributed to its comparatively lower water absorption.

TABLE IV. Density (kg/m^3) of Four Experimental Treatments.

Sample No.	FB1	FB2	FB3	FBc
1	760	680	480	480
2	860	680	520	440
3	860	800	680	480
4	720	760	560	560
5	720	720	520	480
6	640	640	480	520
7	760	680	480	440
8	640	640	520	520
9	720	680	560	480
10	720	640	520	520
Mean	740	692	532	492
Standard Deviation	75.42	53.5	59.8	37.95
EN 622-5 Requirement	MDF: 600–800 kg/m³	MDF: 600–800 kg/m³	MDF: 600–800 kg/m³	MDF: 600–800 kg/m³

TABLE V. Water Absorption (%) of Four Experimental Treatments

Sample No.	FB1	FB2	FB3	FBc
1	170	191	190	189
2	150	178	167	271
3	150	155	175	213
4	175	175	200	317
5	167	175	200	420
6	156	100	257	300
7	127	91	213	257
8	118	150	156	300
9	108	175	189	225
10	140	178	213	213
Mean	146	157	211	270.5
Standard Deviation	22.64	34.42	36	68.12
EN 622-5 Requirement	≤35%	≤35%	≤35%	≤35%

For thickness swelling, all fiberboards complied with the EN 622-5 requirement of ≤17% after 24 hours of water immersion. FB1 recorded the lowest swelling (6.572%), followed by FB2 (7.35%), FBc (9.97%), and FB3 (10.28%). Although FB3 showed the highest average swelling and greater variability, all treatments demonstrated acceptable dimensional stability. The results indicate that while higher egg tray fiber content increased moisture uptake and swelling, thickness expansion remained within acceptable limits, showing that high water absorption does not necessarily result in excessive thickness swelling.

TABLE VI. Thickness Swelling (%) of Four Experimental Treatments.

Sample No.	FB1	FB2	FB3	FBc
1	7.22	9.28	7.29	10.53
2	8.16	5.21	16.7	17.02
3	6.1	7.29	9.47	3.16
4	4.12	7.22	5.21	10.42
5	7.14	9.18	8.70	10.53
6	8.33	5.15	18.8	14.58
7	8.16	8.33	7.37	3.125
8	6.19	4.21	5.32	10
9	5.2	9.38	7.37	11.83
10	5.1	8.25	16.5	8.51
Mean	6.572	7.35	10.28	9.97
Standard Deviation	1.46	1.89	5.07	4.35
EN 622-5 Requirement	≤ 17% after 24 h	≤ 17% after 24 h	≤ 17% after 24 h	≤ 17% after 24 h

3.2 Mechanical Testing of Fabricated Eco-fiberboards

The mechanical performance of the fabricated eco-fiberboards was evaluated using the Modulus of Rupture (MOR) in accordance with ANSI A208.2 standards. FB1 recorded the highest mean MOR (2.349 MPa), followed by FB2 (1.764 MPa), FB3 (1.319 MPa), and the control FBc (0.720 MPa). Although FB1 demonstrated the greatest flexural strength, all treatments fell well below the ANSI minimum requirement of 20 MPa for medium-density fiberboard. The relatively low standard deviations indicated consistent results within each treatment. The reduced mechanical strength was attributed to the use of recycled agricultural fibers, the absence of synthetic resin binders, lower board densification, and weaker inter-fiber bonding, consistent with previous studies showing that eco-friendly fiberboards generally exhibit lower MOR than conventional MDF.

TABLE VII. Modulus of Rupture (MPa) of Four Experimental Treatments.

Sample No.	FB1	FB2	FB3	FBc
1	2.06	1.854	1.373	0.961
2	2.47	1.964	1.264	0.824
3	2.206	1.648	1.236	0.755
4	2.184	1.346	1.099	0.687
5	2.088	1.923	1.456	0.961
6	2.376	1.765	1.511	0.714
7	2.50	1.813	1.305	0.549
8	2.472	1.935	1.305	0.575
9	2.50	1.744	1.373	0.687
10	2.637	1.648	1.266	0.449
Mean	2.3493	1.764	1.3188	0.72
Standard Deviation	0.1995	0.1847	0.1169	0.17
ANSI A208.02 Requirement	≥ 20 MPa	≥ 20 MPa	≥ 20 MPa	≥ 20 MPa

3.3 Durability and Safety Properties of the Fabricated Eco-Fiberboards

The biodegradability test, conducted through a 14-day soil burial experiment, showed visible signs of decomposition, including surface discoloration, edge softening, and structural deterioration. FB1 exhibited the highest biodegradability with a mean mass loss of 48.25%, followed by FB2 (30.88%) and FB3 (14.33%). These results indicate that higher cabbage fiber content enhanced microbial degradation, confirming the environmental compatibility of the fiberboards and supporting previous findings on the biodegradability of natural fiber-based composites.

TABLE VIII. Mass Loss of Biodegradability (%) of Four Experimental Treatments

Sample No.	FB1	FB2	FB3	FBc
1	41.18	40.74	12.73	5.26
2	42.65	27.27	15.09	13.21
3	38.60	20.69	25.93	4
4	35.19	35.19	9.43	6.12
5	35.19	28.57	10.91	11.11
6	51.92	25	16.07	4
7	54	31	13.79	3.77
8	40	35.85	10.17	4.26
9	75	30.65	14.55	8.16
10	68.75	33.85	12.96	15.09
Mean	48.25	30.88	14.33	7.50
Standard Deviation	14.017	5.83	4.53	4.21

The fire resistance test revealed that FB1 exhibited the best fire performance, characterized by gradual ignition, localized flame spread, moderate smoke emission, controlled char formation, and minimal after-flame activity. FB2 and FB3 showed progressively faster flame spread and greater surface degradation, while the control treatment (FBc) displayed the poorest fire resistance, with rapid ignition, extensive flame propagation, heavy smoke emission, and prolonged glowing after flame removal. The results suggest that increasing the proportion of recycled egg tray fibers, which are rich in combustible cellulose, reduced fire resistance, whereas higher cabbage fiber content and the banana peel biocoating improved thermal stability and slowed flame propagation.

Fig. 3. FB1 Fire Resistance Samples.

3.4 Test Statistical Results of Each Parameter

The statistical analyses indicated that the fabricated eco-fiberboards differed significantly in most of the evaluated properties. Significant differences among treatments were observed for density, water absorption, modulus of rupture (MOR), and biodegradability ($p < 0.001$), indicating that fiber composition significantly influenced these properties. In contrast, thickness swelling showed no statistically significant difference among treatments ($p=0.058$), suggesting comparable dimensional stability despite variations in fiber composition. The statistical analyses indicate that the results demonstrate that the composition of the fiberboards had a significant effect on their physical, mechanical, and biodegradability characteristics, while thickness swelling remained relatively unaffected.

TABLE IX. Test Statistical Results of Each Parameter

Parameter	(df)	Shapiro-Wilk	Levene's Test	ANOVA	Kruskal-Walis
Density	3	0.003	0.486	-	<0.001
Water Absorption	3	0.007	0.027	-	<0.001
Thickness of Swelling	3	0.151	0.006	0.058	-
Modulus of Rupture	3	0.620	0.288	<0.001	-
Fire Resistance	-	-	-	-	-
Biodegradability	3	0.004	<0.001	-	<0.001

3.5 Normality and Homogenous Testing

The statistical assumptions for Analysis of Variance (ANOVA) were first evaluated using the Shapiro–Wilk and Levene's tests. Thickness swelling ($p = 0.151$) and Modulus of Rupture (MOR) ($p=0.620$) satisfied the normality assumption, whereas density ($p=0.003$), water absorption ($p = 0.007$), and mass loss ($p=0.004$) did not. Homogeneity of variances was met for density ($p=0.486$) and MOR ($p = 0.288$), but not for thickness swelling ($p=0.045$). Consequently, ANOVA was applied to datasets that satisfied the required assumptions, while the Kruskal–Wallis test was used for datasets that violated these assumptions. The analysis further showed that thickness swelling did not differ significantly among treatments ($p = 0.058$), indicating comparable dimensional stability across all fiberboard formulations. All statistical analyses were conducted at a 5% significance level ($\alpha=0.05$) to ensure reliable evaluation of treatment effects.

3.6 Ranking of Physical Properties of Eco-Fiberboard

The ranking of the physical properties identified FB1 as the best-performing treatment, achieving the highest total score (8) due to its superior density and lowest water absorption, indicating greater compactness, improved dimensional stability, and better moisture resistance. FB2 ranked second (6), demonstrating balanced physical properties with moderate resistance to moisture. FB3 ranked third (4), exhibiting lower density and higher water absorption, which resulted in reduced dimensional stability. The control treatment (FBc) ranked last (2), showing the poorest physical performance because of its low density and high susceptibility to water absorption. Overall, the results indicate that increasing the proportion of cabbage fibers improved the physical performance of the eco-fiberboards, with FB1 demonstrating the most favorable combination of density and moisture resistance.

TABLE X. Test Statistical Results of Each Parameter

Test Parameter	FB1	FB2	FB3	FBc
Density	4	3	2	1
Water Absorption	4	3	2	1
Total Score	**8**	**6**	**4**	**2**
Overall Rankings	**1st**	**2nd**	**3rd**	**4th**

3.7 Ranking of Mechanical Property Eco-Fiberboard

The mechanical property ranking based on Modulus of Rupture (MOR) identified FB1 as the best-performing treatment, followed by FB2, FB3, and the control (FBc). FB1 exhibited the highest bending strength, indicating superior internal bonding and structural integrity, while FBc showed the weakest mechanical performance. Although FB1 demonstrated the greatest improvement among the formulations, all treatments failed to meet the minimum MOR requirement of 20 MPa specified by EN 622-2, indicating that further enhancement of fiber bonding, binder formulation, and board densification is necessary to achieve commercial fiberboard standards.

TABLE XI. Scoring Systems for Mechanical Property of Eco-Fiberboards

Test Parameter	FB1	FB2	FB3	FBc
Bending Strength (MOR)	4	3	2	1
TOTAL	**4**	**3**	**2**	**1**
Overall Rankings	**1st**	**2nd**	**3rd**	**4th**

3.8 Ranking of Durability and Safety Properties of Eco-Fiberboard

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The ranking of the durability and safety properties identified FB1 as the best-performing treatment, followed by FB2, FB3, and the control (FBc). FB1 demonstrated the highest biodegradability and fire resistance, indicating the best balance between environmental sustainability and operational safety. Comparison with commercial MDF standards showed that FB1 met the requirements for density and thickness swelling, but exceeded the allowable water absorption limit and failed to achieve the required Modulus of Rupture (MOR), highlighting the need for improved moisture resistance and mechanical strength. Compared with commercial MDF, FB1 exhibited faster biodegradation and better fire resistance, attributed to its natural fiber composition and char-forming behavior during combustion. Despite its limitations, FB1 showed potential as a sustainable alternative for lightweight, non-structural applications, including corkboard materials, due to its superior overall performance among the fabricated eco-fiberboards.

TABLE XII. Scoring Systems for Durability and Safety Properties of Eco-Fiberboards

Test Parameter	FB1	FB2	FB3	FBc
Biodegradability	4	3	2	1
Fire Resistance	4	3	2	1
Total Score	**8**	**6**	**4**	**2**
Overall Rankings	**1st**	**2nd**	**3rd**	**4th**

IV. CONCLUSIONS

This study demonstrated the feasibility of converting cabbage waste and molded pulp egg trays into eco-friendly fiberboards enhanced with a banana peel biocoating. Among the developed treatments, FB1 (40:60 cabbage-to-egg tray ratio) exhibited the best overall performance, achieving the highest density, lowest water absorption, least thickness swelling, highest modulus of rupture, and superior fire resistance and biodegradability. While FB1 and FB2 met the density requirements for medium-density fiberboards and all treatments satisfied the thickness swelling standard, none met the required water absorption or mechanical strength standards for commercial MDF. Compared with commercial MDF, FB1 showed greater environmental sustainability due to its biodegradable composition but remained inferior in terms of mechanical strength and moisture resistance, limiting its current application to non-structural interior uses. Overall, the study confirmed that agricultural and paper waste can be successfully valorized into sustainable fiberboards with promising environmental and safety benefits.

APPENDICES

Fig. 4. Unearthed Eco-Fiberboards Week 1 (FB1).

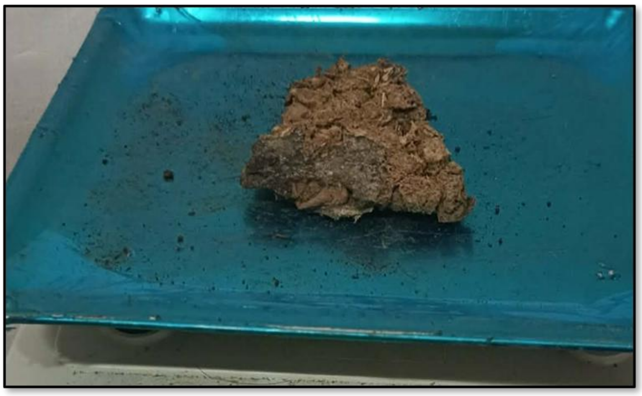

Fig. 5. Unearthed Eco-Fiberboards Week 2 (FB1).

Fig. 6. Detailed Observation of Fire Resistance Test of FB1.

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REFERENCES

[1] American National Standards Institute, ANSI A208.2: *American National Standard for Medium Density Fiberboard (MDF) for Interior Applications.* National Particleboard Association, 1994.

[2] American Society for Testing and Materials, *ASTM D1037-12: Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials*. ASTM International, 1994.

[3] ASTM International, *Standard Test Methods for Evaluating Properties of Wood-Based Fiber and Particle Panel Materials (ASTM D1037), 2017.*

[4] E. Athanasopoulou, P. Charpa, M. Sarafidou, E. Kalogianni, A. Tsouknidas, and G. Voulgaridou, "*Extraction of pectin from banana peels and utilization in a bioactive coating for postharvest banana preservation,"* Discover Food, vol. 5, p. 286, 2025. doi: 10.1007/s44187-025-00606-0.

[5] European Committee for Standardization, EN 622-5: Fibreboards—Specifications—Part 5: Requirements for Dry Process Boards (MDF)*. CEN, 1993.

[6] H. M. N. Iqbal, G. Kyazze, and T. Keshavarz, *"Advances in the valorization of lignocellulosic materials by biotechnology: An overview,"* Journal of Environmental Management, vol. 232, pp. 545–554, 2019. doi: 10.1016/j.jenvman.2018.11.060.