Research

Assessing the Effectiveness of Durian (*Durio zibethinus murray*) Rind Fiber with Zea Mays Starch and Bentonite Clay (*Calcium Montmorillonite*) as a Thermal and Sound Insulator

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This study evaluated the effectiveness of durian (*Durio zibethinus*) rind fiberboard combined with bentonite clay and corn starch as a sustainable thermal and acoustic insulator. The fiberboard was tested against both commercial insulation and a control (no insulation) setup to assess its capacity to reduce internal temperatures and sound pressure levels. The results indicated that while the fiberboard reduced temperatures and sound levels, the performance in some cases did not significantly surpass that of the commercial insulator. ANOVA and post-hoc tests confirmed statistically significant differences in temperature and sound pressure levels across conditions. However, critical analysis revealed that the practical significance of these differences requires further validation. For temperature reduction, the fiberboard showed a modest improvement over the control, but its performance under real-world conditions remains uncertain. For sound insulation, the fiberboard achieved a noise reduction coefficient (NRC) of 0.68, which is promising but below industry benchmarks for high-performance insulators. The study highlights the potential of durian fiberboard as a low-cost, eco-friendly solution for insulation, but further research is necessary to optimize its properties and ensure its effectiveness across different environmental conditions.

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Extreme heat and rising temperatures are some of the most apparent problems that our society suffers from nowadays. Most studies assessing the health-related risks of rising temperatures are often focused on urban areas, with the fact that urban areas have higher surface temperatures than rural areas due to the urban heat island (UHI) effect (Mohajerani et al., 2017). Nevertheless, Odame et al. (2018) found that rural inhabitants are equally susceptible to heat as urban populations, even without the presence of the urban heat island phenomenon. Additionally, rural areas are at a high disadvantage due to socioeconomic factors such as limited access to healthcare, lower economic opportunities, poor housing quality and infrastructure, inadequate education and awareness, and several more.

In rural areas, a lack of adequate income is a major obstacle to owning a home and investing in quality housing. Soseco et al. (2018) found that new households encounter significant challenges in obtaining suitable housing, with a lack of income being the main limitation. This lack of financial resources prevents people living in rural areas from buying homes with improved insulation or protection from extreme temperatures, making them more susceptible to the effects of increasing heat. Adding to this problem, limited income also hinders the ability to obtain crucial resources and technologies that could assist in adjusting to higher temperatures. Rural households need help in meeting basic needs like food, education, and transportation due to high housing costs, leaving little money for cooling solutions that could save lives.

This economic burden leads to a pattern of poverty that sustains the difficulties rural communities encounter in dealing with high temperatures. Due to insufficient resources, people living in rural areas may turn to less effective and occasionally dangerous ways of dealing with their problems. Soseco et al. (2018) suggest that due to financial limitations, individuals often need better living conditions like poorly ventilated homes or working in high temperatures without proper cooling to save money. These decisions increase the chances of heat-related illnesses and highlight the urgent requirement for affordable housing enhancements and adaptive resources in these communities.

Moreover, higher temperatures are posing greater health risks in rural areas, as research shows a troubling connection between rising temperatures and death rates. In their study, Odame et al. (2018) discovered that with every 1°C increase in average daily temperature, the overall death rate of rural inhabitants rose by 3%, with cardiovascular-related deaths climbing by 11.1%. These results highlight the specific vulnerability of rural areas, where lack of proper housing, healthcare, and cooling options can worsen the impact of heat on health results. Lack of proper adaptation measures can leave rural residents vulnerable to heat-related illnesses, potentially worsening existing disparities in health and quality of life.

The connection between rising temperatures and deaths caused by cardiovascular-related issues is especially alarming since heart conditions are common and can worsen due to heat pressure.

Meanwhile, although the impact of noise exposure on cardiovascular health is still uncertain, a study by Sivakumaran et al. (2022) proposes that noise could be a factor in cardiovascular problems through various pathways. Initially, noise functions as a stress inducer, causing the production of stress hormones such as cortisol and adrenaline that can elevate heart rate and blood pressure, increasing the risk of cardiovascular issues. Moreover, being exposed to noise at night can disturb sleep, causing changes in sleep cycles, heightened stress, lack of energy, and ultimately, a greater vulnerability to cardiovascular problems.

Additionally, Sivakumaran et al. (2022) point out that continuous exposure to noise can play a role in causing mild inflammation, which is linked to the onset of heart disease. This inflammation could worsen the other processes since stress and lack of sleep can also increase inflammatory markers in the body. Further investigation is required, but the results suggest a potentially important connection between environmental noise and cardiovascular well-being, emphasizing the significance of including noise mitigation in public health efforts.

Noting that, increasing temperatures not only present direct threats to health but also impact social interactions and environmental settings, resulting in elevated noise levels within neighborhoods. Mercado et al. (2018) propose that elevated temperatures can worsen noise production, mainly because of their effect on human behavior and comfort. The research emphasizes that as temperatures increase, it creates a disturbance that results in excessive noise, leading to increased feelings of annoyance and agitation among individuals.

This shift in behavior can appear in different forms, including more time spent outdoors, louder discussions, and higher levels of irritation, leading to an overall increase in noise levels. Communities may suffer from physical discomfort due to heat and psychological stress, which can worsen due to environmental noise, leading to more health problems related to temperature exposure and noise pollution. Recognizing the relationship between heat and noise is essential for creating successful strategies to enhance the quality of life for vulnerable rural communities.

Developing innovative solutions is essential to tackle these interrelated issues, as existing ones are deemed unaffordable due to the financial inadequacy experienced by people living in rural environments. Potential methods include using durian waste, specifically the outer layer or rind, in combination with natural clay, specifically Bentonite clay, as environmentally friendly materials for thermal and sound insulation.

The durian (*Durio zibethinus*), a fruit well-known in the area, is grown, eaten locally, and also shipped to different Southeast Asian countries. This fruit usually has a round to oval form and can weigh between 2 to 4.5 kg, depending on the type, with around 30 different species. The thick, semi-woody outer peel of the durian, comprising over half of the fruit's weight, is distinguished by its sharp, pyramid-shaped thorns that change color from green to yellowish-brown. Significantly, the portion of the durian that is edible makes up only 15 to 30 percent of its total weight, leading to a significant amount of waste. If not properly handled, approximately 70 to 85 percent of the discarded durian fruit is typically either disposed of in landfills or left to decompose in the environment.

Moreover, pure bentonite stands out for its low thermal conductivity, a key feature that boosts its efficacy as an insulation material. While exact numbers for the thermal conductivity of pure bentonite are not given, its lower thermal conductivity in comparison to various other materials makes it beneficial for thermal insulation purposes. Pure bentonite has the ability to effectively reduce the transfer of heat, which assists in keeping internal temperatures in structures stable. According to Sah et al. (2023), this characteristic is especially advantageous in insulation uses, where minimizing heat transfer is crucial for energy conservation and comfort. As a result, incorporating unadulterated bentonite into insulation materials enhances thermal efficiency, rendering it an essential element in eco-friendly construction options designed to tackle issues related to extreme temperatures.

In summary, the objective of this study is to assess the effectiveness of durian rind-based fiberboard that not only addresses the challenges posed by extreme heat but also improves thermal and sound insulation in rural housing, ultimately enhancing the living conditions for communities facing socioeconomic disadvantages.

Methods

A. Preparation and Collection of Materials

1. Approximately 15 kg of Durian waste (rinds and seeds) was collected through solicitation from 2 different sources: Magsaysay Fruit Market – Davao and a random Durian stand along Garcia Heights, Davao City.
2. Additionally, about 300g of cornstarch was bought at a nearby sari-sari store in San Antonio Bajada, Davao city.
3. Moreover, around 300g of Calcium Bentonite Clay was purchased at a store in Abreeza Mall, Davao City, ½ of Beeswax was purchased at a Candle Store in Boulevard, Davao City.
4. Preparation of the rinds and seeds consisted of cleaning and cutting them into smaller pieces for an easier and faster soaking and sun-drying process.
5. Several used plastic containers (13 cm by 10 cm) were also prepared to act as a mold to facilitate the molding process, and lastly, Hygrometers were prepared for the testing phase.

B. Extraction of Durian Fibers

Following the extraction process of Lubis et al., (2018) the small pieces of Durian rinds were soaked for one (1) week to allow the outer surface of the rinds to soften fully. In this whole soaking interval, the water was changed multiple times to accelerate the softening process of the rinds. Afterward, the fibers were extracted manually and thoroughly through a food processor to quickly and easily remove the smaller pieces of hard rinds. Lastly, the fibers were sun-dried for 1 ½ days to remove water content.

Figure 1. Chopped Durian rinds ready for soaking

C. Making of Binding Agent

For the binding agent, a ratio of 1:3 of powdered durian seed and water (respectively) was initially prepared, and mixed under heat (Cahyono et al. 2017). Through multiple trials, it was noted that 1 part of Calcium Bentonite along with 1 part of cornstarch was the best measurement added to the durian seed and water mixture, resulting in a 1:1:1:3 ratio of powdered durian seeds, Calcium Bentonite, Cornstarch, and water, respectively.

Figure 2. Sun-dried chopped durian seeds

D. Fabrication

To make the fiberboard, the binding agent and dried fibers were layered and compressed in a 13 x 10 x 5 cm mold, then air-dried for several days to harden the mixture.

Figure 3. Molding process

E. Heat Insulation Performance Test

The method employed by Mercado et al. (2018) was used to test the effectiveness of the durian fiberboard insulators. Small boxes, designed to represent miniature houses, were utilized, with each box proportionally scaled to match the size of the fiberboards. This setup simulated how the fiberboards would perform as insulating materials in real household applications. Hygrometers were strategically placed within the experimental setup to measure the effectiveness of the boards. Three of the miniature boxes were lined with durian fiberboards to evaluate their insulating properties. Additionally, one box contained only a hygrometer, serving as a baseline for comparison. For further control, one hygrometer head was left completely exposed to direct sunlight to record ambient conditions. This arrangement provided a comprehensive means to assess and compare the insulating performance of the fiberboards under various conditions.

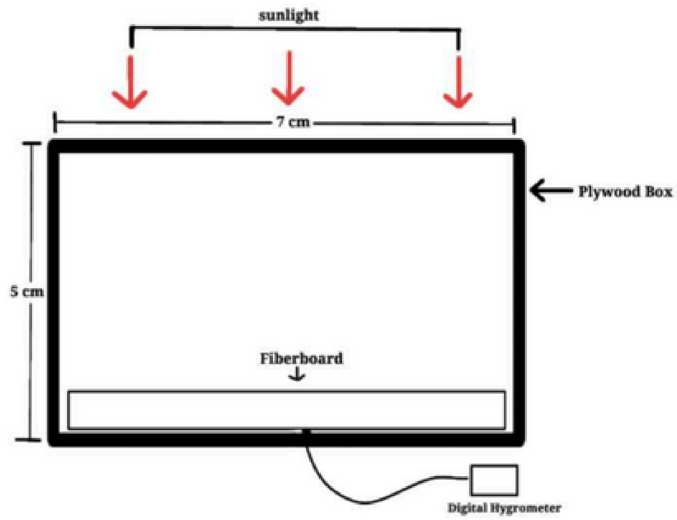

Fig 4. Diagram for Heat Insulation Performance Test

F. Sound Absorbing Capacity

The boards are enclosed in a plywood box for insulation during the sound capacity testing. A small JBL Bluetooth speaker was placed inside the test box. The Bluetooth speaker was connected to the phone to produce sound at its highest volume. During the sound capacity testing, the researchers played an 800 Hertz audio since it is within the frequency range where human hearing is most sensitive. To measure the sound produced, a Digital Sound Level Meter AS804 was used at a distance of 20 centimeters from the test box. In each test, the researchers made sure that the distance of the decibel meter and the volume of the speaker were consistently maintained. Additionally, the testing environment was controlled to minimize external noise interference for accurate measurements.

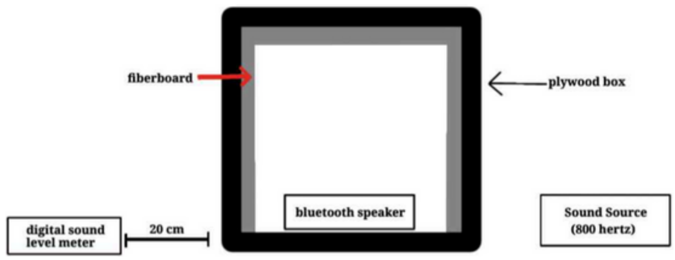

Fig 5. Diagram for Sound Insulation Performance Test

The decrease in decibel levels recorded during each trial was used in the calculation of the Noise Reduction Coefficient (NRC) using the formula,

$$C = 1 - 10^{-\left(\frac{d}{20}\right)} \quad \text{(Formula 1)}$$

where *c* signifies the coefficient and *d* represents the decibel decrease.

G. Risk and Safety

Safety measures were carefully observed throughout the course of this research to ensure the well-being of the researchers. One of the primary precautions involved the use of gloves to protect their hands from potential injuries, such as cuts or pricks caused by the sharp spikes on the durian rinds. These gloves not only safeguarded the researchers from physical harm but also helped maintain hygiene during the handling of the raw materials.

Additionally, the researchers conducted their work in a controlled and safe environment, which minimized risks and provided a secure workspace. This setup allowed them to handle the rinds and seeds of the durian effectively and efficiently while reducing the likelihood of accidents. By adhering to these safety protocols, the researchers ensured that the project was carried out responsibly and with minimal risk.

H. Data Analysis

Descriptive statistics, including mean and standard deviation, were employed to analyze the data. These metrics were utilized to evaluate the sound pressure levels of the prepared treatments and to assess their thermal insulating performance. Additionally, a One-Way Analysis of Variance (ANOVA) was conducted to determine whether the differences in sound pressure levels among the treatments and the variations in temperature readings between the samples were statistically significant. To further pinpoint the specific differences among the treatments, a Tukey Post Hoc Test was performed.

	Trial 1				Trial 2			
Treatment	n	Min	Max	Mean±Sd	n	Min	Max	Mean±Sd
External	28	44	53.8	48.12±4.24	28	41	55.7	49.91±3.67
Control	28	38.9	49	45.03±2.93	28	40	49	45.74±2.31
Insulated	28	35	43	40.43±2.09	28	37	44.6	41.32±2.4

Table 1. Temperature Readings

The results in Table 1 indicate that the insulated condition consistently maintained lower mean temperatures compared to both the external and control conditions across two trials. However, while the data shows a clear trend that insulation using durian fiberboard reduces internal temperatures, there are critical aspects that need further analysis.

Firstly, the temperature differences between the external and insulated conditions appear significant at face value, but the relatively high standard deviations, particularly in the external condition, suggest that environmental factors could have introduced variability. This raises questions about the consistency of the testing environment. For example, the maximum temperature recorded for the external condition in Trial 2 (55.7°C) is notably higher than in Trial 1 (53.8°C), despite similar setups. This fluctuation might be attributed to differences in sunlight exposure or ambient weather conditions, which were not explicitly controlled for. Future experiments should consider more precise environmental controls or conduct tests in a climate-controlled chamber to reduce variability.

Moreover, while the insulated condition shows a reduction in mean temperature, the difference between the control and insulated conditions in both trials is relatively modest (around 4°C). This suggests that while the fiberboard does have insulating properties, it may not be significantly more effective than a basic enclosure without additional insulation. The practical implication of this finding is that the material may need further optimization, such as increasing fiber density or adding reflective coatings, to enhance its thermal performance.

Cases	Sum of Squares	df	Mean square	F	p
Trial 1					
TREATMENT	378.132	2	189.066	20.893	<.00001
Residual	352.926	39	9.049		
Trial 2					
TREATMENT	605.003	2	302.502	50.489	<.00001
Residual	233.666	39	5.991		

Note. Type III Sum of Squares Levene's (F=2.934; p=0.065) (Trial 1)

Note. Type III Sum of Squares Levene's (F=0.180; p=0.836) (Trial 2)

Shapiro-Wilk; External=0.957, p=0.668; Control=0.957, p=0.716; Insulated=0.896, p=0.497 (Trial 1)

Shapiro-Wilk; External=0.970,p=0.883; Control=0.917, p=0.599; Insulated=0.955, p=0.639 (Trial 2)

Table 2. Test of Difference Among Temperatures

The ANOVA results in Table 2 confirm that the differences in mean temperatures between the external, control, and insulated conditions are statistically significant ($p < 0.00001$ for both trials). While this indicates that the insulation treatment had a measurable impact, it is crucial to interpret these results critically. The large F-values (20.893 for Trial 1 and 50.489 for Trial 2) suggest substantial variability between the groups, but this could also be influenced by the variability within the external condition noted earlier. The residual mean square values (9.049 for Trial 1 and 5.991 for Trial 2) indicate that some degree of unexplained variability remains, which again points to the importance of controlling external factors more rigorously. Lastly, while the ANOVA results indicate significant differences, the practical significance of these differences should be considered. The mean temperature difference between the control and insulated conditions, although statistically significant, may not be large enough to make a meaningful impact in real-world applications. This highlights the need for further research to optimize the material's thermal properties and to test its performance in various environmental conditions over longer periods.

Trial 1		Mean Difference	SE	t	p_{tukey}
External	**Controlled**	2.66	0.804	3.308	.6153
	Insulated	7.26	0.804	9.030	.00000
Controlled	**Insulated**	4.60	0.804	5.721	.00069
Trial 2					
External	**Controlled**	4.88	0.654	7.642	.00002
	Insulated	9.29	0.654	14.205	.00000
Controlled	**Insulated**	4.41	0.654	6.743	.00008

Table 3. Post Hoc Comparisons in the Temperature among Treatments

The post-hoc analysis in Table 3 reveals significant differences between the external, control, and insulated conditions. In both trials, the insulated condition showed the most substantial reduction in temperature compared to the external condition, with mean differences of 7.26°C in Trial 1 and 9.29°C in Trial 2. These results are statistically significant, but a critical evaluation is necessary to determine the practical implications.

While the post-hoc comparisons confirm that the insulated condition performs better than the control and external conditions, the temperature reductions, particularly between the control and insulated setups (mean difference of 4.60°C in Trial 1 and 4.41°C in Trial 2), may not be sufficient to make a significant impact in real-world applications where extreme heat poses a serious health risk. It would be beneficial to test the material's performance in prolonged heat exposure scenarios to assess its durability and effectiveness over time.

Moreover, the statistically significant differences reported in the post-hoc tests must be interpreted alongside the variability observed within the groups. The relatively high standard errors suggest that further refinement of the experimental setup is necessary to reduce variability and improve the precision of the measurements. This could involve increasing the sample size or conducting tests under more controlled conditions to minimize external influences.

Treatments	n	Min	Max	Mean±Sd
Commercial	6	64.2	71.6	67.9±2.79
Control	6	72	75.7	72.64±2.71
Durian	6	60	64.2	62.78±1.34

Table 4. Sound Pressure Level (SPL) in decibels (dB) using 800 Hertz (Sound Source)

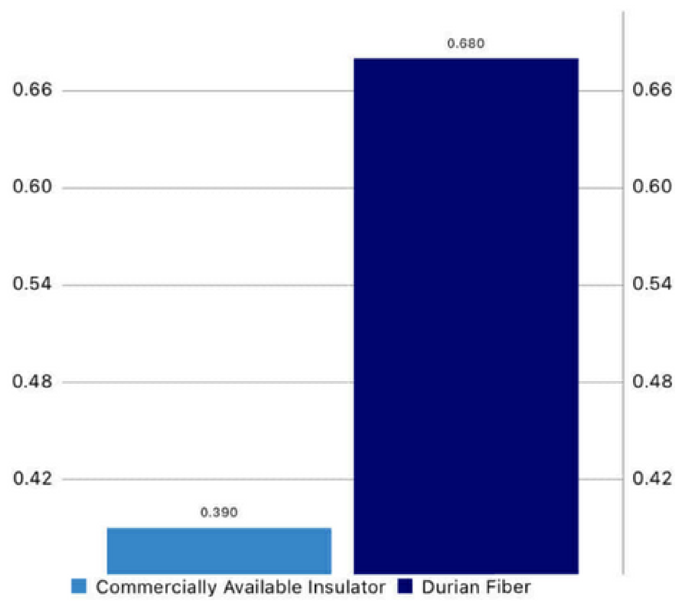

Fig 6. Results of the Noise Reduction Coefficient (c) of Commercially Available Insulator and Durian Waste Insulator at 800 Hertz

Table 4 shows that the durian-based fiberboard achieved the lowest mean sound pressure level (62.78 dB), outperforming both the control (72.64 dB) and commercial insulation (67.9 dB). The small standard deviation in the durian group (±1.34 dB) indicates consistent performance across trials, suggesting that the material has reliable sound-insulating properties.

However, while the data suggests that the durian-based fiberboard is effective at reducing sound pressure levels, it is important to compare these results to industry benchmarks for commercial sound insulators. The Noise Reduction Coefficient (NRC) value

of 0.68 reported for the durian fiberboard is promising but falls short of the NRC values of high-performance commercial insulators, which often exceed 0.90. This comparison highlights that while the durian fiberboard offers a sustainable and cost-effective solution, it may not yet match the performance of commercial products.

Additionally, the testing methodology should be critically assessed. The use of an 800 Hz sound source is appropriate for human hearing sensitivity, but real-world noise pollution involves a wider frequency range. Future tests should incorporate a broader spectrum of frequencies to better assess the fiberboard's acoustic performance.

Table 5. Test of Difference in the Sound Pressure Among Treatments

Cases	Sum of Squares	df	Mean Square	F	p
TREATMENT	285.421	2	142.711	21.816	.000036
Residual	98.122	15	6.541		

Note. Type III Sum of Squares Levene's (F=1.148; p=0.344)
Shapiro-Wilk; Commercial=0.910, p=0.511; Control=0.865, p=0.238; Durian=0.832, p= 0.130

Table 5. Test of Difference in the Sound Pressure Among Treatments

The ANOVA results for sound pressure levels in Table 5 reveal that the differences between the control, commercial, and durian-based insulation treatments are statistically significant ($p = 0.000036$). The large F-value (21.816) indicates a substantial effect of the type of insulation on sound pressure reduction. However, this statistical significance must be interpreted with caution.

Firstly, while the F-value is large and the p-value is well below the 0.05 threshold, the relatively small sample size (n=6 per group) raises concerns about the robustness of the findings. Small sample sizes can inflate the likelihood of Type I errors (false positives), meaning that the observed differences might not hold in larger, more diverse samples. Future research should replicate these findings with a larger sample size to confirm their validity.

Secondly, the assumption of homogeneity of variances was tested using Levene's test, which reported a p-value of 0.344. This indicates that the variances between groups were not significantly different, suggesting that the ANOVA results are reliable. However, given the small sample size, it would be prudent to also report results from a non-parametric test, such as the Kruskal-Wallis test, to ensure robustness.

Lastly, while the ANOVA confirms significant differences between treatments, the practical significance of these differences should not be overlooked. The mean sound pressure reduction achieved by the durian-based insulation (approximately 10 dB lower than the control) is promising, but the real-world applicability of this finding depends on factors such as the material's durability, ease of installation, and cost-effectiveness.

Table 6. Post Hoc Comparisons on the Sound Pressure Among Treatments

		Mean Difference	SE	t	P_{tukey}
Commercial	Control	4.63	1.044	4.435	.01752
	Durian	5.12	1.044	4.904	.00913
Control	Durian	9.75	1.044	9.339	.00002

Table 6. Post Hoc Comparisons on the Sound Pressure Among Treatments

The post-hoc analysis in Table 6 confirms that the durian-based insulation significantly outperforms both the control and commercial insulation in reducing sound pressure levels. The mean difference of 9.75 dB between the control and durian treatments is particularly noteworthy, as it suggests a substantial improvement in sound insulation.

However, the comparison between the commercial and durian treatments shows a mean difference of only 5.12 dB, which, while statistically significant, may not be large enough to justify the replacement of commercial insulators with durian-based ones in all contexts. The practical applicability of this difference depends on the specific requirements of the environment in which the insulation will be used.

Finally, the post-hoc results highlight the importance of considering both statistical and practical significance. While the durian-based insulation shows promise, future studies should explore its performance under different environmental conditions and across a broader range of sound frequencies to provide a more comprehensive assessment of its acoustic properties.

Conclusion

The findings of this study demonstrate that durian rind fiberboard has potential as a sustainable thermal and acoustic insulator, particularly for resource-constrained communities. However, while the material showed statistically significant improvements in both temperature and sound reduction compared to a control setup, its performance relative to commercial insulation warrants further investigation. The mean temperature reduction achieved by the fiberboard was modest, suggesting that further optimization of the material's composition or thickness is necessary to improve its thermal insulation capabilities. Similarly, while the sound pressure levels achieved by the fiberboard were lower than both the control and commercial insulation, the differences in sound reduction between the commercial and control groups were smaller than expected, raising questions about the quality and type of commercial insulator used.

Critically, the study highlights several limitations that should be addressed in future research. The small sample sizes used in the tests may have impacted the reliability of the results, particularly for sound insulation. Additionally, the testing environment could have introduced variability that influenced the measurements. Future studies should consider conducting tests in more controlled environments and across a broader range of sound frequencies to better assess the material's acoustic performance.

In conclusion, while the durian rind fiberboard shows promise as a cost-effective and environmentally friendly insulation material, further research is required to enhance its thermal and acoustic properties, address limitations in the testing methodology, and validate its performance under real-world conditions. The study contributes to the ongoing exploration of sustainable building materials but underscores the need for continuous refinement to meet industry standards and practical requirements.

1. Cahyono, R., Santoso, J., & Miliati, R. (2017). Biomass Briquettes Using Indonesia Durian Seeds as Binder Agent: the Effect of Binder Concentration on the Briquettes Properties. *Chemical Engineering Transactions*, *56*, 1663–1668. https://doi.org/10.3303/cet1756278
2. Lubis, R., Saragih, S., Wirijosentono, B., & Eddyanto, E. (2018). Characterization of durian rinds fiber (Durio zibethinus, murr) from North Sumatera. AIP Conference Proceedings 2049, 020069 (pp. 020069 - 020069-8). AIP Publishing.
3. Mercado, R. D. T., Ureta, R. M., & Templo, R. J. D. (2018). The Potential of Selected Agricultural Wastes Fibers as Acoustic Absorber and Thermal Insulator Based on their Surface Morphology via Scanning Electron Microscopy. *World News of Natural Sciences*, *20*, 129–147.
4. Mohajerani, A., Bakaric, J., & Jeffrey-Bailey, T. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. *Journal of Environmental Management*, *197*, 522–538. https://doi.org/10.1016/j.jenvman.2017.03.095
5. Odame, E., Li, Y., Zheng, S., Vaidyanathan, A., & Silver, K. (2018). Assessing Heat-Related Mortality Risks among Rural Populations: A Systematic Review and Meta-Analysis of Epidemiological Evidence. *International Journal of Environmental Research and Public Health*, *15*(8), 1597. https://doi.org/10.3390/ijerph15081597
6. Sah, P. K., Kumar, S. S., & Sreedeep, S. (2023). Thermophysical properties of Bentonite–Sand/Fly Ash-Based backfill materials for underground power cable. *International Journal of Thermophysics*, *44*(4). https://doi.org/10.1007/s10765-023-03163-9
7. Sivakumaran, K., Ritonja, J. A., Waseem, H., AlShenaibar, L., Morgan, E., Ahmadi, S. A., Denning, A., Michaud, D. S., & Morgan, R. L. (2022). Impact of noise exposure on risk of developing Stress-Related health effects related to the cardiovascular system. *Noise and Health*, *24*(114), 107–129. https://doi.org/10.4103/nah.nah_83_21
8. http://psjd.icm.edu.pl/psjd/element/bwmeta1.element.psjd-b46a75af-7f16-4888-ac9c-7d33d43045f6/c/WNOFNS_20__2018__129-147.pdf
9. Soseco, T., Wulandari, D., Utomo, S. H., & Narmaditya, B. S. (2018). House Ownership Circumstances in Rural Area: Evidence from Indonesia. *Jurnal Pendidikan Ekonomi Dan Bisnis (JPEB)*, *6*(2), 93–102. https://doi.org/10.21009/jpeb.006.2.2