

Rambushield: Evaluating the Thermal Conductivity and Resistance of Rambutan (*Nephelium lappaceum* L) Peels as an Insulating Material

Alicaba, Dhanayah Ai Con., Aradillos, Fiona Gail E., Basalan, Franz Rafael G., Diez, Mary Eunice O., Ende, Adri Doniel C., Gallego, Paul Andrew W., Geralde, Kirk Jared M., Grande, Dave M., Ladiza, Aeron Joshua P.

Senior High School, Cor Jesu College, Inc, Digos City

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ABSTRACT

The growing reliance on air conditioning and cooling devices due to extreme heat emphasizes the urgent need for sustainable and affordable eco-friendly insulation options. Sunlight exposure increases excessive heat, prompting the use of air conditioners, electric fans, and other cooling devices. Using a quantitative experimental method, data were gathered by measuring the thermal conductivity and thermal resistance of bio-composite material as an insulator in comparison to commercial insulators. The samples were tested using a FOX 200 Heat Flow Meter to measure thermal conductivity. Thermal resistance was calculated using the sample thickness and the conductivity value from the machine's datasheet. Results showed that the first rambutan fiber with the binding agent had a thermal conductivity of 0.34046 W/mmK and thermal resistance of 0.06635667 m².K/W, while adding another binding agent slightly increased conductivity (0.38279 W/mmK) and reduced resistance (.07460667 m².K/W). Commercial insulation had significantly better performance, with a conductivity of 0.02740 W/mmK and resistance of 2.61793667 m².K/W. The findings confirm a significant difference in thermal conductivity between the experimental and commercial setups, indicating varying insulation capacities. The study highlights the potential of rambutan peels as an alternative insulation material, though its thermal performance is significantly lower than commercial insulation. The higher thermal conductivity and lower thermal resistance of rambutan fiber indicate it is less effective at preventing heat transfer.

Keywords: rambutan fiber, heat, insulator, bio-composite material, eco-friendly insulator

INTRODUCTION

Background of the Study

The growing reliance on air conditioning and cooling devices due to extreme heat emphasizes the urgent need for sustainable and affordable eco-friendly insulation options. Sunlight exposure increases excessive heat, prompting the use of air conditioners, electric fans, and other cooling devices. This has resulted in many developers searching for sustainable and affordable cooling materials, such as insulators. The development of bio-insulators, which offer a natural alternative, is essential in reducing reliance on inorganic materials and replacing them with biodegradable ingredients that pose no risk to the environment. As a result, using environmentally friendly insulators, especially from natural alternative materials, offers significant potential as an eco-friendly insulation material.

In a global context, eco-friendly insulation provides numerous benefits, contributing to environmental sustainability, energy efficiency, and improved indoor air quality. In the Caribbean region, intense heat and high temperatures pose significant climate risks, severely affecting sectors such as agriculture and public health, particularly in the country of Haiti (Elusma et al., 2022). The abnormal rise in temperatures and discomfort of hot weather lead people in Haiti to seek solutions to cope with the tropical climate. In the study of Montrose (2023), thermal insulation on buildings using bio-based materials to efficiently manage excessive

heat, aiming to make the inhabitants of the living spaces comfortable while reducing their energy use. The same is the case in Colombia, where people use many eco-friendly insulation materials that are derived from renewable resources, such as wool, cotton, and cellulose, which helps preserve natural resources and reduce reliance on non-renewable materials. According to Ezema (2019), this natural and eco-friendly type of insulator helps to be a sustainable and effective cooling material. By lowering heat gain in hot weather and heat loss in cold weather, insulation enhances the building envelope's thermal performance and decreases the need for cooling and heating. This leads to lower greenhouse gas emissions during manufacturing and throughout their lifecycle.

Different fibrous materials have been considered worldwide, the use of natural materials rich in fiber has been a trend in making natural insulators. One of the promising alternatives offering a good number of fibers and other materials, such as cellulose, is rambutan. Rambutan (*Nephelium lappaceum* L.) is an exotic fruit native to Southeast Asia, gaining attention for its underutilized yet valuable components, particularly its peel, pulp, and seed. Studies have shown that rambutan peels contain significant bioactive compounds and lignocellulosic materials, making them a promising source for various industrial applications, including food, medicine, and sustainable biomaterials (Gimongala et al., 2020). The presence of cellulose, hemicellulose, and lignin in rambutan peel provides good thermal stability, making it suitable for fiber production, heat insulation, and environmental applications such as heavy metal adsorption (Hernández-Hernández et al., 2019; Rinaldi et al., 2018). Additionally, rambutan fat, which consists of a balanced composition of saturated and monounsaturated fatty acids, forms a stable solid structure at room temperature, making it a viable alternative fat source for confectionery products (Bhattacharjee et al., 2022).

Another study by Afzaal et al. (2023) has also explored eco-friendly extraction and pretreatment methods to enhance the efficiency of obtaining bioactive compounds from rambutan peels, demonstrating their antioxidant, antimicrobial, anti-inflammatory, and therapeutic properties. The use of soda lignin extracted from rambutan peels has been shown to improve the thermal resistance and barrier properties of starch-based films, though microbial growth remains a challenge. Furthermore, electrothermal pretreatment methods have been explored to improve fiber production efficiency while reducing energy consumption, making rambutan peels a sustainable alternative to woody biomass (Torgbo et al., 2023). Despite these promising applications, further research is needed to improve extraction efficiency, assess bioavailability, and optimize industrial applications of this natural resource.

Extreme heat across Southeast Asia since April 2024 has caused significant economic losses, health crises, and disruptions to education. Reports indicate that human-caused climate change contributed to an average of 41 additional days of dangerous heat worldwide in 2024, with Southeast Asia among the hardest hit regions (Associated Press, 2024). In the garment industry, workers in countries like Bangladesh and Vietnam faced severe health risks due to high wet-bulb temperatures, potentially threatening billions in export earnings (Reuters, 2024). Education has also been disrupted, with extreme weather affecting at least 242 million children globally; over 118 million faced interruptions during April heatwaves, with school closures reported in countries like the Philippines (Associated Press, 2024; ABC News, 2024).

A study of Reynoso et al. (2021) explores the potential of recycled expanded polystyrene (EPS) as an environmentally friendly thermal insulation material for construction applications. Their study examines its thermal conductivity, mechanical properties, and performance compared to conventional insulation. Findings show that recycled EPS effectively reduces heat transfer, enhances energy savings, and has suitable strength and durability for construction, making it a sustainable, cost-effective alternative to traditional insulation materials. Using waste materials offers a way to create more eco-friendly insulation (Kalaw et al., 2022), and further research confirms recycled EPS composites exhibit promising thermal and sound insulation performance (MDPI, 2023).

The urgency of conducting this study arose from the extreme heat and lack of research on the thermal performance of alternative insulation materials. Other studies have explored different fruits as alternatives for insulation materials (Bhattacharjee et al., 2022) has specifically analyzed the potential of rambutan peel for industrial use. There had been insufficient measurements of the exact resistance, thermal conductivity, and

moisture management values of insulators manufactured from rambutan peels under various conditions, such as temperature and humidity.

Addressing this gap could contribute to sustainable waste management and eco-friendly insulation, anchoring the theory of Victor Papanek (1998), which is the Theory of Sustainable Design. The Theory of Sustainable Design by Victor Papanek puts a major focus on creating resource-efficient and environmentally friendly solutions. This theory is relevant to this research because it encourages the development of sustainable insulation using locally accessible, biodegradable waste materials, such as rambutan peels. Heat Transfer Theory by Joseph Fourier (1830) aimed to assess the capacity, particularly assessing the thermal resistance and thermal conductivity of using rambutan peels as an insulation material. This theory describes the thermal conduction, convection, processes that heat uses to flow through materials. Since it offers basic recommendations to evaluate the thermal conductivity and resistance of rambutan peels, this theory is relevant to the study. To determine how effective the peels are as insulators, it is essential to understand these heat transfer methods.

Statement of the Problem

This study aimed to investigate the potential of rambutan (*Nephelium lappaceum* L.) peels as an effective insulation material. Specifically, the research addressed the following questions:

1. What is the level of insulation capacity of rambutan peel fiber with a natural binding agent in terms of:
 - 1.1 thermal conductivity and;
 - 1.2 thermal resistance?
2. What is the level of insulation capacity of rambutan peel fiber with a natural binding agent and modified starch in terms of:
 - 2.1 thermal conductivity and;
 - 2.2 thermal resistance?
3. What is the level of insulation capacity of commercial insulation products in terms of:
 - 3.1 thermal conductivity and;
 - 3.2 thermal resistance?
4. Is there a significant difference between the thermal conductivity of a rambutan thermal insulator with a natural binding agent, a rambutan thermal insulator with a natural binding agent and modified starch, and a commercial thermal insulator?
5. Is there a significant difference between the thermal resistance of a rambutan thermal insulator with a natural binding agent, a rambutan thermal insulator with a natural binding agent and modified starch, and a commercial thermal insulator?

Hypothesis of the Study

This hypothesis was investigated by comparing the thermal conductivity and the general effectiveness of rambutan peel insulation against the performance of standard insulators.

Ho: There is no significant difference in such as thermal resistance and thermal conductivity between rambutan peel fiber with a natural binder agent and modified starch, and a commercial thermal insulator.

Significance of the Study

This study aimed to analyze the performance of rambutan peels as an eco-friendly insulator. This research also helped to reduce the environmental effect of insulation materials and added to the existing body of information on sustainable building techniques. The findings of the study would be beneficial to the following:

Department of Energy and Natural Resources (DENR) Officers. This study could benefit the DENR officials from studying eco-friendly heat insulation by promoting energy efficiency in various systems, such as buildings, industrial equipment, and renewable energy devices, which reduces overall energy consumption and greenhouse gas emissions. This research could supports the development of sustainable insulation materials

that minimize reliance on non-renewable resources, aligning with global energy conservation goals. Additionally, it provides innovative solutions for thermal management in renewable energy technologies, such as solar panels and wind turbines, enhancing their efficiency and lifespan while ensuring minimal environmental impact.

Construction Firm Owners. This study could benefit the construction industry by offering a cost-effective and sustainable alternative to traditional insulation. Its sustainable nature could make it a greener option compared to synthetic insulators, contributing to a healthier working environment.

Philippine Green Building Council (PHILGBC) Officers. This study would help organizations that employ and promote eco-friendly buildings for sustainable living. By utilizing rambutan peel-based insulators, the department could advance green building initiatives and achieve energy-efficient infrastructure goals.

Homeowners. This study could help homeowners find ways to reduce energy consumption and environmental impact. Also, the use of agricultural waste aligns with environmentally conscious practices, promoting waste reduction and sustainability in household owners.

Future Researchers. This study could provide a foundation for further experimentation to improve the thermal properties, durability, and scalability of bio-based insulators, potentially leading to eco-friendly solutions. The study also could highlights the value of agricultural waste in advancing circular economy practices.

Scope and Limitations

This study explored the potential of peels as eco-friendly insulation materials, evaluating their thermal resistance, thermal conductivity, and moisture management capabilities. It focuses on examining the material's moisture management, thermal conductivity, and thermal resistance. The procedures were carried out from January 13 to February 5. Rambutan peels are gathered as part of the research process, then they are shredded and adhered with a plant-based glue. Molds and drying tools are then used to shape the resulting slurry into insulation samples. The creation of the product was only limited to improvised tools because of the lack of standardized materials. The replicates are also limited due to limited materials. These samples are subjected to controlled thermal performance testing in Digos City. The study's primary goals are to determine how well rambutan peel-based insulation maintains thermal comfort, look into how well it controls moisture, and gauge its effects on the environment.

Definition of Terms

The following terms were defined to have a better understanding of this study:

Commercial Insulator. It is a protective envelope that reduces heat transfer, keeping interiors warm in winter and cool in summer. (Pwddadmin, 2024). This refers to the insulation material that would be the controlled group of the experiment. This could be bought in commercial stores and hardware stores.

Thermal Insulator. Thermal insulation reduces heat transfer between solid objects, fluids, or gases by introducing a barrier between them (Concept Group LLC, 2024). This refers to a material used to reduce heat transfer between two spaces, The mixture would be from Rambutan peels that would be dried and shredded.

Rambutan Peel. Rambutan peels considered as a good source of both mineral elements and biologically active compounds, making it a valuable natural resource for pharmaceutical applications (Torgbo et al., 2022). This refers to the skin of the rambutan fruit obtained in fruit stalls and vendors. This would be the base ingredient for the mixture of this study using dry and wet peels.

Thermal Conductivity. Refers to measuring a product's heat-conducting capacity. Heat moves quickly through materials with high thermal conductivity (Thermal Conductivity – What It Is and It's Formula, 2024b).

Thermal Resistance. Refers to the product's ability to withstand heat flow and high temperatures. It also indicates how well an insulator is, depending on how well it endures the heat (Thermal Conductivity and Thermal Resistance Calculator - ThermTest, 2023).

Rambushield. The product name for this research is "Rambu," derived from the word "rambutan," a tropical fruit known for its refreshing properties. The term "shield" signifies its primary function: to protect users from excessive heat. Rambu is designed to offer innovative solutions for thermal comfort, drawing inspiration from the natural cooling effects of the rambutan fruit. By combining these elements, Rambu aims to provide an effective barrier against high temperatures while promoting well-being in hot climates.

METHODS

This chapter highlights the research framework, the study's focus, sampling methods, data collection procedure, metrics used, and data analysis methodology.

Research Design

This quantitative experimental study used a true experimental research design. In this design, the researchers evaluated the results in the experimental group following implementation and compared them to the control group, commercial insulators. This allowed the researchers to assess the effectiveness of various compositions of the rambutan peel insulator on the properties of commercial insulators. Then, the intervention's effectiveness was evaluated by determining the outcome after the intervention had taken place (Chandrababu, 2022).

Moreover, this design included subjecting three (3) types of composition of the insulator to the same tests, as well as the control group, which was the commercial insulator. In this particular case, the rambutan peel insulator simply varies the amount of rambutan peel with a binder agent mixed with a modified starch and rambutan peel with a binder agent. At the same time, the third is the control group, which was the commercial insulator. The experimental groups' results were evaluated to identify the efficacy of the rambutan peels insulator, as well as to compare their effect to the control group to estimate the thermal conductivity of rambutan (*Nephelium lappaceum* L.) peels as an insulation material.

Sampling Method

The study utilized a Complete Random Design, selecting rambutan cellulose samples from various sources, including local markets, farms, and processing facilities. The sample selection criteria include mixed rambutan varieties, various cellulose extraction methods, moisture content, and minimal contamination. Complete random sampling is a subset of a statistical population in which every member has an equal chance of being selected. The goal of a basic random sample is to represent a group objectively (Hayes, 2024). This method is the simplest of all the probability sampling techniques since it only requires one random selection and little prior population knowledge (Thomas, 2023). A post-test only design, defined as an experimental design where subjects are randomly assigned to groups and measured only after the intervention (Creswell & Creswell, 2018), was used in this study to evaluate the effects of different cellulose extraction methods on the samples without the influence of pre-treatment measurements.

Moreover, because it eliminates the need for critical analysis of the selected samples, random sampling is a time and money-efficient sampling technique. It enabled researchers to collect data effectively without the limitations and difficulties of several tests and procedures. This could be helpful when time and resources are limited. The goal of this study was to evaluate the thermal conductivity of rambutan (*Nephelium lappaceum* L.) peels as an insulating material.

Data Gathering Procedure

The data-gathering procedure was adapted from Silva et al. (2023) study, which used rice husk and reed fibers as materials to make thermal insulation plates. The researchers conducted the following steps to gather data for the study.

A. Laboratory Access and Coordination Procedure

1. The researchers sent a courteous message to the school along with the attached documents and filled out forms, introducing the researchers, briefly explaining the purpose of our request, and asking for their approval to use the machine in their laboratory.
2. Upon receiving a positive response from the school, the researchers coordinated with the assigned laboratory personnel to finalize the schedule, review the laboratory policies, and ensure that all requirements were met prior to conducting the actual procedures.

B. Gathering and preparing the rambutan peels

1. The researchers gathered enough rambutan peels from markets and rural areas to separate the peel from the fruit meticulously.
2. The researchers removed the remaining seeds inside the rambutan.
3. The researchers washed the rambutan peels and cleaned them to remove dirt and pulp residues.
4. Following the cleansing process, the researchers sun-dried the peels until they became brittle. Once dried, the researchers ground the dried peels using a blender.

C. Formulating and mixing the solution for the prepared rambutan peels

1. The researchers prepared two types of mixture for the rambutan insulator. The first mixture consisted of 165 g blended rambutan peels and 310 g wood glue as a binding agent.
2. The second mixture consisted of 165 g of rambutan peels, 275 g of modified starch, and 310 g of wood glue.
3. The mixture of binding agents was slowly poured into the crushed rambutan peels and manually mixed by the researchers.
4. The researchers then poured the mixture again into the blender to avoid lumps from forming and to achieve an even coating of the binding agents throughout the mixture.

D. Forming the rambutan thermal insulator

1. The rambutan mixture was poured into a 6in x 6in x 2in rectangular mold with parchment paper on the bottom to avoid the mixture sticking to the wooden mold, shaping it into its desired shape.
2. The researchers then placed parchment paper and a wooden plate on top of the mold, which was stored in a dry place. It is then be pressed using 25 kg of weight.
3. The researchers ensured that the cold and dry storage maintained consistent temperature and humidity levels to optimize curing.
4. The researchers left the mixture for 15 hours inside the mold until it reached the desired shape.
5. The thermal insulator is sun-dried for 7 hours until it dries and hardens into a square-shaped rambutan insulator.

E. Assessing the thermal conductivity/resistance of the rambutan thermal insulator

1. The technician placed the samples in a Heat Flow Meter (HFM) machine, specifically a FOX 200 Heat Flow Meter, where the thermal conductivity and resistance of the rambutan peel were measured.
2. The technician first placed the rambutan thermal insulator with 165 g of rambutan peels, 275 g of modified starch, and 310 g of wood glue. After 2-3 hours of testing, the Heat Flow Meter (HFM) machine showed the results of the rambutan thermal insulator.
3. The technician then placed the second rambutan thermal insulator with 310 g of wood glue and 165 g of rambutan peels and waited another 2-3 hours for testing using the same Heat Flow Meter (HFM) to evaluate the results of the rambutan thermal insulator.
4. The Heat Flow Meter (HFM) machine showed the gathered data of the two rambutan insulator samples, which is the thermal conductivity of the insulator.
5. The researcher then computed the thermal resistance using the formula for the thickness divided by the lambda given by the Heat Flow Meter's datasheet.

6. The gathered data were collected by the researchers and computed by a statistician.

Measures

To test the effectivity of using rambutan peels as an insulation material, the researchers measure the thermal resistance and conductivity of the insulation. The promising properties of the rambutan peels, which have significant levels of cellulose, hemicellulose, and lignin, indicate that it is a valuable source of lignocellulosic material for applications such as bio-nanocomposites, in addition to possessing physical and chemical qualities. This prepares the peels for making thermal insulators efficiently, providing bioactive compounds (Oliveira et al., 2016). Drying and heating the rambutan peels reduced the moisture and thermal bridges, enhanced the durability, and made the material lightweight.

In addition, with the drying and heating, the rambutan peels were more able to be exposed to environmental conditions such as light, oxygen, temperature, and moisture, making them more stable (Oliveira et al., 2016). The ability of thermal insulation to retain its thermal properties over time and its thermal conductivity determines its effectiveness. The researchers measured the Heat Flow Meter (HFM) when measuring the thermal conductivity. The primary barrier to heat transfer between materials is interfacial thermal resistance (ITR) (Chen et al., 2022). The thickness of the material was first measured with a caliper or ruler and recorded in meters to calculate the thermal resistance (RRR value). Buildings are becoming required to utilize thermal insulation materials as energy becomes increasingly valuable. When applied correctly, a material or mixture of materials known as thermal insulation slows the rate of heat transfer by conduction, convection, and radiation. The rate at which heat moves through a substance under controlled circumstances is used to measure thermal conductivity (Anh & Pásztor, 2021). Precipitation, leakage, vapor, and condensation are all examples of moisture, which is widely regarded as one of the biggest threats to the long-term performance and durability of materials (Kamel et al., 2023).

Table 1. Table of interpretation about Heat Insulation Capacity in terms of Thermal Conductivity

Mean Score Interval (in W/(m•K))	Performance Level	Interpretation
1.325 and above	Excellent Performance	The standard thermal conductivity level that proves the material is effective as an insulator.
0.38 – 1.324	Moderate Performance	A moderate thermal conductivity level for insulation would fall between the low and high effectiveness ranges, indicating moderate performance in resisting heat flow.
0.0 – 0.37	Low Performance	A lower thermal conductivity level indicates that a material is not very effective at insulating, as it allows more heat to pass through.

Table 2. Table of interpretation about Heat Insulation Capacity in terms of Thermal Resistance

Mean Score Interval (in m ² •K/W))	Performance Level	Interpretation
1.75 and above	Excellent Performance	The insulator shows high thermal resistance, effectively minimizing heat transfer and maintaining stable performance.
1.25 – 1.74	Moderate Performance	The insulator shows moderate thermal resistance, suitable for applications with moderate temperature exposure, but may not perform well under extreme heat conditions.
0.00 – 1.24	Low Performance	The insulator shows low thermal resistance, allowing significant heat transfer.

To measure the thermal resistance of each insulator, it is calculated by dividing the thickness of the material by its thermal conductivity, giving an R-value specific to that thickness.

$$R = \frac{L}{\lambda}$$

Where R = As the Thermal Resistance

L = As the thickness of the material (mm)

λ = As lambda or Thermal Conductivity

Data Analysis

In this study, an inferential statistic called the Kruskal-Wallis Test (H test) was employed to test three groups of data, explicitly comparing the various compositions of rambutan peel insulators with commercial insulators. This helped identify any statistically significant differences between them.

1. Descriptive statistics provide concise summary measures that offer insights into a specific data set, whether it represents an entire population or a sample (Hayes, 2024). The mean is a key statistical measure that represents the average value in a dataset, serving as a reference for analysis of overall performance and trends (Testbook, 2023). The standard deviation quantifies how much individual data points deviate from the mean and is especially relevant for normally distributed datasets, offering insight into the distribution of values around the average (Darling, 2022). A low standard deviation suggests that values are closely clustered around the mean, indicating consistency, while a high standard deviation points to greater variability, potentially reducing reliability. This is important for evaluating materials like rambutan peel insulation; low standard deviation indicates stable insulating properties, while high standard deviation signifies variability. Understanding these metrics is essential for assessing insulating material performance.
2. The Kruskal–Wallis test is a statistical test used to compare two or more groups for a continuous or discrete variable. It is a non-parametric test, meaning that it assumes no particular distribution of your data and is analogous to the one-way analysis of variance (ANOVA) (McClenaghan, 2024). This test was utilized to determine if there is a significant difference between our rambutan peel insulators and commercial insulators.
3. Kolmogorov–Smirnov Test is a completely efficient manner to determine if two samples are significantly one of a kind from each other. It is normally used to check the uniformity of random numbers (GeeksforGeeks, 2024). This test is conducted to determine if the data followed a normal distribution.
4. Dunn’s test is the appropriate nonparametric pairwise multiple comparison procedure when a Kruskal–Wallis test is rejected, and it is now implemented for Stata in the `dunntest` command. `dunntest` produces multiple comparisons following a Kruskal–Wallis k-way test by using Stata’s built-in `kwallis` command (Dinno, 2015). The Dunn's Test is used to assess pairwise differences between treatment groups for significance, specifically when conducting multiple comparisons.

RESULTS AND DISCUSSION

This chapter deals with the presentation, analysis, and interpretation of data. The first part describes the capacity of different insulation materials tested, providing detailed examination results. The second part presents the significance of the differences among the tested materials, analyzing the variations in their thermal properties and explaining their possible causes.

Insulation Capacity of Rambutan Fibers and the Commercial Insulator in Terms of Thermal Conductivity

The study investigated the insulation capacity of the different natural insulator setup of rambutan fibers and the commercial insulator by assessing the thermal conductivity of the following experiment setup: Setup 1, with 165 g of Rambutan fiber, with 310 g of wood glue (natural binding agent), and with 275 g of modified starch

(Instant Starch); Setup 2, with 165 g of Rambutan fiber, and with 310 g of wood glue (natural binding agent); and Setup 3, a commercial insulator. The researchers assessed the thermal conductivity of the following setup through a brief process involving temperature measurements, data recording, and calculation of thermal conductivity values. To ensure reliability and accuracy, each setup was replicated three times (R1, R2, R3). Hence, the researchers obtained the following results.

Table 1. Insulation Capacity of Rambutan Fibers and Commercial Insulators in Terms of Thermal Conductivity

	Replicate (in Lambda W/mmK)			Mean	SD	Interpretation
	R1	R2	R3			
S1	0.38435	0.38230	0.38172	0.38279	0.00138	Moderate
S2	0.34136	0.34137	0.33866	0.34046	0.00156	Low
Commercial	0.00395	0.03820	0.04005	0.02740	0.02033	Low

Table 1 presents the thermal conductivity of the two setups of rambutan fiber insulators and the commercial insulator. It shows that the first setup with 165 g of Rambutan fiber, 310 g of wood glue, and 275 g of modified starch has an average of 0.38279 W/mmK with minimal variation in replicate data. This indicates that a lower thermal conductivity level indicates that a material is not very effective at insulating, as it allows more heat to pass through. The second setup, with 165 g of Rambutan fiber and with 310 g of wood glue, has an average of 0.34046 W/mmK with a minimal variation in replicate data. This indicates that a lower thermal resistance level is not very effective at insulating, as it allows more heat to pass through. Meanwhile, the commercial insulator has an average of 0.02740 W/mmK with a minimal variation in replicate data. This indicates that a moderate thermal conductivity level for insulation would fall between the low and high effectiveness ranges, indicating moderate performance in resisting heat flow.

Moreover, the results are different from the statement of Tingting (2022), where despite the rambutan peels having cellulose, hemicellulose, and lignin, the peels did not provide excellent insulation that prevented the heat transmission. The peel's fibers provide insulation that prevents heat transmission. The findings of this study revealed that the rambutan peel insulator showed lower values compared to the commercial insulator.

Insulation Capacity of Rambutan Fibers and the Commercial Insulator in Terms of Thermal Resistance

The study investigated the insulation capacity of the different natural insulator setup of rambutan fibers and the commercial insulator by assessing the thermal resistance of the following experiment setup: Setup 1, with 165 g of Rambutan fiber, with 310 g of wood glue (natural binding agent), and with 275 g of modified starch (Zoy); Setup 2, with 165 g of Rambutan fiber, and with 310 g of wood glue (natural binding agent); and Setup 3, a commercial insulator. Hence, the researchers obtained the following results.

Table 2. Insulation Capacity of Rambutan Fibers and Commercial Insulators in Terms of Thermal Resistance

	Replicate (in m ² ·K/W)			Mean	SD	Interpretation
	R1	R2	R3			
S1	.6609	66.44	66.54	.66357	.00023	Low
S2	.7441	74.41	75.00	.74606	.00034	Low
Commercial	.62025	667.54	986.27	2.6179	3.10624	Excellent

Table 1 presents the thermal resistance of the two setups of rambutan fiber insulators and the commercial insulator. It shows that the first setup with 165 g of Rambutan fiber, 310 g of wood glue, and 275 g of modified starch has an average of .66357 m²·K/W with a minimal variation in replicate data. This indicates that a lower thermal resistance level indicates that a material is not very effective at insulating, as it poorly resists heat. The second setup with 165 g of Rambutan fiber and with 310 g of wood glue has an average of

.74606 $\text{m}^2\cdot\text{K}/\text{W}$ with a minimal variation in replicate data. This indicates that a lower thermal resistance level indicates that a material is not very effective at insulating, as it poorly resists heat. Meanwhile, the commercial insulator has an average of 2.6179 $\text{m}^2\cdot\text{K}/\text{W}$ with a minimal variation in replicate data. The study conducted by Hurtado et al. (2016) shows that the typical thermal resistance for cellulose fiber insulators is approximately 3.17500 $\text{m}^2\cdot\text{K}/\text{W}$, which highlights the difference in performance between the experimental setups and standard cellulose-based insulators.

Moreover, the results are in congruence with the statement of PCC Group (2025), which states that the higher the thermal resistance, the more difficult it is for heat to pass through a material, making it a better insulator. This value is the reciprocal of the thermal conductivity coefficient, denoted as λ (λ), and is one of the key parameters considered in the design of building insulation. Higher thermal resistance means better thermal insulation, allowing less energy to be used to heat or cool the building.

Significant Difference in the Insulation Capacity of Rambutan Fibers and the Commercial Insulator in Terms of Thermal Conductivity

Table 3 presents the results of the comparative analysis of the insulation capacity between the experimental groups and the control group in terms of their thermal conductivity. According to Hurtado et al. (2016), the typical value for a Cellulose Fiber Insulator's thermal conductivity is around 0.040 W/mK, which provides a useful benchmark for assessing insulation performance. To evaluate the statistical validity of the study, a normality test using the Kolmogorov-Smirnov test was conducted to determine if the data followed a normal distribution. The test indicated a significant deviation from normality ($W = 0.367$, $p = 0.001$), suggesting that the data on the thermal conductivity did not meet the assumptions necessary for parametric analysis. As a result, alternative statistical methods were considered. Therefore, the Independent-Samples Kruskal-Wallis Test was employed for analysis. This non-parametric method is appropriate for comparing setups if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable without requiring normality, given that the data is skewed. (Kruskal-Wallis H Test in SPSS Statistics | Procedure, Output and Interpretation of the Output Using a Relevant Example, 2018.) It could be noted that the test statistic value for the overall thermal conductivity is 7.200, with 3 degrees of freedom and a p-value of 0.027, which is less than 0.05. This means that the study needs to reject the null hypothesis. This indicates that there is a significant difference in the thermal conductivity of the experimental and control setups. Further, this means that different setups have varying degrees of insulation capacity in terms of thermal conductivity.

Table 3. Significant Difference in the Insulation Capacity of Rambutan Fibers and the Commercial Insulator in Terms of Thermal Conductivity

Variables Reviewed	Test Statistic	df	p-value	Decision	Interpretation
Thermal Conductivity	7.200	3	0.027	Reject H_o	Significant Difference

To determine which of the three setups significantly differs from the others, a post hoc analysis was conducted, specifically, pairwise comparisons of sample means using Dunn's test. The Dunn's Test is used to assess pairwise differences between treatment groups for significance, specifically when conducting multiple comparisons. This non-parametric test compares all possible pairs of groups while controlling the probability of making one or more Type I errors.

Table 4 presents the results of post hoc comparisons conducted using Dunn's test. The analysis revealed significant differences between setups. Specifically, the comparison between S1 and S2 revealed no significant difference ($p = 0.178$), indicating that the two groups were comparable. Similarly, the comparison between S2 and Control also showed no significant difference ($p = 0.178$). However, a significant difference was found between S1 and Control ($p = 0.007$), suggesting that these two groups differ notably. Using the sample average rank and the test statistic, it indicates that S1, with a 6x6x2 inch model, has a promising insulating capacity in terms of thermal conductivity.

Table 4. Post Hoc Comparisons using the Dunn's Test for Thermal Conductivity

	Test Statistic	SE	p	Decision	Interpretation
Between S1 and S2	-3.000	2.227	0.178	Fail to Reject H_o	Not Significant
Between S1 and Control	-6.000	2.227	0.007	Reject H_o	Significant
Between S2 and Control	-3.000	2.227	0.178	Fail to Reject H_o	Not Significant

This means that the S1 and S2 did not differ from their thermal conductivity ($p = 0.178$). Similarly, the S2 and the Control group also did not differ in their thermal conductivity ($p = 0.178$). Though the Setup 1 and the Control group have a comparable thermal conductivity ($p = 0.007$). However, a statistically significant difference was observed between S1 and the Control group ($p = 0.007$), indicating distinct thermal resistance properties.

Table 5. Significant Difference in the Insulation Capacity of Rambutan Fibers and the Commercial Insulator in Terms of Thermal Resistance

Variables Reviewed	Test Statistic	df	p-value	Decision	Interpretation
Thermal Resistance	7.200	3	0.027	Reject H_o	Significant Difference

Based on the results presented in Table 5, there is a significant difference in the insulation capacity, specifically in terms of thermal resistance — between Rambutan fibers and the commercial insulator. The test yielded a statistic of 7.200 with 3 degrees of freedom, and a p-value of 0.027, which is less than the conventional significance level of 0.05. Therefore, the null hypothesis was rejected, indicating that the type of material has a statistically significant effect on thermal resistance. A study that had better results by Le and Pásztor (2023) investigated the thermal resistance (RSI value) of various natural fiber insulating materials, including coir fiber, rice straw fiber, energy reed fiber, and coconut wood. They found that the highest RSI value was reported for a binderless coir fiber panel at $0.909 \text{ m}^2\cdot\text{K}\cdot\text{W}^{-1}$ with a thickness of 50 mm. This suggests that certain natural fibers can achieve thermal resistance values comparable to commercial insulators, depending on their composition and thickness.

Table 6. Post Hoc Comparisons using the Dunn's Test for Thermal Resistance

	Test Statistic	SE	p	Decision	Interpretation
Between S1 and S2	3.000	2.236	0.180	Fail to Reject H_o	Not Significant
Between S1 and Control	6.000	2.236	0.007	Reject H_o	Significant
Between S2 and Control	3.000	2.236	0.180	Fail to Reject H_o	Not Significant

This means that the S1 and S2 did not differ from their thermal resistance ($p = 0.180$). Similarly, the S2 and the Control group also did not differ in their thermal resistance ($p = 0.180$). Though the Setup 1 and the Control group have a comparable thermal resistance ($p = 0.007$). However, a statistically significant difference was observed between S1 and the Control group ($p = 0.007$), indicating distinct thermal resistance properties. A study that shows better result by Muthukumar et al. (2024) conducted a study on banana fiber and recycled polyester (r-PET) nonwovens, focusing on their thermal insulation and biodegradation properties. The research revealed that nonwovens made from a 90% banana and 10% r-PET blend exhibited superior thermal insulation, with thermal resistance values ranging from 0.248 to $0.299 \text{ m}^2\cdot\text{K}/\text{W}$. These findings suggest that specific compositions and bonding techniques can significantly influence the thermal resistance of natural fiber-based insulation materials, supporting the notion that certain setups may exhibit distinct thermal properties.

SUMMARY

This study evaluated the thermal conductivity and thermal resistance of rambutan peels as alternative insulation. Results showed that both rambutan-fiber composites allowed more heat transfer than the commercial insulator. Setup 1 (with starch binder) had a mean λ of $0.3828 \text{ W}/\text{mm}\cdot\text{K}$, while Setup 2 (without starch) had a slightly lower λ of $0.3405 \text{ W}/\text{mm}\cdot\text{K}$, though both remained far behind the control's 0.0274

W/mm·K. Despite Tingting's (2022) findings on rambutan's insulating potential, both natural blends underperformed.

In thermal resistance, Setup 1 and Setup 2 had R-values of $0.6636 \text{ m}^2\cdot\text{K}/\text{W}$ and $0.7461 \text{ m}^2\cdot\text{K}/\text{W}$, respectively both low compared to the commercial insulator's $2.6179 \text{ m}^2\cdot\text{K}/\text{W}$, supporting PCC Group's (2025) assertion linking high resistance to better insulation. Statistical analysis using Kruskal–Wallis ($H = 7.200$, $p = 0.027$) showed a significant difference among setups. Dunn's test confirmed a gap between S1 and the control ($p = 0.007$), but not between S1 and S2 or S2 and control. In conclusion, while rambutan fibers show promise, the tested formulations especially with starch fall short of commercial standards. Optimization in fiber density, binders, or surface treatments is needed to improve eco-friendly performance.

CONCLUSIONS

The growing reliance on air conditioning and cooling devices due to extreme heat emphasizes the urgent need for sustainable and affordable eco-friendly insulation options. This study arose from the extreme heat and lack of research on the thermal performance of alternative insulation materials. It aimed to assess the thermal resistance and thermal conductivity of rambutan peels as an insulation material.

1. The insulation capacity of rambutan fiber, when measured by its ability to resist heat transfer, showed a relatively low level of thermal conductivity and a correspondingly low level of thermal resistance.
2. When combined with a natural binding agent, the rambutan fiber exhibited a slightly higher thermal conductivity and slightly lower thermal resistance, indicating a modest decline in its insulating performance.
3. In comparison, the commercial insulation material demonstrated significantly better performance, with very low thermal conductivity and a much higher thermal resistance, making it a far more effective insulator.
4. There is a significant difference in the thermal conductivity of the experimental and control setups. This means that different setups have varying degrees of insulation capacity in terms of thermal conductivity.

RECOMMENDATIONS

Write recommendations for beneficiaries of the results of the study cited in Significance of Study.

1. The Department of Energy and Resources Officers should explore and promote sustainable insulation materials, such as fibers from rambutan peels, for use in architecture, industry, and renewable energy systems. By focusing on bio-based materials that enhance energy efficiency, the department could lower energy consumption and greenhouse gas emissions. Furthermore, executing motivations for research and integrations of these materials would support the transition from non-renewable resources, aligning with long-term goals for energy preservation and environmental stewardship.
2. For construction firm owners, rambutan peel must be further evaluated and tested as a suitable alternative insulating material. Its biodegradable characteristics offer an eco-friendly solution, promoting a healthier indoor environment and reducing overall environmental impact. Further, rambutan peel could be sourced at lower expenses, providing cost benefits while aligning with the rising demand for sustainable building practices, ultimately enhancing competitive advantage in the market.
3. To the Philippine Green Building Council Officials, it is recommended that they should look into the potential of rambutan peel as a viable alternative insulating material. Utilizing this natural resource not only promotes sustainable building initiatives but also helps with the objectives of achieving energy-efficient infrastructure. This approach supports the overarching goal of reducing environmental impact while enhancing thermal performance in building design.
4. For homeowners, it is advised that they must look into the utilisation of nature based insulators such as those made from cellulose rich materials (e.g rambutan peels) as an alternative insulation material. This could present a viable strategy for reducing energy consumption and minimizing environmental impact. This procedure could not only enhance thermal efficiency in residential settings, but could also align

with sustainable practices by promoting waste reduction and contributing to overall ecological sustainability.

5. For future researchers, it is recommended to enhance the study by conducting additional experiments (e.g testing more samples) to optimize the thermal properties, durability, and scalability of bio-based insulators. This would contribute to more environmentally sustainable solutions. Researchers should consider using a 6x6x2-inch model to ensure consistency and reliability in the results. Furthermore, the immediate utilization of rambutan, due to its short shelf life and seasonal availability, is essential to avoid potential limitations in its use. Additionally, emphasizing the role of agricultural waste in promoting circular economy practices would further support sustainable development.

Approval Sheet

This study entitled **“RAMBUSHIELD: EVALUATING THE THERMAL CONDUCTIVITY AND RESISTANCE OF RAMBUTAN (*Nephelium lappaceum* L.) PEELS AS AN INSULATING MATERIAL”** prepared and submitted by **ALICABA, DHANAYAH AI CON, ARADILLOS, FIONA GAIL E., BASALAN, FRANZ RAFAEL G., DIEZ, MARY EUNICE O., ENDE, ADRI DONIEL C., GALLEGO, PAUL ANDREW W., GERALDE, KIRK JARED M., GRANDE, DAVE M., LADIZA, AERON JOSHUA P.**

In partial fulfillment of the requirements for Practical Research is hereby accepted.

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As we conclude this research, we dedicate our hard work and findings to all those who played a role in its success and to everyone who believed in our ability to carry out this meaningful study.

REFERENCE

1. Abobakr, S. M., Abdullah, A. A., Abdelkader, H. H., Khalil, M., & El-Lawindy, A. E. (2024). The role of agricultural waste in achieving high efficacy in residential sustainable buildings in Egypt. *International Journal of Industry and Sustainable Development*, 5(2), 83–94. <https://doi.org/10.21608/ijisd.2024.298012.1063>
2. Afzaal, M., Saeed, F., Bibi, M., Ejaz, A., Shah, Y. A., Faisal, Z., Ateeq, H., Akram, N., Asghar, A., & Shah, M. A. (2023). Nutritional, pharmaceutical, and functional aspects of rambutan in industrial perspective: An updated review. *Food Science & Nutrition*, 11(7), 3675–3685. <https://doi.org/10.1002/fsn3.3379>
3. Anh, L. D. H., & Pásztor, Z. (2021). An overview of factors influencing thermal conductivity of building insulation materials. *Journal of Building Engineering*, 44, 102604. <https://doi.org/10.1016/j.job.2021.102604>
4. Albuquerque, B. R., Pinela, J., Dias, M. I., Pereira, C., Petrović, J., Soković, M., Calhella, R. C., Oliveira, M. B. P., Ferreira, I. C., & Barros, L. (2023). Valorization of rambutan (*Nephelium lappaceum* L.) peel: Chemical composition, biological activity, and optimized recovery of

- anthocyanins. Food Research International, 165, 112574. <https://doi.org/10.1016/j.foodres.2023.112574>
5. Alhabeeb, B. A., Mohammed, H. N., & Alhabeeb, S. A. (2021, February). Thermal insulators are based on abundant waste materials. In IOP Conference Series: Materials Science and Engineering (Vol. 1067, No. 1, p. 012097). IOP Publishing.
6. Ali, A., Issa, A., & Elshaer, A. (2024). A comprehensive review and recent trends in thermal insulation materials for energy conservation in buildings. *Sustainability*, 16(20)
7. ASTM International (2020). ASTM C272-17, Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Panels.
8. Becker, N. (2024). The essential guide to eco-friendly home insulation. <https://climatesort.com/eco-friendly-insulation/> 8782. <https://doi.org/10.3390/su16208782>
9. Bhattacharjee, P., Das, S., Das, S. K., & Chander, S. (2022). Rambutan (*Nephelium lappaceum* L.): A potential fruit for industrial use, serving nutraceutical and livelihood interests and enhancing climate resilience. *South African Journal of Botany*, 150, 26–33.
10. Bharadwaj, P., & Jankovic, L. (2020). Self-organized Approach to Designing building thermal insulation. *Sustainability*, 12(14), 5764. <https://doi.org/10.3390/su12145764>
11. Chandrababu, R. (2022, October 30). Posttest-only control group design. [researchgate.net. https://www.researchgate.net/post/Whether_the_posttest-only_control_group_design_can_be_called_as_Randomized_Controlled_Trial](https://www.researchgate.net/post/Whether_the_posttest-only_control_group_design_can_be_called_as_Randomized_Controlled_Trial)
12. Chen, J., Wang, H., & Xie, P. (2019). Pavement temperature prediction: Theoretical models and critical affecting factors. *Applied Thermal Engineering*, 158, 113755. <https://doi.org/10.1016/j.applthermaleng.2019.113755>
13. Chen, J., Xu, X., Zhou, J., & Li, B. (2022). Interfacial thermal resistance: Past, present, and future. *Reviews of Modern Physics*, 94(2). <https://doi.org/10.1103/revmodphys.94.025002>
14. Concept Group LLC. (2024, November 7). What are the different types of heat transfer? | Thermal Engineers Explain. <https://conceptgroupllc.com/glossary/what-is-heat-transfer/>
15. Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
16. Danpal (2022). Why thermal insulation is so important when choosing roofing materials. <https://danpal.com/thermal-insulation-important-choosing-roofing-materials/>
17. Delmastro, C. Chen, O. D'Agrain, F. De Bienassis, T.; Camarasa, C. Le Marois, J.-B. Petrichenko, K. IEA (2022), US International Energy Agency, Buildings, IEA, Paris. Available online: <https://www.iea.org/energy-system/buildings> (22 December, 2023)
18. Dinno, A. (2015). Nonparametric pairwise multiple comparisons in independent groups using Dunn's Test. PDX Scholar. https://pdxscholar.library.pdx.edu/commhealth_fac/44/#:~:text=Dunn's%20test%20is%20the%20appropriate,Stata's%20built%20Din%20kwallis%20command.3
19. Do, N. H., Luu, T. P., Thai, Q. B., Le, D. K., Chau, N. D. Q., Nguyen, S. T., ... & Duong, H. M. (2020). Heat and sound insulation applications of pineapple aerogels from pineapple waste. *Materials Chemistry and Physics*, 242, 122267. <https://www.sciencedirect.com/science/article/pii/S025405841931082>
20. Elusma, M., Tung, C., & Lee, C. (2022). Agricultural drought risk assessment in the Caribbean region: The case of Haiti. *International Journal of Disaster Risk Reduction*, 83, 103414. <https://doi.org/10.1016/j.ijdrr.2022.103414>
21. Ezema, I. C. (2019). *Materials*. In Elsevier eBooks (pp. 237–262). <https://doi.org/10.1016/b978-0-12-811749-1.00007-9>
22. Fučkar, N. S. (2024). Extreme heatwaves in south and south-east Asia are a sign of things to come. The Conversation. <https://theconversation.com/extreme-heatwaves-in-south-and-south-east-asia-are-a-sign-of-things-to-come-229832>
23. Gary. (2024, May 31). Thermal Insulator Examples and their Uses. Axim Mica. <https://aximmica.com/thermal-insulator-examples/>
24. Gaziulusoy, İ., & Öztekin, E. E. (2019). Design for Sustainability Transitions: origins, attitudes, and future Directions. *Sustainability*, 11(13), 3601. <https://doi.org/10.3390/su11133601>
25. GeeksforGeeks. (2024, February 1). KolmogorovSmirnov test (KS test). GeeksforGeeks. <https://www.geeksforgeeks.org/kolmogorov-smirnov-test-ks-test/>

26. Gimongala, A. S., Hasudungan, P., & Vergara, D. (2020, March 25). Localization of Areas to Maximize Production of Rambutan, *Nephelium lappaceum* (Linn.) In the Philippines... International Journal of Cognition and Technology; John Benjamins Publishing Company. https://www.researchgate.net/publication/350373320_localization_of_areas_to_maximize_production_of_rambu
27. Hayes, A. (2024, June 27). Descriptive Statistics: definition, overview, types, and examples. Investopedia. https://www.investopedia.com/terms/d/descriptive_statistics.asp
28. Hernández-Hernández, C., Aguilar, C., Rodríguez-Herrera, R., Flores-Gallegos, A., Morlett-Chávez, J., Govea-Salas, M., & Ascacio-Valdés, J. (2019). Rambutan(*Nephelium lappaceum* L.): Nutritional and functional properties. *Trends in Food Science & Technology*, 85, 201–210. <https://doi.org/10.1016/j.tifs.2019.01.018>
29. Hot Disk AB. (2024, November 22). ISO-Standards of the Hot Disk® Method - Technology - Hot Disk. Hot Disk. <https://www.hotdiskinstruments.com/technology/iso-standardisation-of-the-hot-disk-method/>
30. Huang, H.; Zhou, Y.; Huang, R.; Wu, H.; Sun, Y.; Huang, G.; Xu, T. Optimum insulation thicknesses and energy conservation of building thermal insulation materials in Chinese zone of humid subtropical climate. *Sustain. Cities Soc.* 2020, 52, 101840.
31. Hurtado, P. L., Rouilly, A., Vandenbossche, V., & Raynaud, C. (2015). A review of the Properties on the properties of cellulose fibre insulation. *Building and Environment*, 96, 170–177. <https://doi.org/10.1016/j.buildenv.2015.09.031>
32. Insulation, M. (2022, December 7). Benefits of sustainable insulation materials. MILO Insulation <https://www.miloinsulation.com/post/benefits-of-sustainable-insulation-materials>
33. Kamel, E., Habibi, S., & Memari, A. M. (2023). State of the practice review of moisture management in residential buildings through sensors. *Structures*, 59, 105698. <https://doi.org/10.1016/j.istruc.2023.105698>
34. Katharina. (2024, December 11). Method of the HFM - Linseis. Linseis. <https://www.linseis.com/en/methods/heat-flow-meter-method-hfm/>
35. Kenton, W. (2024, July 30). What is an analysis of variance (ANOVA)? Investopedia. <https://www.investopedia.com/terms/a/anova.asp>
36. Khargotra, R., Alam, T., Thu, K., Sebestyén, V., András, K., & Singh, T. (2023). Experimental study of eco-friendly insulating materials for solar thermal collectors: A sustainable built environment. *Results in Engineering*, 21, 101681. <https://doi.org/10.1016/j.rineng.2023.101681>
37. Kruskal-Wallis H Test in SPSS Statistics | Procedure, output and interpretation of the output using a relevant example. (2018). <https://statistics.laerd.com/spss-tutorials/kruskal-wallis-h-test-using-spss-statistics.php#:~:text=The%20Kruskal%2DWallis%20H%20test,continuous%20or%20ordinal%20dependent%20variable.>
38. Kumar, P., et al. (2016). Thermal and acoustic properties of coconut coir insulation. *Journal of Building Engineering*, 6, 239-246.
39. Kumar, P., et al. (2020). Thermal and crystalline properties of rambutan cellulose. *Carbohydrate Polymers*, 230, 115704
40. Le, D. H. A., & Pásztor, Z. (2023). Experimental study of thermal resistance values of natural fiber insulating materials under different mean temperatures. *South-East European Forestry*, 14(1), 93–99. <https://doi.org/10.15177/seefor.23-03>
41. Liu, Y., et al. (2019). Corn cob insulation: Thermal and mechanical properties. *Journal of Building Engineering*, 24, 102739.
42. Maafa, I. M., Abutaleb, A., Zouli, N., Zeyad, A. M., Yousef, A., & Ahmed, M. (2023). Effect of agricultural biomass wastes on thermal insulation and self-cleaning of fired bricks. *Journal of Materials Research and Technology*, 24, 4060–4073. <https://doi.org/10.1016/j.jmrt.2023.03.189>
43. Marín-Calvo, N., González-Serrud, S., & James-Rivas, A. (2023). Thermal insulation material produced from recycled materials for building applications: cellulose and rice husk-based material. *Frontiers in Built Environment*, 9. <https://doi.org/10.3389/fbuil.2023.1271317>
44. Martínez-García, C., González-Fontebao, B., Carro-López, D., Martínez-Abella, F., & Pérez Ordóñez, J. L. (2019). Characterization of mussel shells as a bio-based building insulation material. *Academic Journal of Civil Engineering*, 37(2), 525-531. <https://doi.org/10.26168/icbbm2019.76>

45. McClenaghan, E. (2024, May 3). The Kruskal–Wallis Test. Informatics From Technology Networks. <https://www.technologynetworks.com/informatics/articles/the-kruskal-wallis-test-370025>
46. Molesky, S., Venkataram, P. S., Jin, W., & Rodriguez, A. W. (2020). Fundamental limits to radiative heat transfer: Theory. *Physical Review. B/Physical Review. B*, 101(3). <https://doi.org/10.1103/physrevb.101.035408>
47. Montrose, G. (2023). Study of the Thermal Performance of Bio-Sourced Materials Used as Thermal Insulation in Buildings under Humid Tropical Climate. www.academia.edu. https://www.academia.edu/100807153/Study_of_the_Thermal_Performance_of_Bio_Sourced_Materials_Used_as_Thermal_Insulation_in_Buildings_under_Humid_Tropical_Climate
48. Muthukumar, N., Thilagavathi, G., & Kiruba, T. (2024). Effect of bonding techniques on thermal insulation and biodegradation of banana fiber/recycled polyester nonwovens. *Journal of Reinforced Plastics and Composites*. <https://doi.org/10.1177/07316844231162138>
49. Nurul, F., et al. (2018). Extraction and characterization of cellulose from rambutan fruit. *Journal of Polymers and the Environment*, 26(4), 1056-1065.
50. Oliveira, E., Santos, J., Goncalves, A., Mattedi, S., & Jose, N. (2016). Characterization of the Rambutan Peel Fiber (*Nephelium lappaceum*) as a Lignocellulosic Material for Technological Applications. *Chemical Engineering Transactions*, 50, 391–396. <https://doi.org/10.3303/cet1650066>.
51. Paragondeve. (2020, April 21). Types of heat transfer to prevent for effective insulation - paragon.Paragon Protection. <https://www.paragon-protection.com/types-of-heat-transfer-to-prevent-for-effective-insulation/>
52. PCC Group. (2025, January 23). Thermal resistance – a key parameter in building insulation. PCC Group Product Portal. <https://www.products.pcc.eu/en/blog/thermal-resistance-a-key-parameter-in-building-insulation/>
53. Pwdadmin. (2024, December 2). A Comprehensive Guide to Commercial Insulation | AIS Group. AIS Group. <https://www.ais-group.com.au/blog/a-comprehensive-guide-to-commercial-insulation/#:~:text=Understanding%20Commercial%20Insulation&text=It%20is%20a%20protective%20envelope,cooling%20systems%20to%20work%20overtime>
54. Rahman, M. M., et al. (2020). Mechanical properties of rambutan cellulose-reinforced polypropylene composites. *Journal of Reinforced Plastics and Composites*, 39(11-12), 435-444.
55. Rahman, M. A., et al. (2020). Rambutan cellulose-based biocomposites: Mechanical and thermal Properties. *Journal of Composite Materials*, 54(11), 1421-1433.DOI: 10.1177/00219983209223
56. Reddy, K. R., et al. (2018). Banana fiber insulation: Thermal and acoustic properties. *Journal of Natural Fibers*, 15(4), 539-547.
57. Santos, P. H. S., et al. (2019). Sugarcane bagasse insulation: Thermal and fire resistance properties. *Journal of Building Engineering*, 25, 102774.
58. Suharty, N. S., et al. (2019). Properties of paper made from rambutan cellulose. *Journal of Natural Fibers*, 16(4), 539-547.
59. Reynoso, L. E., Romero, Á. B. C., Viegas, G. M., & Juan, G. a. S. (2021). Characterization of an alternative thermal insulation material using recycled expanded polystyrene. *Construction and Building Materials*, 301, 124058. <https://doi.org/10.1016/j.conbuildmat.2021.124058>
60. Rony, M. K. K., & Alamgir, H. M. (2023). High temperatures on mental health: Recognizing the Association and the need for proactive strategies-A perspective. *Health science reports*, 6(12), e1729. <https://doi.org/10.1002/hsr2.1729>
61. Schritt, H., & Pleissner, D. (2022). Recycling of organic residues to produce insulation composites: A review. *Cleaner Waste Systems*, 3, 100023.
62. Simond, M. (2023, September 6). Thermal conductivity measurement - Calnesis Laboratory. Calnesis Laboratory. <https://www.calnesis.com/en/measurements/thermal-conductivity/>
63. Suharty, N. S., et al. (2019). Mechanical properties of rambutan cellulose paper. *Journal of Pulp and Paper Science*, 45(1), 1-8. DOI: 10.3183/JPPS-2019-006
64. Silva, A., Gaspar, F., & Bakatovich, A. (2023). Composite Materials of Rice Husk and Reed Fibers for Thermal Insulation Plates Using Sodium Silicate as a Binder. *Sustainability*, 15(14), 11273.

65. Tec-Science. (2020, February 11). tec-science. <https://www.tec-science.com/thermodynamics/heat/laser-flash-method-for-determining-thermal-conductivity-lfa/>
66. Testbook. (2023, April 11). Average Deviation Calculator With Steps - Check Solved Examples. Testbook. [https://testbook.com/calculators/average-deviation-calculator#:~:text=The%20mean%20deviation%20\(also%20known,each%20value%20in%20the%20set.](https://testbook.com/calculators/average-deviation-calculator#:~:text=The%20mean%20deviation%20(also%20known,each%20value%20in%20the%20set.)
67. Thermtest. (2015). History.2 – The Guarded Hot Plate Method. <https://thermtest.com/history-2-the-guarded-hot-plate-method>
68. Tingting, Z., Xiuli, Z., Kun, W., Liping, S., & Yongliang, Z. (2022). A review: extraction, phytochemicals, and biological activities of rambutan (*Nephelium lappaceum* L) peel extract. *Heliyon*, 8(11), e11314. <https://doi.org/10.1016/j.heliyon.2022.e11314>
69. Tinoy, M. M., Novero, A. U., Landicho, K. P., Baloloy, A. B., & Blanco, A. C. (2019). Urban effects on land surface temperature in Davao City, Philippines. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42, 433-440.
70. Tripathi, P. C. (2021). Rambutan (*Nephelium lappaceum* var. *lappaceum*). *Tropical Fruit Crops: Theory to Practical*, 542-575.
71. Thermal conductivity – what it is and it's formula. (2024, November 18). Thermtest. <https://thermtest.com/what-is-thermal-conductivity>
72. Thermal Conductivity and Thermal Resistance Calculator - ThermTest. (2023, April 14). Thermtest. <https://thermtest.com/thermal-resources/thermal-conductivity-and-thermal-resistance-calculator>
73. Thomas, L. (2020, August 28). Simple random sampling: Definition, steps & examples. <https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.scribbr.com/methodology/simple-random-sampling/&ved=2ahUKEwj60Puaw2JAXX3zjQHYYVhCXoQFnoECBQQAQ&usq=AOvVaw1QEZuZN-teizUCs-VTdkRn>
74. Torgbo, S., Sukyai, P., Khantayanuwong, S., Puangsin, B., Srichola, P., Sukatta, U., Kamonpatana, P., Beaumont, M., & Rosenau, T. (2022). Assessment of Electrothermal Pretreatment of Rambutan (*Nephelium lappaceum* L.) Peels for Producing Cellulose Fibers. *ACS Omega*, 7(44), 39975–39984. <https://doi.org/10.1021/acsomega.2c04551>
75. Torgbo, S., Sukyai, P., Sukatta, U., Böhmendorfer, S., Beaumont, M., & Rosenau, T. (2023). Cellulose fibers and ellagitannin-rich extractives from rambutan (*Nephelium Lappaceum* L.) peel by an eco-friendly approach. *International Journal of Biological Macromolecules*, 259, 128857. <https://doi.org/10.1016/j.>
76. What is ANOVA and what can I use it for? | Qualtrics AU. (2024, March 7). Qualtrics. <https://www.qualtrics.com/en-au/experience-management/research/anova/>
77. Wong, Y. C., et al. (2022). Adsorption of methylene blue dye onto rambutan cellulose-based adsorbents. *Journal of Environmental Chemical Engineering*, 10(2), 107344. WWO.BLL.Weather.bllGlobalResources.GetGlobalResourceValue("Default_Title. (2024). Digos annual weather averages - davao del sur, PH. [Worldweatheronline.com. https://www.worldweatheronline.com/digos-weather-averages/davao-del-sur/ph.aspx](https://www.worldweatheronline.com/digos-weather-averages/davao-del-sur/ph.aspx)
78. Wong, K. L., et al. (2022). Thermal insulation properties of rambutan cellulose-based foams. *Journal of Cellular Plastics*, 58(1), 53-64. DOI: 10.1177/0021955X221077551
79. Yang, Q., et al. (2020). Cotton stalk insulation: Thermal and acoustic properties. *Construction and Building Materials*, 242, 118144.
80. Yana, D. ., Husna, R. ., Kusmawati, I., Ginting, D. ., Syahputra, R. F., & Taer, E. (2024). FABRICATION OF THERMAL BIO-INSULATOR FROM OIL PALM TRUNK FIBER: ANALYSIS OF THERMAL, PHYSICAL AND MECHANICAL PROPERTIES. *Indonesian Physical Review*, 7(2), 194–208. <https://doi.org/10.29303/ipr.v7i2.279>
81. Zander, K. K., Cadag, J. R., Escarcha, J., & Garnett, S. T. (2018). Perceived heat stress increases with population density in urban Philippines. *Environmental Research Letters*, 13(8), 084009. <https://doi.org/10.1088/1748-9326/aad2e5>
82. Zhang, Y., et al. (2018). Rice straw insulation: Thermal and moisture buffering properties. *Construction and Building Materials*, 173, 681-688.
83. Zdybel, E., Tomaszewska-Ciosk, E., Głowczyńska, G., & Drożdż, W. (2014). The heat insulating properties of potato starch extruded with the addition of chosen by-products of the food industry. *Polish Journal of Chemical Technology*, 16(4), 28–32. <https://doi.org/10.2478/pjct-2014-0065>

APPENDIX

Appendix A

Certificate of Editing and Statistical Review

Certificate of Editing and Statistical Review

Name of Students: Dhanayah Ai Con Alicaba, Fiona Gail E. Aradillos, Franz Rafael G. Basaln, Mary Eunice O. Diez, Adri Doniel C. Ende, Paul Andrew W. Gallego, Kirk Jared M. Geralde, Dave M. Grande, Aeron Joshua P. Ladiza

Grade and Specialization: GRADE 12 – HEALTH STUDIES

Research Title: Rambushield: Evaluating The Thermal Conductivity And Resistance Of Rambutan (*Nephelium lappaceum* L.) Peels

As An Insulating Material

PART I. For Editor

This is to certify that the above study, prepared as a requirement for the basic education, was submitted to the undersigned for grammar checking and proofreading. I endorse the manuscript submitted as it has generally met the standards and requirements, including the form and style as prescribed by Cor Jesu College.

Signed: APPLE JOY P. FLORES, MEd-LT

Date: _____

PART II. For Statistician

I endorse the manuscript submitted by the student with the statistical requirements checked and found appropriate for thesis purpose(s).

Signed: CLEFORD JAY D. BACAN, MAEd-MT

Date: _____

PART III. For Research Adviser/Mentor

I am satisfied with the student's manuscript and accept this in partial fulfillment of the requirements for the degree identified.

Signed: CLEFORD JAY D. BACAN, MAEd-MT

Date: _____

Appendix B

Letter Of Permission

January 30, 2025

DIGOS CITY

Greetings!

I am writing to request permission to use the equipment of **CENTER FOR SUSTAINABLE POLYMERS - CSP** for conducting research entitled **RAMBUSHIELD: EVALUATING THE THERMAL PROPERTIES AND MOISTURE MANAGEMENT OF RAMBUTAN (*Nephelium lappaceum* L.) PEELS AS AN INSULATING MATERIAL**

We assure you that we will adhere to all laboratory rules, safety protocols, and guidelines during our activities. If needed, we can provide additional details or documentation regarding our project. We kindly request your support in granting permission for the use of the laboratory.

Respectfully yours,

Aradillos, Fiona Gail E.

Noted by:

Cleford Jay Bacan

Research Adviser

Appendix C

Practical Research 2

Financial Statement

Research Title:	RAMBUSHIELD: ASSESSING THE THERMCONDUCTIVITY OF RAMBUTAN (<i>Nephelium lappaceum</i>) PEELS AS AN INSULATING MATERIAL
Grade and Section:	Grade 12 - STEM 1
Submission Date:	January 15, 2025

Particulars	Price	Quantity	Amount
Rambutan	₱30.00	10 (kilo)	₱300.00
Heat Flow Meter	₱1,850.00 (per test)	2	₱3,700.00
Wooden sticks	₱25.00	1	₱25.00
Wood Glue	₱80.00	3	₱240.00
Plywood	₱580	1	₱580
TOTAL	₱6,695.00		

Prepared by

Fiona Gail E. Aradillos

Group Leader

Noted by

Cleford Jay D. Bacan, Maed-Mt

Research Teacher

Approved by

Jun Rey D. Dequiña, Matcc

School Principal

Appendix D

Captured Photo Evidence



(a)



(b)



(c)



(d)



(e)



(f)

Figure 1. Creation and testing of the RAMBUSHIELD insulator. The materials such as rambutan peels, binding agent, and wood were gathered (a). The rambutan peels are then cut into small bits (b). The binding agent was then applied to the cut up rambutan peels (c). The mold was made in order to help shape the insulator (d). The rambutan mixture was put on the mold to be shaped (e). The rambutan was then tested for its thermal conductivity and resistance (f).

RAMBUTAN PEEL 1									
	Tupper	Tlower	Qupper	Qlower	T-difference	Q-difference	Thickness	Area	Lambda
	[°C]	[°C]	[μV]	[μV]	[°C]	[μV]	mm	A	[W/mmK]
-ne-	15.05	35.03	-3506	3600	19.98	7106	25.4	23225.76	0.3889497547
-te-	14.97	34.99	-3368	3537	20.02	6905			0.3771927985
-te-	15.01	35.01	-3436	3578	20	7014			0.3835301837
-te-	15.01	35.01	-3352	3601	20	6953			0.3801946632
-te-	15.01	35.01	-3388	3610	20	6998			0.3826552931
-pe-	15.04	35.02	-3409	3613	19.98	7022			0.384351981
-pe-	14.99	35.02	-3388	3614	20.03	7002			0.3823005649
-pe-	15	35.02	-3375	3613	20.02	6988			0.3817267597
								Average:	0.3826127498
RAMBUTAN PEEL 2									
	Tupper	Tlower	Qupper	Qlower	T-difference	Q-difference	Thickness	Area	Lambda
	[°C]	[°C]	[μV]	[μV]	[°C]	[μV]	mm	A	[W/mK]
-ne-	15.24	34.44	-3771	5517	19.2	9288	25.4	23225.76	0.5290354331
-ne-	15.03	35.01	-3098	3456	19.98	6554			0.3587358137
-te-	14.97	34.78	-3141	3243	19.81	6384			0.3524294446
-ne-	15.03	35.01	-3083	3309	19.98	6392			0.3498686788
-te-	15.03	34.74	-3070	3156	19.71	6226			0.3454508572
-ne-	15.04	35.01	-3070	3271	19.97	6341			0.3472509727
-te-	15.02	34.71	-3123	3114	19.69	6237			0.346412704
-ne-	15.02	35.01	-3166	3246	19.99	6412			0.3507878174
-te-	15.02	34.81	-3172	3117	19.79	6289			0.3475358279
-ne-	15.03	35.02	-3183	3205	19.99	6388			0.3494748249
-te-	15.03	35.28	-3142	3278	20.25	6420			0.3467159198
-ne-	15.03	35.01	-3148	3147	19.98	6295			0.344559345
-te-	15	35.08	-3088	3186	20.08	6274			0.3416996929
-te-	15.01	35.01	-3097	3154	20	6251			0.3418088364
-pe-	15.01	35.02	-3092	3154	20.01	6246			0.3413647507
-pe-	15.02	35.02	-3092	3151	20	6243			0.3413713911
-pe-	14.97	35.02	-3059	3150	20.05	6209			0.3386655845
								Average:	0.3572451703

Figure 2. Statistical Results of Rambushield's Thermal Conductivity. The figure includes the average thermal conductivity calculated from the results of setup 1 and setup 2. This shows the evaluation of both the individual setup performance and the overall average thermal conductivity. Thermal Resistance was calculated using the formula for the thickness divided by the lambda given by the Heat Flow Meter's datasheet.

APPENDIX E

Plagiarism Report

RAMBUSHIELD EVALUATING THE THERMAL CONDUCTIVITY AND RESISTANCE OF RAMBUTAN (*Nephelium lappaceum* L.) PEELS AS AN INSULATING MATERIAL.docx

ORIGINALITY REPORT:

9%	8%	2%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS
PRIMARY SOURCES:			
1	www.products.pcc.eu	Internet Source	1%
2	www.coursehero.com	Internet Source	1%
3	Submitted to auf	Student Paper	1%
4	www.mdpi.com	Internet Source	1%
5	huggingface.co	Internet Source	1%
6	Submitted to Liverpool John Moores University	Student Paper	1%
7	www.geeksforgeeks.org	Internet Source	<1%
8	physics-network.org	Internet Source	<1%

Appendix F

Spss Results

Tests of Normality									
		Kolmogorov-Smirnov			Shapiro-Wilk				
		Statistic	df	Sig.	Statistic	df	Sig.		
Thermal Conductivity		.364	9	.001	.698	9	.001		
Thermal Resistance		.402	9	.000	.645	9	.000		
a. Lilliefors Significance Correction									
Descriptives									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Thermal Conductivity	T1	3	.38279000	.001381774	.000797768	.37935748	.38622252	.381720	.384350
	T2	3	.34046333	.001561740	.000901671	.33658375	.34434291	.338660	.341370
	Control	3	.04833667	.000609289	.000351773	.04682311	.04985022	.047640	.048770
	Total	9	.25719667	.157717313	.052572438	.13596441	.37842893	.047640	.384350
Thermal Resistance	T1	3	.06635667	.000236291	.000136423	.06576969	.06694365	.066090	.066540
	T2	3	.07460667	.000340637	.000196667	.07376048	.07545286	.074410	.075000
	Control	3	.31718333	.004027224	.002325119	.30717915	.32718751	.314330	.321790
	Total	9	.15271556	.123419153	.041139718	.05784720	.24758391	.066090	.321790

Nonparametric Tests

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Thermal Conductivity is the same across categories of Setup.	Independent-Samples Kruskal-Wallis Test	.027	Reject the null hypothesis.
2	The distribution of Thermal Resistance is the same across categories of Setup.	Independent-Samples Kruskal-Wallis Test	.027	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is .050.				

Independent-Samples Kruskal-Wallis Test

Thermal Conductivity across Setup

Independent-Samples Kruskal-Wallis Test Summary					
Total N			9		
Test Statistic			7.200 ^a		
Degree Of Freedom			2		
Asymptotic Sig.(2-sided test)			.027		
a. The test statistic is adjusted for ties.					
Pairwise Comparisons of Setup					
Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. ^a
Control-T2	3.000	2.236	1.342	.180	.539
Control-T1	6.000	2.236	2.683	.007	.022
T2-T1	3.000	2.236	1.342	.180	.539
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .05.					
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.					

Thermal Resistance across Setup

Independent-Samples Kruskal-Wallis Test Summary	
Total N	9
Test Statistic	7.261 ^a
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.027
a. The test statistic is adjusted for ties.	

Pairwise Comparisons of Setup					
Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. ^a
T1-T2	-3.000	2.227	-1.347	.178	.534
T1-Control	-6.000	2.227	-2.695	.007	.021
T2-Control	-3.000	2.227	-1.347	.178	.534
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .05.					
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.					

Curriculum Vitae



PERSONAL BACKGROUND

Name : Dhanayah Ai Con Alicaba
Birth Date : June 8, 2006
Birth Place : Digos City
Address : 1619 Purok Liwanag Gatmaitan St. Bansalan Davao Del Sur
Civil Status : Single
Religion : Catholic

EDUCATIONAL BACKGROUND

Elementary : St. Marys College of Bansalan Inc.
Junior High School : St. Marys College of Bansalan Inc.
Senior High School : Cor Jesu College Inc.



PERSONAL BACKGROUND

Name : Fiona Gail E. Aradillos
Birth Date : June 5, 2007
Birth Place : Digos City
Address : Luna Ext., Digos City Davao Del Sur
Civil Status : Single
Religion : Catholic

EDUCATIONAL BACKGROUND

Elementary : Don Mariano Marcos Elementary School

Junior High School : Cor Jesu College, Inc.

Senior High School : Cor Jesu College, Inc.



PERSONAL BACKGROUND

Name : Franz Rafael G. Basalan

Birth Date : May 31, 2006

Birth Place : Digos City

Address : Jancito Corigidor

Civil Status : Single

Religion : Catholic

EDUCATIONAL BACKGROUND

Elementary : Digos Central Adventist Academy

Junior High School : Digos Central Adventist Academy

Senior High School : Cor Jesu College Inc.



PERSONAL BACKGROUND

Name : Mary Eunice O. Diez

Birth Date : January 27, 2007

Birth Place : Southern Philippines Medical Center

Address : Poblacion Hagonoy Davao Del Sur

Civil Status : Single

Religion : Baptist

EDUCATIONAL BACKGROUND

Elementary : Hagonoy Central Elementary School

Junior High School : Holy Cross of Hagonoy Inc.

Senior High School : Cor Jesu College Inc.



PERSONAL BACKGROUND

Name : Adri Doinel C. Ende

Birth Date : August 2, 2007

Birth Place : Dominican Hospital, Digos City

Address : Burgos, Corregidor street, Digos City Davao Del Sur

Civil Status : Single

Religion : Free Methodist

EDUCATIONAL BACKGROUND

Elementary : Ramon Magsaysay Elementary School Digos City

Junior High School : Holy Cross Inc., Digos City

Senior High School : Cor Jesu College Inc., Digos City



PERSONAL BACKGROUND

Name : Paul Andrew W. Gaellego

Birth Date : July 29, 2007

Birth Place : Barinque Clinic, Digos City, Davao Del Sur

Address : Chapter 7, Tienda Aplaya, Digos City

Civil Status : Single

Religion : Christian

EDUCATIONAL BACKGROUND

Elementary : Bulacan Elementary School
Junior High School : Holy Cross of Malalag, Inc.
Senior High School : Cor Jesu College, Inc.



PERSONAL BACKGROUND

Name : Kirk Jared M. Geralde
Birth Date : February 26, 2007
Birth Place : MCDC, Digos City
Address : Ceboley Beach Zone III
Civil Status : Single
Religion : Roman Catholic

EDUCATIONAL BACKGROUND

Elementary : Santa Cruz Central Elementary School
Junior High School : Santa Cruz National High School
Senior High School : Cor Jesu College, Digos City



PERSONAL BACKGROUND

Name : Aeron Joshua P. Ladiza
Birth Date : December 11, 2006
Birth Place : Davao Doctors Hospital, Quirino Avenue, Davao City
Address : Emily Homes Subdivision, Tres De Mayo, Digos City
Civil Status : Single

Religion : Born Again Christian

EDUCATIONAL BACKGROUND

Elementary : Digos City Central Elementary School

Junior High School : Cor Jesu College, Inc. - Digos City National High School

Senior High School : Cor Jesu College, Inc.