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The Potential of Durian Husk, Durian Leaf-Litter and Banana Pseudo Stem as Bio-Leather

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Abstract- This study aimed to investigate the potential of durian husk, durian leaf litter, and banana pseudo stem as bio-leather. The bio leather was made from durian husk, durian leaf litter and banana pseudo stem. The bio leather made from these materials were tested in terms of its thickness, elongation and tensile strength. Also, as comparison the synthetic leather was tested according to its thickness, elongation and compression strength. The tests were performed at TERMS Concrete and Materials Testing Laboratory, Inc. Data were analyzed using mean and Mann Whitney U test. Results showed that, bio leather can be used to make light weight wallets since it only requires less thickness, low percentage of elongation and low tensile strength. For synthetic leather, can be used to make bags since the values of the indicators are high. The bio leather and synthetic leather do not significantly differ in terms of thickness, elongation and tensile strength; therefore, bio leather can be a good substitute for synthetic leather in making valuable items with high economic value.

Index Terms- Durio zibethinus, Seed, Waste

I. INTRODUCTION

Waste doesnt have to be necessarily wasted away, but rather transform that nothing, into something, something that could lessen the agricultural wastes in our community, along with this are the durian husk, durian leaf litter, and banana pseudo stem. Just to let everyone know; environmental problems stem from actions affecting our surroundings through pollution control issues, like waste disposal and climate shifts leading to greenhouse gas emissions and global warming concerns.

Durian (Durio zibethinus), approximately its edible part that can only be eaten is 1530% of the entire mass of the fruit. In Malaysia, approximately 70 85% of the fruit is discarded as waste and would be an environmental problem if not disposed of in a proper manner. Durian husk can be seen as the primary contributor for agricultural wastes with increasing volume, with approximately reached 480 000 metric tons of durian wastes produced every year. It will account a larger area for disposal area, especially in landfill sites, and with limited spaces exist nowadays that needed to decompose the waste (Payus, et al, 2021). In Thailand, durian leaves are commonly discarded as waste in the process of pruning the tree branches along the crop production (Kam, et al, 2018). As per data, from the Department of Agriculture; around 22 thousand metric tons of durian husks are generated yearly in the country; a large portion ends up in landfills or worse left decaying by roadsides (RAJ Gamay, 2024). On the other hand, (Daphne Ewing-Chow, 2022) stated that banana is the second most widely enjoyed tropical fruit consumed worldwide, with the accounts for 16% of global fruit output with an estimated 119.83 million tons produced every year.
In the Philippines durian remnants, the shells are commonly thrown away leading to pollution, in the environment. Philippines produces around 54,700 metric tons of durian, with majority of production areas located in Mindanao. The flesh and seeds make up around 60 percent of the fruit, while the husk or skin which is generally considered waste material represents 40 percent or 21,880 metric tons (Gamay et al., 2024c). On the other hand, in the Philippines, banana pseudo stems (BPS), which comprise about 60% of a banana plant's mass, represent a significant waste fraction in banana farms as they are cut down after each harvest (Castillo,et. al, 2023). In the Philippines, the banana waste is significant, with approximately 60% of banana biomass discarded post-harvest, leading to environmental concerns such as greenhouse gas emissions (Acevedo et al., 2021). The durian leaf litter is decomposed in the soil with not much use.

With the enormous waste generated by durian husks, durian leaf litter and banana pseudo stem, therefore it is essential to reduce these wastes by making them as composite materials for bio leather. Reducing these wastes will result to low percentage of carbon footprints and making these wastes more economically helpful to the community.

Durian leather is made from genuine hide, sourced from the finest Italian tanneries. With its grained yet buttery soft texture, it looks and feels opulent. The leather ages and grows with you, making it one of a kind. Breathable upholstery maintains a balance of aesthetics and comfort of your leather sofas and chairs. A perfect choice of material meant for those looking to infuse a sense of grandeur into their space. (Durian furniture, 2023)

Thailand is known for its range of durian types. Is a major player, in exporting this fruit globally. In 2022 Thailand generated USD 3.3 billion, as mentioned in a report by the Food and Agriculture Organization of the United Nations (FAO). The different kinds of durians from Thailand offer a variety of characteristics such, as pulp colors, flavors and ripening times after harvesting. Different parts of the world have preferences when it comes to fruits. Malaysia and Indonesia lean towards pungent and bitter types while Singaporeans also share a similar taste palette; on the other hand, Thailand opts for sweeter varieties, with a more subtle fragrance. The popularity of durian is increasing globally thanks to its tastes and perceived health benefits. There's a growing need for types of durians that not taste great but also offer vibrant colors in their flesh along, with improved nutritional value and longer shelf life to meet this rising demand sustainably (Gargett, 2024).

In the Philippines, durian flowers usually bloom in April to June and the durians are harvested in August to November. This gives the Philippines great prospects for export as the harvest season Is later than in other Southeast Asian countries. Presently, the country is actively expanding durian production, especially in the typhoon-free areas in Mindanao. Durian trees grow almost exclusively in Mindanao, particularly in Davao, Cotabato, Sulu and Agusan. In fact, Southern Mindanao is considered as the durian republic in the Philippines. In 2021, the Philippines yielded more than 70,000 (73,867) metric tons of fresh Durian, with Davao Region as the top producer after covering 78% of the total Durian production, (DTI, 2023).

Planet earth is getting warmer, habitat is destroyed, synthetic dyes impact on the environment and human health, animal skin and hair are used to create expensive fashionable clothes. The Fast fashion industry trend has proliferated due to its fast production and affordable prices. However, its adverse implication on the climate and the environment is quite pronounced. From various studies conducted in the past, it was already proven that Fast Fashion contributes to high greenhouse gas emissions, excessive water usage, water pollution, and generation of non-biodegradable waste or textile waste. All these factors harm environmental sustainability. Additionally, the mass production model of Fast Fashion also encourages excessive consumption, creates non-biodegradable textile waste, and increases pressure on natural resources (Anisah et al., 2024). Since the beginning of time, leather has met the necessities of humankind. Throughout history, leather has been used extensively to provide, involving the transformation of animal hides into a wide range of products such as clothes, shelter, footwear, and furniture. People have been drawn to it throughout history due to its intrinsic qualities, even if it has developed into a luxury material (The Editors Encyclopedia Britannica 2024b, 2023). Leather is always recognized as a noble material and valued for its unique properties, such as strength and elasticity, water vapor permeability, abrasion resistance, durability, and longevity (Meyer et al., 2021).

As stated by (Fernandes et al., 2019), over the last decades, the gradual push toward the development of leather analogues has been trailed by scientific researchers and the footwear industry, leading to the design of various synthetic and natural materials.

Based on (Vaisen et al., 2016), the increase in the manufacturing of leather fashion products from natural resources like animal skin is gradually becoming a critical issue to sustainability for current and future generations. Therefore, the development of alternative sources and design of eco-friendly materials is essential.

Statement of the Problem

This study aimed to investigate the potential of durian husk, durian leaf litter, and banana pseudo stem as bio-leather. Specifically, the study sought to answer the following questions;

What is the capability of durian husk, durian leaf litter, and banana pseudo stem as bio-leather when tested in terms of:

- thickness;
- elongation; and
- tensile strength?

What is the test result of synthetic leather in terms of:

- thickness
- elongation; and
- tensile strength?

Is there a significant difference in the quality of the leather between synthetic leather and bio leather made?

Research Hypothesis

This study was tested at 0.05 level of significance

Ho: There is no significant difference in the quality of the leather between synthetic and bio leather made.

Significance of the Study

This research sought to provide a benefit to such groups of people by utilizing the potential of durian husk, durian leaf litter and banana pseudo stem as bio-leather.

Department of Environmental and Natural Resources. By leveraging agricultural by-products, specifically Banana pseudo stems, Durian husk and Durian leaf litter, this study can also help the environmental agencies to promote sustainable practices. It highlights the goals of minimizing pollution and promoting eco-friendly sustainable alternatives.

Leather producers and Manufacturers. Companies and individuals that are under or working in the leather industry can benefit. By exploring plant-based bio-leather as an alternative animal leather, this offers a sustainable and potentially cost-effective option in which can help to adapt the growing demand for eco-friendly products.

Consumer Awareness and Choice. The research emphasizes the benefits of bio leather. Promotes making more eco-friendly purchasing choices to increase consumer awareness of sustainable materials.

Future Researchers. For students interested in environmental science and sustainable materials, the study can be a useful educational resource. It offers real-world examples of how to use natural resources wisely in order to solve environmental problems.

II. METHODS

In this section, the researchers presented the research design, the preparation of the materials, experimentation and data gathering procedure used in the study.

1. Research Design

This study employed a true experimental design that aimed to explore the potential of Durian husk (Durio zibethinus Murr), Durian leaf litter (Durio zibethinus) and Banana pseudo stem (Musa genus), as bio-leather. Material characteristics were observed and described. The researchers began by defining the research questions and hypotheses, with the goal of understanding the capability of durian husk, durian leaf litter and banana pseudo stem as bio-leather in terms of thickness, elongation and tensile strength and appearance, as compared to synthetic leather using the same properties. As stated in True Experimental Design (Wood et al., 2024), these properties allow other explanations for the phenomenon to be ruled out, enhancing the design's suitability for testing cause-effect relationships. This approach was applicable to the study since the goal was to determine whether it has the potential to become a bio-leather based on its thickness, elongation and tensile strength.

Phase I. Preparation of Materials

The primary materials are durian husk (Durio zibethinus Murr) 1 kg of Durian husk, 50 g, Banana pseudo stem, 100 g, Sodium Hydroxide (NaOH) 50 g (5% solution), Distilled Water 1 L, Honey 20 grams (2% solution) Beeswax 10 grams (1% solution), Polyester resin 50 g (5% solution), Lemon and Brush. Overripe Durian skins are obtained by the researchers from the Magsaysay Fruit Market Association located in Davao City, Davao del Sur. Additionally, the researchers acquired the banana pseudo stem (Musa Genus) and durian leaf litter (Durio zibethinus) from R.L.S. Avenue in Batalia Village Catalunan Pequeño, Davao City, Davao del Sur. The researchers purchased sodium hydroxide (NaOH) from Chem Vest Commercial Trading, located at Damaso Suazo ST., Brgy 30-C, Davao City.

Phase II. Experimentation

The Durian husk (Durio zibethinus) was cut into smaller pieces. In a large aluminum basin, 50g of Sodium Hydroxide was mixed with Distilled water to make a 5% solution. It is stirred until fully dissolved. The cutted durian husk was soaked in sodium hydroxide (NaOH) with 5% solution for 20 hours in the aluminum basin at room temperature. This breaks down lignin and hemicellulose. Durian husk proportionally contains high cellulose (50-60%) and lignin content (5%) and low starch content (5%) so it can be indicated that the ingredients can be used as a mixture of processed raw materials and other compressed products.

Meanwhile, banana pseudo stem (Musa Genus) was peeled to get the inner core. The 50g peeled inner core of the banana pseudo stem was soaked in a large aluminum basin with 1L of distilled water mixed with sodium hydroxide (NaOH). Soak it in 20 hours to break down the lignin and hemicellulose. The fiber contains 62.24% cellulose which is the highest among the fibers obtained from other parts of the banana plant, 15.23% hemicellulose, 18.51% lignin, 0.29% wax, 5.03% ash and 11.53% moisture. The durian leaf litter (Durio zibethinus) were also soaked with 1L of distilled water that is mixed with sodium hydroxide (NaOH) for 20 hours in a large aluminum basin. Additionally, 20g of beeswax (Cera Alba) is prepared and incorporated into the mixture to contribute to the desired leather-like texture. Beeswax plays a crucial role in enhancing the durability and water resistance of bio leather by providing hydrophobic properties and improving the feel of the finished product.

Fiber Extraction and Pulp Preparation

During the fiber extraction, after 20 hours of soaking with distilled water and NaOH, the durian husk (Durio Zibethinus Murr), durian leaf litter (Durio Zibethinus), and banana pseudo stem (Musa Genus) undergo the filtration process to remove the water.

Place the aforementioned main materials in a blender with a pure lemon extract for pulp preparation. After the main materials are pulped, add 20g of beeswax and a pinch of cinnamon and heat it for about 30 minutes. After the process, prepare the tray and pour the pulp into the tray.

Casting and Dehydration
After the husk is poured into the tray, the husks in the tray was refine using a knife. Dry it in the oven at 40 or 50 degrees Celsius for 20 minutes. After heating in the oven, the tanned leather is brushed with beeswax and honey. This helps tan the leather, improving durability and microbial resistance. 10 grams of beeswax are melted in a double boiler. Remove from heat and mix in 20 grams of honey until smooth. The beeswax and honey mixture are applied to both sides of the tanned skin using a brush. Allow it to absorb for 30 minutes. Beeswax softens and protects the leather. This helps the leather maintain its breathability but strengthens it at the same time. (Gusti Leather, 2022). In a bowl, 50 g of polyester resin is used in the coating process. The coating mixture is applied evenly to both sides of the plasticized skin using a roller or brush. The coated skin is completely dry in a well-ventilated area out of direct sunlight. The mixture should be spread evenly to achieve a uniform thickness, which will contribute to the consistency of the final bio-leather. The researchers regularly checks the mixture to ensure it is drying evenly. Any air bubbles or inconsistencies are gently smoothed out during this process. The dehydration process may take several hours, depending on the thickness of the spread mixture and the humidity level in the environment. Once the mixture has mostly dried, the temperature can be slightly increased (if necessary) to ensure all remaining moisture is removed. The bio-leather should be completely dry and firm to the touch, but still flexible. After the dehydration process is complete, the tray is removed from the oven and allowed to cool to room temperature. Once cooled, the bio-leather is carefully peeled off the surface. The bio-leather is trimmed to the desired shape and size, ready for further processing or use in making the final product If needed, a thin layer of beeswax can be applied to the surface to enhance its texture and durability.

Phase III. Testing of Parameters
Indicators in Testing
All testing indicators are performed at TERMS Concrete and Materials Testing Laboratory, Inc.. at Blk.14 Lot 51 Phase, El Rio, 4a Bacaca Road, Davao City, The laboratory in-charge managed to test the thickness, elongation and tensile strength of the bio-leather and synthetic leather.

Disposal Procedure
The extra durian skin, durian leaves and banana stem were dumped in the soil to decompose it easily. The bio leather with additives as bio-composite waste was labeled poisonous. It was sent in the Material Recovery Facility (MRF) at Barangay 28-C, Davao City.

Data Analysis
In analyzing the result of the study, the researchers used the following statistical tools.

Mean. It was utilized to measure the effectiveness of bio leather and synthetic leather respectively in terms of thickness, elongation and tensile strength.

Mann-Whitney U Test. This was used to determine if there is significant difference between the bio leather and synthetic leather.

III. RESULTS

In this section, presents the findings based on the data gathered. The presentation is organized into (3) parts. First, is the capability of durian husk, durian leaf litter, and banana pseudo stem as bio-leather when tested in terms of thickness, elongation and tensile strength. Second, is the test result of synthetic leather in terms of thickness, elongation and tensile strength. Third, is the significant difference between the quality of bio leather and synthetic leather.

Capability of Durian husk, durian leaf litter, and banana pseudo stem as bio leather

Presented in Table 1 is the result per trial and its mean of bio leather in terms of thickness, elongation and tensile strength.

Table 1: Mean Capability of Durian husk, durian leaf litter, and banana pseudo stem as bio leather

Parameters	Trials			
	Trial 1	Trial 2	Trial 3	Average
Thickness (mm)	12.110 mm	12.102 mm	12.151 mm	12.121mm
Elongation (%)	15%	16%	18%	16.3%
Tensile Strength (KN)	7.12 KN	8.21 KN	11.03 KN	8.79 KN

As presented in table 1, shows the mean capability of Durian husk, durian leaf litter, and banana pseudo stem as bio leather when tested in terms of thickness, elongation and tensile strength. For thickness it has an average of 12.121 mm, elongation has an average of 16.3% and tensile strength has an average of 8.79 KN. The thickness of the bio leather means that the more it is thicker, the more it is durable and last longer. The bio leather elongated up to 16.3% from its original length which means that the bio leather will be stretched into 16.3% before it breaks. The tensile strength of the bio leather is 8.79 KN, which means that the bio leather can hold maximum load within that value without fracture when being stretched.

Capability of synthetic leather when tested in terms of thickness, elongation and tensile strength

Presented in Table 2 is the test result of synthetic leather in terms of thickness, elongation and tensile strength.

As presented in table 2, shows the capability of synthetic leather when tested in terms of thickness, elongation and tensile strength. For thickness, elongation and tensile strength respectively it has 24.511 mm, 25% and 18.59 KN. The thickness of the synthetic leather means that the more it is thicker, the more it is durable and last longer. The synthetic leather elongated up to 25% from its original length which means that the synthetic leather will be stretched into 25% before it breaks. The tensile strength of the synthetic leather is 18.59 KN, which means that the synthetic leather can hold maximum load within that value without fracture when being stretched.

Difference between Bio leather and Synthetic leather in terms of thickness, elongation and tensile strength

Presented in Table 3 is the difference between bio leather and synthetic leather in terms of thickness, elongation and tensile strength.

Indicators	*Mean*	W	P-V*alue*	*Decision on HO*
Bio-leather	12.40	6.00	0.20	*Accept*
Synthetic leather	21.76			

Level of Significance: 0.05

The table 3 shows that the bio leather has an average of 12.40 while synthetic leather has an average of 21.76 in terms of thickness, elongation and tensile strength. It also shows that at 0.05 level of significance, do not significantly differ the thickness, elongation and tensile strength between bio leather and synthetic leather. Therefore, the study accepted the null hypothesis. This means that the quality in terms of thickness, elongation and tensile strength between bio leather and synthetic leather is the same. This means that bio leather can be a good substitute for synthetic leather that can be used in different valuable items and has great economic value.

IV. DISCUSSION

For bio leather with the mean thickness of 12.121 mm, elongation of 16.3% and tensile strength of 8.79 KN, it can be used to make light weight wallets since it only requires less thickness, low percentage of elongation and low tensile strength. According to (Kefale, 2023), bio-based leather alternatives are eco-friendly, non-toxic, and sustainable and ultimately can substitute natural leather made by conventional processing. For instance, research by Akkan (2024) points out that developments in bio-based materials (such as mushroom leather, Piñatex from pineapple fibers, and lab-grown leather) are producing vegan fabrics that mimic the texture and durability of traditional materials. This technological leap allows luxury brands to maintain high standards of quality while transitioning to more sustainable options (Kefale et al., 2023).

For synthetic leather, the thickness is 24.511 mm, elongation of 25 % and tensile strength is 18.51 KN, these data can be used to make bags since the values of the indicators are high. Synthetic leather via natural can be described as faux leather which has been emerged in recent years and became the most ideal substitute for real leather (Mohamed, et al, 2015).

Bio leather can be a good substitute for synthetic leather in making valuable items with high economic value. While traditional leather and its alternatives are sourced from animals and synthetic polymers, these renewable and sustainable leather substitutes are gained from bacterial cellulose, mycelium, plant cellulose, and animal cells using tissue engineering and other eco-friendly techniques. In conclusion, bio-based leather alternatives are eco-friendly, non-toxic, and sustainable and ultimately can substitute natural leather made by conventional (Kefale, et al., 2023).

V. CONCLUSION AND RECOMMENDATION

Presented in this section is the conclusions and recommendations drawn based on the findings of the study.

- For bio leather with the mean thickness of 12.121 mm, elongation of 16.3% and tensile strength of 8.79 KN, it can be used to make light weight wallets since it only requires less thickness, low percentage of elongation and ow tensile strength.
- For synthetic leather, the thickness is 24.511 mm, elongation of 25 % and tensile strength is 18.51 KN, these data can be used to make bags since the values of the indicators are high.
- Bio leather can be a good substitute for synthetic leather in making valuable items with high economic value

Recommendation

- Explore other agricultural waste items aside from durian husk, durian leaf litter, and banana pseudo stem as bio leather that have good properties as leather.
- Use various levels and kinds of organic binding agents like cassava starch, tree back tannins, plant extracts and preservatives that are readily available and low cost. Also, it enhances durability and flexibility even more.
- Use testing machines for leather to arrive accurate testing results.
- Create more trials in making bio leather to come up with aesthetic and durable goods and environmentally friendly and sustainable.

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