United International Journal for Research & Technology
Volume 06, Issue 05, 2025 | Open Access | ISSN: 2582-6832

Pilinana Bag: A Resilient Pineapple, Limestone, and Banana Fiber Paper as an Alternative for Paper Bag

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***Abstract*—** The study aimed to develop an eco-friendly paper bag replacement called Pilinana Bag, which uses pineapple leaves, banana tree trunks, and limestone to help minimize deforestation, pollution, and waste production. It also intended to analyze its acceptance level in terms of durability, marketability, and appearance. To that end, the participants, including paper-making professionals, business owners, and consumers, were selected using quota and snowball sampling methods. Furthermore, an innovative research design was used, in which participants completed a self-made survey questionnaire after utilizing the product. The acquired data were then statistically analyzed. Statistical treatment such as frequency, mean, standard deviation, t-Test of Independent Means, and ANOVA were used to analyze the acceptance of the Pilinana Bag. Based on the findings, the durability, marketability, and appearance of the Pilinana Bag were all rated highly acceptable. However, males considered it more marketable compared to females' assessment to the product. Therefore, the study confirmed that Pilinana Bag is acceptable in terms of sex and social roles. This indicates that using pineapple leaves, banana tree trunks, and limestone to make paper bags is a feasible option, noting its long-term sustainability.

***Keywords*—** banana tree trunks, deforestation, limestone, paper bag, Pilinana Bag, pineapple leaves, pollution.

INTRODUCTION

The Philippines is classified as a middle-income nation that faces significant challenges related to plastic waste. With an annual 591 plastic sachets used by each person, the nation utilizes close to 60 billion plastic sachets annually (Global Alliance for Incinerator Alternatives, 2019). As a result, the Philippines adopted rules and processes for paper bags as an alternative to plastic bags. However, Filipinos are now beginning to realize how harmful paper bags are damaging the environment since the production of paper bags requires the cutting down of trees, which negatively impacts both wildlife and vegetation, leading to extensive repercussions. This material change may not always result in an environmentally less harmful solution. The manufacturing of paper bags originates from trees, which points out a significant irony. Due to the rising need for paper bags, extensive tracts of forest have been cleared, resulting in deforestation. Trees are essential to the balance of nature because they absorb carbon dioxide and give. By upsetting these fragile ecosystems, deforestation puts biodiversity at risk and accelerates climate change (Uhabiba, 2023).

Paper is likely a more ecologically friendly material than plastic as it is manufactured from trees. Nevertheless, because it comes from trees, it is necessary to cut down trees in order to produce the paper. On the contrary, one ton of paper requires 24 trees to produce. Approximately 90% of paper pulp is derived from wood, and 35% of all fallen trees are used to create paper. Yearly, 3 billion trees are cut down globally for paper-based packaging (Oxo-Biodegradable Plastics Association, 2019), and according to Department of Environment and Natural Resources (DENR), the Philippines alone needs 52,000 trees to produce paper bags daily.

Producing paper bags removes one of the most effective methods for reducing contamination and contributes additional waste to the environment (Lober, 2018). Furthermore, one of the biggest producers of waste products, gases that contribute to the changes environmentally, and pollutants in the air and water worldwide is the pulp and paper sector (CARTLY,2023).

Lober (2018) claims that paper bags emit 70 percent more pollutants than plastic bags. During the papermaking process, industries generate several hazardous gases. Among these gases include methanol, volatile organic compounds, ammonia, carbon monoxide, nitrogen oxide, nitrates, mercury, benzene, and chloroform (CARTLY, 2023).

Paper bags contribute to the pollution of water bodies, creating a significant issue as a substantial quantity of wastewater is generated for every metric ton of paper manufactured, depending on the initial resources,

completed item, and amount of water. The pulp and paper mills generate solids, dissolved materials like lignin, and nutrients. They blend effectively with the nearby water bodies. Chlorine and bleach are important chemicals needed in the production of paper, and these all end up in streams and water sources. These contaminants harm essential microorganisms and insects within the water. Furthermore, these harmful substances affect aquatic plants, and producing paper demands a considerable amount of water (CARTLY, 2023).

Considering the harm that paper bags cause to the society, producing alternative paper bags from a mix of pineapple and banana fibers with limestone is more economically advantageous because these are more plenty in the Philippines. This means these are faster to develop compared to trees that take up to 15 years to produce (Paper Pledge, 2023).

Using pineapple fibers can be a good alternative to paper bags. In line with Sibaly and Jeetah (2017), pineapples developed by selective breeding were found to have a greater cellulose content than wood fiber, indicating that such non-timber fibers are acceptable alternatives. Aside from less tree cutting, additional benefits of the plant include short growth cycles and low lignin content, which improves the use of energy and chemicals during the pulping process. On top of that, Silang, Cavite (Philippines) is known as consistently the highest producer of pineapple, producing 23,222.10 metric tons and pineapple leaves that would otherwise end up on materials discovered in a landfill. These may be appreciated for their true potential as a source of natural fibers (Provincial Government of Cavite, 2020). Alongside pineapple fiber, banana fiber can also be used. As studies show that almost all components of the banana plant's processing leftovers can be converted into paper. Due to the significant availability of banana waste in the country, it is a promising idea to implement cleaner production methods for producing banana paper (Ramdhonee & Jeetah, 2017). The concept may potentially produce a sustainable economy in the Philippines as banana plants grow well in hot temperatures and tropical regions of the world.

The durable Pilinana bag's pineapple and banana fibers are bound together with limestone. Limestone is an innovative material that may replace traditional paper owing to its qualities and is utilized as an ecological alternative for numerous applications. It is a well-made alternative for paper bags. Even with a lower grammage, limestone is used as a binding agent will enhance the tear resistance of the bag compared to standard paper bags. Furthermore, the material itself is resilient (Stone Paper, 2024). Using this information, the researchers created an environmental-friendly substitute for paper bags that incorporates fibers from pineapples and bananas, with limestone serving as a binding agent. Pilinana bags will be utilized to assess whether the use of pineapple and banana fibers is an effective method for producing paper bags to reduce different types of pollution and encourage localization. This study aims to determine the Pilinana bag's level of acceptability in terms of durability, marketability, and appearance.

METHODOLOGY

A. Research Design

The study used innovative research design. Innovative research is a method that combines creative and analytical thinking to provide new and improved solutions. It encourages stakeholder engagement in the research process while emphasizing user-centered design, experimentation, and prototyping.

It also aims to better understand the cultures, beliefs, and of various individuals and groups (CEOpedia, 2023).

Pilinana Bag is an alternative paper bag that utilizes the use of waste from pineapple and banana with limestone. It provides environmental benefits by addressing deforestation, pollution, and waste reduction to maintain an eco-friendly nature.

Ingredients:

- Banana Tree Trunk
- Pineapple Leaves
- Agricultural Limestone

Material and Equipment:

- Knife
- Large Cooking Pots
- Paper Molder
- Microwave Oven
- Scale
- Fiber Crushing Machine
- Dryer
- Scissors
- Bucket
- Strainer
- Dipper
- Sealer

General Procedure:

- **Gathering of Banana Tree Trunks.** To guarantee maturity and strength, the harvesting method collects just four outer layers of the tree trunks when gathering banana fiber. Make sure that the banana tree has been harvested for their fruits already.
- ***Gathering of Pineapple Leaves.*** Collect 150 pieces of pineapple leaves. Be certain that the fruits have previously been picked but the leaves were left as trash.
- ***Separation.*** Set the collected banana tree trunks on the ground with sacks to keep the area clean. Use a knife to carefully separate the inner layer from the outer layer from the banana tree trunk. Soak the pineapple leaves in boiled water for 30 minutes to soften these before being placed on a flat surface and carefully separate from the fiber with a knife.
- ***Drying Banana Fiber and Pineapple Fiber.*** Expose the detached outer layer of the banana tree trunk and pineapple leaves to the sun and allow these to dry naturally. This will be achieved by placing it in a drying rack and leaving it to dry for one week until no remaining moisture.
- ***Boiling Fiber.*** Cook the banana fiber and pineapple fiber in a large cooking pot with 20 liters of water to soften, (35 minutes for the pineapple fiber and 40 minutes for the banana fiber). After that, soak the fibers in cold water and then squeeze to remove extra water.
- ***Cutting of Banana Fiber.*** Cut the banana fiber into 1inch using a pair of scissors; thus, it will not clump in the grinding machine.
- ***Radiation Cooking of Pineapple Fiber.*** Shred the pineapple fiber. Placed it in a microwave oven for 10 minutes to remove excess moisture.
- ***Drying of Banana Fiber.*** Put the banana fiber in the dryer for 3-5 minutes to eliminate any remaining water and moisture.
- ***Grinding Pineapple Fiber and Banana Fiber.*** Put the pineapple fiber and banana fiber in a fiber-crushing machine for 5-6 minutes. Ensure that the fibers are not clumps in the paper-making process.
- ***Weighing materials.*** Weigh the pineapple and banana fibers in a scale at 2.5 kilograms and the limestone at 25 grams.
- ***Mixing materials.*** Mix the correct measured fibers and limestone in a bucket using the hands.
- ***Paper Making.*** Use a dipper to scoop a significant amount of the mixture. Pour this over a paper molder that has a size of 120 cm by 270 cm to remove any fiber clumps. Repeat the process until the thickness is approximately correct.
- ***Drying Pilinana Bag.*** Place it in a hot room for 24 hours to speed up the drying process.
- ***Cutting.*** Cut a 7 in x 4 in x 7.5 in piece for small size, a 6 in x 4 in x 11 in piece for medium size, and a 9 in x 4 in x 15 in piece for large size, out of the paper using scissors to make a Pilinana Bag.
- ***Making of Pilinana Bag.*** Fold the cut-out paper in half lengthwise, ensuring the sides are nicely aligned. Crease the fold thoroughly to get a clean, sharp edge. Fold around 2-3 centimeters of paper towards the center and crease it well. This will be the bottom flap of the bag. Open the Pilinana Bag and gently press the bottom flap inward to create a level foundation. This gives the bag a box-like form. Finally, add paper-braided grips for the handle of the bag.

B. Participants

The target participants of this study consisted of 18 individuals, including paper-making professionals, business owners, and consumers based on their sex and social roles. This research used quota and snowball sampling techniques to select participants for this study. The researchers looked at certain characteristics to select participants where the quota sampling technique was used. The quota sample technique is a type of non-probability technique where the researchers select participants using a specific characteristic of an individual. This technique ensures the qualifications, and not all the population can participate, and the final sample will be selected based on the researcher's judgment (Sikmus, 2023). This study needed 6 paper-making professionals, 6 business owners, and 6 consumers for the shopping industries. The snowball sampling method was also used to find participants. The snowball sampling technique, also known as chain referral or network sampling, is a non-probability type of sampling technique where the participants provide a referral or recruit participants that can participate in the study because of their characteristics. This sampling technique is very popular when the population is rare and unknown, making it difficult to collect primary data sources (Baht, 2024). This type of sampling technique helped to find participants with the same professions. Since the participants with the same professions, like papermakers and business owners, were interrelated. They could help by referring to individuals who can participate in the study. Table 1 shows the projected distribution of participants by sex and social roles.

Table 1. Distribution of Participants

Social Role	Male	Female	Total
Paper-Making Professionals	3	3	6
Business Owners	3	3	6
Consumers	3	3	6
Total	9	9	18

C. Research Instrument

This study used a self-made survey questionnaire as the research instrument to assess the durability, marketability, and appearance of the Pilinana bag. This study relied on reliable literature that applies to creating a research questionnaire.

The researchers of this study produced the survey questionnaire based on related literature consisting of "Sustainable Product Design Concept Metrics for Developing the Eco-Bag from Pineapple Leaf Fiber" (2023), "The Potential of Banana Stem Fiber in Eco-Bag Production" (2023), and "Development of Flexible Calcium Carbonate for Papermaking Filler" (2020). This questionnaire was examined and approved by a grammarian.

The survey questionnaire included information about the participants' social roles and sex. Participants were given options from which to reply to each given statement to evaluate their level of acceptance of Pilinana Bag.

Table 2 presents the ratings and descriptions which the participants used to assess the Pilinana Bags' durability, marketability, and appearance.

Table 2. Rating and Description used in Survey Questionnaire

Rating	Description
5	Strongly Agree
4	Agree
3	Undecided
2	Disagree
1	Strongly Disagre

D. Work Plan and Target Deliverables

In Phase 1, the researchers conceptualized an alternative and environmentally friendly product called the Pilinana bag. The new product was created by blending pineapple fiber and banana fiber with limestone as the key components. This was done for the research proposal defense.

In Phase 2, the researchers attempted to create a prototype of the Pilinana Bag using the general procedure: gathering of pineapple leaves and banana tree trunks, separation, drying of the banana fiber and pineapple fiber, boiling of fiber, drying of banana fiber, cutting, radiation cooking, crushing of pineapple fiber, crushing of banana fiber, weighting of materials, mixing of materials, paper making, and drying. Fiber-crushing machines were used to produce the greatest product outcomes and improve the product.

In Phase 3, the researcher had a proposal defense in front of the professionals to improve the product. This happened on November 5, 2024.

In Phase 4, the researchers improved the product and the Pilinana bag based on experts' recommendations.

In Phase 5, the product was assessed by the participants between December 2024 and January 2025. The researchers provided authorization letters to the barangay leaders requesting that the study be conducted in their chosen community.

Each barangay (Lumil, Pooc1, Silang and Carasuchi-Anuling, Indang) received an informed consent form, as well as the participants. Once decided, the product was tested, and the survey questionnaires were answered between December 2024 to January 2025. Following that, the data were collected, statistically processed, analyzed, and interpreted to establish the acceptance level of Pilinana's Bag in terms of durability, marketability, and appearance.

Table 3 was used to understand the collected data based on the survey mean scores pertaining to the three stated variables.

Table 3. Scale and Description for the Acceptability Level of Pilinana Bag

Rating	Description
4.21 – 5.00	Highly Acceptable
3.41 – 4.20	Acceptable
2.61 – 3.40	Moderately Acceptable
1.81 – 2.60	Fairly Acceptable
1.00 – 1.80	Poorly Acceptable

In Phase 6, the researchers completed their final work and presented for the final defense.

E. Statistical Data Analysis

The data collected were analyzed using the following statistical treatments.

- **Frequency.** This was applied to determine the number of participants categorized by their sex and social roles.
- **Mean.** This was used to assess the acceptability level of Pilinana Bag by calculating the average survey scores.
- **Standard Deviation.** This was used to measure the extent to which the survey scores deviate from the average.
- **t-Test of Independent Means.** This was employed to compare the acceptability levels of Pilinana Bag based on the average survey scores in terms of sex.
- **ANOVA.** This was used to compare participants' level of acceptance of the Pilinana bag based on their social roles.

RESULTS AND DISCUSSIONS

Table 4 presents the actual number, and the corresponding percentage of the participants based on sex.

Table 4. Distribution of Participants by Sex

Sex	f	%
Male	9	50.00
Female	9	50.00
Total	18	100.00

This study had a total of 18 participants. This table also shows that the participants are evenly spread out, with 9 men and 9 women. The distribution of participants in this research is 50.00% each, for a total of 100.00%.

Table 5 displays the actual participants' number and equivalent percentage based on their social role.

Table 5. Distribution of Participants by their Social Role

Social Role	f	%
Paper-Making Professional	6	33.33
Business Owners	6	33.33
Consumers	6	33.33
Total	18	100.00

It included 18 participants, divided into three categories: paper-making professionals, business owners, and consumers, with six in each. The study used an equal percentage of 33.33% for each social role to prevent any bias in the results.

Table 6 illustrates the mean scores, standard deviation, and descriptions of the participants' acceptability levels of the Pilinana Bag based on the survey results.

Table 6. Mean Scores, Standard Deviation, and Description of the Participants' Acceptability Level of Pilinana Bag

Components	Mean	SD	Description
Durability	4.52	0.62	Highly Acceptable
Marketability	4.67	0.36	Highly Acceptable
Appearance	4.47	0.45	Highly Acceptable

The participants' responses demonstrated an overall average score of 4.52 (SD = 0.62) for durability, signifying that it was highly acceptable. The marketability of the Pilinana bag obtained the highest mean score of 4.67 (SD = 0.36), also falling within the highly acceptable category. Meanwhile, the appearance

received an average score of 4.47 (SD = 0.45), which, despite being slightly lower, was still considered highly acceptable. In summary, all components attained high scores, indicating that the participants appreciated the product in terms of durability, marketability, and appearance. Table 7 shows the results of comparing the acceptability level of Pilinana Bag when participants were grouped according to sex. This provides the p-value and decision for each component.

Table 7. *Results of t-Test of Independent Means on the Acceptability Level of Pilinana Bag based on Participants' Sex*

Components	Sex	Mean	SD	p-value (a=0.05)	Decision
Durability	Female Male	4.67 4.37	0.44 0.75	0.33	Fail to reject H0
Marketability	Female Male	4.85 4.48	0.18 0.41	**0.03	Reject the H0
Appearance	Female Male	4.44 4.49	0.42 0.50	0.84	Fail to reject H0

Table 7 shows that the durability's p-value of 0.33 is greater than the alpha (0.05) [p-value (0.33) > alpha (0.05)]; which means that the null hypothesis is not rejected. In terms of durability, there is no significant difference on the acceptability level of the product based on sex.

When it comes to marketability's p-value of (0.03), it is less than the alpha, which is (0.05) [p-value (0.03) < alpha (0.05]; as a result, the null hypothesis is rejected. There is a significant difference in the acceptability level on the acceptability level of Pilinana Bag's marketability based on sex.

Lastly, the appearance's p-value of (0.84) surpasses the alpha, which is 0.05 [p-value (0.84) > alpha (0.05)]; therefore, the null hypothesis is not rejected. For both males and females, it was found that there is no significant difference in their acceptability level of the said bag in terms of appearance

The results mentioned above indicate that there is no significant difference in the level of acceptability of Pilinana Bags in terms of durability and appearance between male and female. Meanwhile, the findings demonstrated a notable difference in the marketability of Pilinana Bag between the male and female demographics. The female's greater mean score suggests that they believe it to be more marketable than the males' perception. Apart from marketability, it can be said that both male and female participants find the Pilinana Bag to be equally acceptable.

Table 8 shows the results of Analysis of Variance for the assessment of Pilinana Bag in terms of the three components when participants are categorized according to their social roles.

Table 8. *Results on the Analysis of Variance on the Acceptability Level of Pilinana Bag based on Participants' Social Role*

Components	Social Role	Mean	SD	p-value (a=0.05)	Decision
Durability	Paper-making professional Business Owner Consumer	4.17 4.83 4.56	0.51 0.41 0.78	0.18	Fail to reject the H0
Marketability	Paper-making professional Business Owner Consumer	4.44 4.83 4.72	0.50 0.18 0.25	0.16	Fail to reject the H0
Appearance	Paper-making professional Business Owner Consumer	4.27 4.70 4.43	0.59 0.33 0.34	0.25	Fail to reject the H0

The results indicate that the p-values for durability, marketability, and appearance all exceed the significance level (alpha) of 0.05. For durability, the p-value of 0.18 is higher than the alpha (0.05); consequently, the null hypothesis is not rejected. This suggests that there is no significant difference in the assessment in terms of Pilinana Bags' durability based on the perceptions of paper-making professionals, business owners, and consumers. In terms of marketability, the p-value of 0.16 is higher than the alpha value (0.05); hence, the null hypothesis is accepted. There is no significant difference in the evaluation of the product among the three groups.

For appearance, the p-value of 0.25 surpasses the alpha value (0.05); thus, the null hypothesis is not rejected. This indicates that there is no significant variation in the perception for the product's appearance among paper-making professionals, business owners, and consumers.

Overall, the statistical analysis demonstrates that there are no significant differences among paper-making professionals', business owners', and consumers' perceptions regarding durability, marketability, and appearance of the said product. This consistency across groups suggests uniform perceptions of these attributes.

Conclusions

The purpose of this study was to evaluate the acceptability of the Pilinana bag in terms of durability, marketability, and appearance, considering the participants' sex and social role. As a result, the study's outcomes and findings resulted in the following conclusions.

Based on the findings, the Pilinana Bag's overall mean score is highly acceptable in durability, marketability, and appearance.

Furthermore, the results also demonstrated that individuals across sex found the alternative paper bag highly acceptable in all aspects. Meanwhile, the computed p-value for males and females indicates a significant difference in terms of marketability. Females earned a higher mean score than males, indicating that they believe it is more marketable. This leads to the conclusion that both male and female have distinct preferences for the marketability of the Pilinana Bag. However, the remaining components show that there is no significant difference in the acceptability of Pilinana Bag based on sex. This indicates that using pineapple and banana fiber with limestone is a viable alternative for producing paper bags.

Moreover, the researchers used ANOVA to confirm that the Pilinana bag's level of acceptability was constant across individuals' social roles.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are proposed.

For business owners, the Pilinana Bag can be a good alternative to the paper and plastic bags they normally use. Promoting this type of product can help in reducing the increasing rate of pollution and deforestation.

For the banana and pineapple farmers, they are encouraged to take advantage of this opportunity to start giving away or selling pineapple leaves and banana trunks. This can help reduce waste while also providing farmers with a chance to earn extra money.

For consumers, the Pilinana bag can serve as an excellent alternative to thin, non-durable paper bags and plastic bags for shopping. It is reusable, durable, and environmentally friendly, making it a practical and sustainable choice. By using Pilinana bags, consumers can contribute to reducing waste and promoting eco-conscious habits.

For future researchers who plan to conduct a study similar to this study, it is recommended to explore enhancements such as incorporating waterproofing features. Additionally, they may consider experimenting with alternative materials that are more unique and environmentally friendly. To make the product more appealing, introducing a variety of colors instead of plain options could appeal to individuals who prefer vibrant designs. These improvements can help make the product more functional, sustainable, and attractive to a broader audience.

Appendix

Figure 1 shows the Pilinana Bags in different sizes.

Figure 1. *Pilinana Bags*

Acknowledgment

We would like to take this opportunity to express our deepest gratitude to Sir John Ritchie Reyes, our research adviser, for his invaluable time and dedication to mentoring us. We sincerely appreciate his insightful guidance and unwavering support throughout our research journey.

Our heartfelt appreciation also goes to Mrs. Raisa Barrot and Masaeco for their assistance in developing and improving our product while graciously accommodating us.

We are immensely grateful to our panelists Engr. Liezl Porras, Mrs. Arlynn Isla, Mrs. Janice Lingan, and Mrs. Hershy Aquino for their valuable contributions as panelists for our research innovation. Their insightful feedback has provided us with invaluable knowledge, significantly enhancing both our product and the credibility of our study.

We also extend our profound gratitude to Sir Del John De Villa for his dedication and support throughout the validation process of our research. His willingness to share his expertise has been instrumental in ensuring the validity and reliability of our study.

We sincerely appreciate the former STEM students of Lumil Integrated National High School for their guidance through their research papers. Their work has provided us with valuable insights and has played a significant role in shaping our research journey. We are truly grateful for their support.

We also appreciate the Barangay Captains who granted us permission to conduct our research in their respective areas.

Special thanks to our participants, whose willingness to participate and answer our questionnaire with honesty has significantly contributed to the success of our study.

We also extend our gratitude to all the authors of the articles and literature that we used for this study. All are mentioned in the bibliography, including those who were cited in our school's full research paper.

Finally, we extend our heartfelt appreciation to our family and friends for their unwavering support emotionally, mentally, and even financially. Their presence and words of encouragement have been a source of strength throughout the duration of our research.

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