



## **DURABILITY OF LAKATAN (MUSA ACUMINATA) PSEUDO-STEM AS A SUSTAINABLE SOURCE FOR PAPER PRODUCTION: A COMPARATIVE STUDY OF TENSILE STRENGTH, ABRASION, AND THICKNESS**

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### **ABSTRACT**

This study aimed to evaluate the durability of an alternative organic paper made from the lakatan (*Musa acuminata*) pseudostem as a sustainable source for paper production. The research was conducted at Isabela State University, Cauayan Campus. Three treatments were tested: commercial Manila paper made from 8 g, lakatan paper made from 5 g, and lakatan paper made from 3 g of pseudostem. The durability of the paper was assessed by tensile strength, abrasion, and thickness tests. The results revealed significant differences among the treatments. The 5 g lakatan pseudostem paper exhibited the highest tensile strength and abrasion resistance compared to the other treatments. Additionally, the 5 g lakatan pseudostem paper was thicker than the commercial Manila paper. These findings suggest that lakatan (*Musa acuminata*) pseudostem paper is durable and can be recommended as an alternative source of material for paper production. This study highlights the potential of utilizing banana pseudostem waste as a sustainable alternative to traditional paper production methods, which contributes to deforestation and air pollution. The use of the lakatan pseudostem for paper production could help reduce the environmental impact of the paper industry, while providing valuable use for agricultural waste.

**Keywords:** *Abrasion, Lakatan, Musa acuminata, Paper Production, Pseudo-stem, Tensile strength*

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## INTRODUCTION

Paper is one of the biggest contributors to environmental damage as waste comes from; it is a big issue for its negative impacts on the environment, such as increasing the rate of deforestation using up to 90% of global wood in the production of paper, as stated in the study by Kempner (2016). In a study by Ferguson (2017), over 40% of industrial wood traded around the world makes paper and responds to Achlin (2021). Logging for paper and wood products is the second leading cause of deforestation, causing loss of habitat for millions of species, as 80% of the world's land animals and plants live in forests.

The papermaking process has been extensively criticized by environmentalists because it contributes to pollution. Paper production has a negative effect on the environment, as it involves the destruction of trees. Data from the Global Forest Resource Assessment show that approximately 80,000–160,000 trees are felled every day worldwide, with a significant portion being utilized by the paper industry. The primary consequence of ongoing deforestation is the alteration of global climatic patterns. In addition to deforestation, the paper manufacturing sector is responsible for contributing to air pollution. According to Claustro (2015), paper production accounts for approximately 20% of the air pollution in the United States.

The New York Declaration on Forests (NYDF) set up ten goals that aim to stop deforestation, and some of these are to stop natural forest loss by 2030 and to reduce the emission of Carbon Dioxide from deforestation. As Rivera (2021) argues yet, despite the clear agenda that is set, global deforestation continues at the rate of one million hectares per year. According to the Food and Agriculture Organization of the United States, the Philippines has shown significant advances in resolving the loss of forest cover in the past years, and its dedication is exemplified by embarking on large tree planting and reforestation software referred to as the National Greening Program. In addition, the Integrated National Resources Management Program (INREMP) and Forestland Management Program (FMP) are also concerned with this initiative. From functioning as one of the pinnacle ten deforestation international locations, contributing to 17-20 percent of worldwide greenhouse gas (GHG) emissions from worldwide woodland loss in 2000 (FAO, 2006), the U.S.A. has recovered with a modest wooded area cowl boom of 55 000 hectares (ha) consistent with year (FAO, 2010); the 2010 Global Forest Assessment Country Report for Philippines mentioned a boom in wooded area cowl from 6. Fifty million hectare in 1990 to 7 sixty-six million ha in 2010. However, these efforts have been sustained for a long time because the sustainability and capacity of re-greening applications have been questioned. The issues brought about by the production of commercial paper prompted researchers to conduct a study evaluate the durability of an alternative organic paper made from Lakatan (*Musa acuminata*) pseudo-stem.

## Research Questions

This study was to evaluate the durability of lakatan (*Musa acuminata*) paper obtained from a pseudo-stem as a sustainable source for paper production. Specifically, it sought to answer the following questions:

1. Is there a significant difference in the tensile strength of the lakatan paper treatments? Treatment 1: Commercial paper (Manila paper) 8 grams  
Treatment 1: Paper made from 5 grams of lakatan fiber with 15 % NaOH  
Treatment 2: Paper made from 3 grams of lakatan fiber with 15 % NaOH
2. Is there a significant difference in the abrasion test results of the lakatan paper among the three different treatments?
3. Is there a significant difference in the thickness of the lakatan paper among the three different treatments?
4. Which of the treatments is the most effective among lakatan paper and commercial paper (Manila paper)?

## Statement of the Null Hypotheses

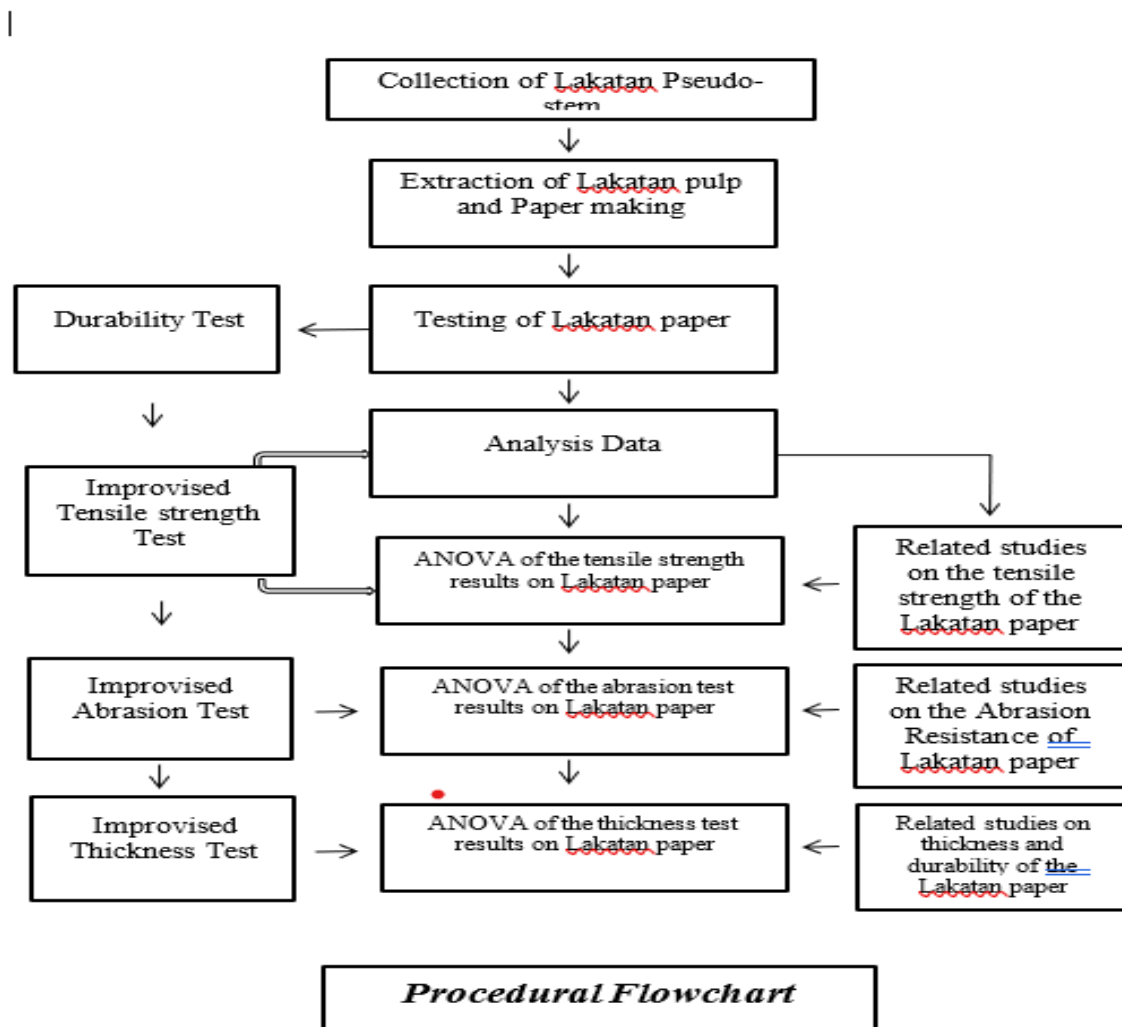
1. There were no significant differences in the tensile strengths of the three treatments.
2. There was no significant difference in the abrasion test results between treatments.
3. There were no significant differences in the thicknesses of the three treatments.

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## METHODOLOGY

### A. Collection of Plant Material Lakatan (*Musa acuminata*) Pseudo-stem

Lakatan (*Musa acuminata*) pseudo-stem plants, especially the lakatan variety, were collected in Tandul, Cabatuan, Isabela. The collection method was guaranteed to follow ethical and sustainability principles. Only plants that had previously been picked for their fruits or were about to be harvested were chosen for inclusion in the study. An important ethical aspect was noted, and no lakatan plants were purposely removed for the purpose of extracting fiber from their pseudo-stems. This choice demonstrates a dedication to environmental stewardship and agricultural resource conservation. The study reduced any potential detrimental influence on ecology by focusing solely on plants that were already being picked for their fruits, ensuring that agricultural methods were sustainable. Appendix B includes additional images relevant to the collection procedure for clarity and visual support. The images offered further context and insight into the approach used to collect lakatan pseudo-stems for this study. They are useful resources for understanding the collection processes and state of the pseudo-stems at the time of acquisition.



## RESULTS AND DISCUSSION

Table 1: Kruskal- Wallis Result

| Tensile Strength Test                      |      |      |      |     |       |     |            |
|--------------------------------------------|------|------|------|-----|-------|-----|------------|
| PS 1                                       | PS 2 | PS 3 | PS 4 | M   | H (2) | P   |            |
| Commercial paper<br>(Manila paper 8 grams) |      |      | .46  | .24 | .27   | .25 | 0.305 Kn/m |
| Lakatan Paper<br>(5 grams)                 |      |      | .66  | .60 | .57   | .59 | 0.605 Kn/m |
| Lakatan Paper<br>(3 grams)                 |      |      | .54  | .50 | .48   | .51 | 0.508 Kn/m |

This table presents the results of the tensile strength tests. The Kruskal- Wallis results for the different treatments, namely a) commercial paper (Manila paper 8 g), b) Lakatan

paper 5 g, and c) Lakatan paper 3 g, reveal that there is a significant difference between the tensile strengths of the three different treatments. Given that the p-value (0.007) is greater than the level of significance (2), the f-value is (9.85). The null hypothesis was dismissed by the researchers, who approved the alternative hypothesis after reviewing the test results in the table. They concluded that there was a notable variation in the tensile strengths of the three treatments. According to a study by Marites S. De Leon at DOST-PTRI in 2014, Lakatan, among six tested banana cultivars including Saba, Lakatan, Bongolan, Pakil, Saksik, and Tordan, exhibited the most promising mean tensile strength, surpassing that of the most common banana variety, Cavendish (Watsons, 2023). The tensile strength is linked to the product toughness. According to a study by Stable Microsystems in 2022, products with higher tensile strengths are more challenging or tougher to stretch. Conversely, products with lower tensile strengths broke more easily.

Table 2: Kruskal- Wallis Result

| Abrasion Test                              |      |      |      |     |             |     |      |
|--------------------------------------------|------|------|------|-----|-------------|-----|------|
| PS 1                                       | PS 2 | PS 3 | PS 4 | M   | H (2, 5.59) | P   |      |
|                                            |      |      |      |     |             |     |      |
| Commercial paper<br>(Manila paper 8 grams) |      |      | .69  | .63 | .63         | .59 | 2.54 |
|                                            |      |      |      |     |             |     |      |
| Lakatan Paper<br>(5 grams)                 |      |      | .57  | .60 | .59         | .61 | 2.37 |
| 0.257                                      |      |      |      |     |             |     | 1.75 |
|                                            |      |      |      |     |             |     |      |
| Lakatan Paper<br>(3 grams)                 |      |      | .59  | .60 | .61         | .57 | 2.37 |

The table presents the results of the abrasion tests. Based on the Kruskal- Wallis Result of the abrasion test on the different treatments, namely a) commercial paper (Manila paper 8 g), b) Lakatan paper 5 g, and c) Lakatan paper 3 g, there is a significant difference between the abrasion resistance of the treatments. Given that the p-value of (0.257) is greater than the significance level (5.59), The F-value of (1.75) is lower than the critical F-value of (2), leading researchers to reject the null hypothesis and accept the alternative hypothesis. They concluded that there was a significant difference in the abrasion resistance of the treatments, as previously stated (Rubtester, 2018). Abrasion testing is the rubbing of a material to a specific weight and speed to determine the wear point of the material being tested. The tested material confirmed the durability of the product being tested based on its results. Abrasion testing is used to measure resistance and can be used for both flexible and rigid materials, one of which is paper (Costells, 2023).

Table 3: Kruskal- Wallis Result

| Table 3: Thickness Test Results            |      |      |      |    |       |    |
|--------------------------------------------|------|------|------|----|-------|----|
| Thickness Test                             |      | PS 3 | PS 4 | M  | H (2) | P  |
| PS 1                                       | PS 2 |      |      |    |       |    |
| Commercial paper<br>(Manila paper 8 grams) |      | .1   | .1   | .1 | .1    | .1 |

|                            |    |    |    |    |    |      |
|----------------------------|----|----|----|----|----|------|
| Lakatan Paper<br>(5 grams) | .3 | .3 | .4 | .4 | .3 | 10.7 |
| Lakatan Paper<br>(3 grams) | .2 | .2 | .2 | .2 | .2 |      |

The table presents the results of the Kruskal-Wallis test. The table of the thickness test results for the different treatments, namely a) commercial paper (Manila paper 8 g), b) Lakatan paper 5 g, and c) Lakatan paper 3 g, reveals that there is a significant difference between the thicknesses of the three treatments. Given a p-value of (0.005), which is lower than the significance level of 2, and an f-value of (10.7), the null hypothesis was rejected. This leads researchers to accept the alternative hypothesis and conclude that there is a significant difference in the thicknesses of the three treatments. Lakobson (2023) states that heavier paper is denser and stronger, while paper with a higher caliper is stiffer and bulkier.

### III. a: Table of the post-hoc Comparisons on Improvised Thickness Test Results

| W                                  | p  |    |       |       |
|------------------------------------|----|----|-------|-------|
| Commercial paper (Manila paper 8g) | vs | 5g | 3.53  | 0.034 |
| Commercial paper (Manila paper 8g) | vs | 3g | 3.74  | 0.022 |
| Lakatan paper 5g                   | vs | 3g | -3.53 | 0.034 |

The table provides a summary of the study of commercial paper (Manila paper 8 g), lakatan paper made from 5 grams, and lakatan paper made from 3 grams. Using a Pairwise Correction Post-Hoc test, the treatments were compared, and the results revealed that the significance was only within the comparisons on the commercial paper (Manila paper 8 g), 5 g lakatan paper, and 3 g lakatan paper because the p-values (0.022) were less than the calculated level of significance and the comparisons on commercial paper (Manila paper 8 g) and 5 g lakatan had a greater p-value (0.034). Based on the results, the researchers concluded that there is a significant difference in the thickness of the commercial paper (Manila paper 8 g), the 5-gram lakatan paper, and the 3-gram lakatan paper. Banana paper, on the other hand, is manufactured by hand from banana fibers, and is thicker and textured. It emphasizes sustainability and distinctive aesthetics and is ideal for eco-friendly crafts and specialized packaging (Yasin, 2018).

## Findings

The study was focused mainly on the making of lakatan (*Musa acuminata*) paper and testing its durability through a) tensile strength test, b) abrasion test, and c) thickness test. The results showed a notable contrast in the tensile strength and abrasion resistance among the various treatments. This implies that lakatan paper can endure abrasion similar to commercial paper (manila paper).. Lastly, the thickness test revealed that there is a significant difference between the treatments of 5 grams lakatan pseudo-stem paper that is thicker than commercial paper (Manila paper). Therefore, lakatan (*Musa acuminata*)

pseudo-stem paper is durable and can be recommended as an alternative source of material for paper production.

## Conclusions

Based on the test results, the following conclusions can be drawn:

1. Papers made from lakatan (*Musa acuminata*) differ significantly in terms of their tensile strength compared to that of commercial paper (Manila paper).
  2. There was a significant difference in the abrasion resistance of the different lakatan (*Musa acuminata*) pseudo-stem papers and commercial paper (Manila paper).
  3. There is a significant difference in the thickness of lakatan 5 grams (*Musa acuminata*) pseudo-stem paper and commercial paper (Manila paper)
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## Recommendations

The following recommendations can be made for this study:

1. Further studies on other banana pseudo-stems are needed.
  2. Further research must be conducted to test the durability of the paper, such as its folding endurance, surface strength, and tear strength.
  3. Improve the whiteness of the paper as it is an indicator for measuring the quality of a paper and improve the methods of paper making to ensure the equal distribution of its fibers.
  4. Other chemical solutions for papermaking should be used to further improve paper quality.
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## Compliance with Ethical Standards

This study was conducted with the approval of the appropriate ethics committee at Isabela State University, Cauayan Campus. All procedures performed in this research involving human participants, if any, were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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**Appendix A:**  
**Collection of *Lakatan* (*Musa acuminata*) Plant Material**



Collection of *Lakatan* (*Musa acuminata*) Plant Material

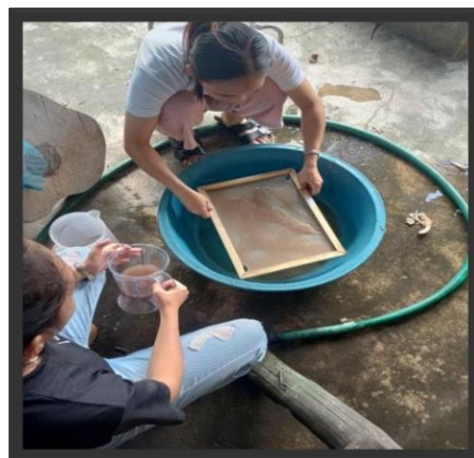
**Appendix B:**  
**Locale for the Production and Testing of *Lakatan* (*Musa acuminata*) Pseudo-stem Paper**



Locale for the Production and Testing of *Lakatan* (*Musa acuminata*) Pseudo-stem Paper

## Appendix C: Production of Lakatan (*Musa acuminata*) paper

### Procedure:



## Appendix D

### Tables

**Table 1: Result of the Improvised Tensile Strength Test**

| Tensile Strength                       |               |               |               |               |            |
|----------------------------------------|---------------|---------------|---------------|---------------|------------|
|                                        | Paper Strip 1 | Paper Strip 2 | Paper Strip 3 | Paper Strip 4 | Avg.       |
| Commercial Paper (Manilapaper 8 grams) | .46           | .24           | .27           | .25           | 0.305 Kn/m |
| Lakatan Paper (5 grams)                | .66           | .60           | .57           | .59           | 0.605 Kn/m |
| Lakatan Paper (3 grams)                | .54           | .50           | .48           | .51           | 0.508 Kn/m |

**Test Table 2: Result of the Improvised Abrasion Test**

|                                        | Paper Strip 1 | Paper Strip 2 | Paper Strip 3 | Paper Strip 4 | Avg. |
|----------------------------------------|---------------|---------------|---------------|---------------|------|
| Commercial Paper (Manilapaper 8 grams) | .69           | .63           | .63           | .59           | 2.54 |
| Lakatan Paper (5 grams)                | .57           | .60           | .59           | .61           | 2.37 |
| Lakatan Paper (3 grams)                | .59           | .60           | .61           | .57           | 2.37 |

**Table3: Result of the Thickness Test**

|                                                 | Thickness<br>(mm) | Thickness<br>(mm) | Thickness<br>(mm) | Thickness<br>(mm) |      |
|-------------------------------------------------|-------------------|-------------------|-------------------|-------------------|------|
|                                                 | Paper Sheet 1     | Paper Sheet 2     | Paper Sheet 3     | Paper Sheet 4     | Avg. |
| Commercial<br>Paper<br>(Manilapaper<br>8 grams) | .1                | .1                | .1                | .1                | .1   |
| Lakatan Paper<br>(5 grams)                      | .3                | .3                | .4                | .4                | .3   |
| Lakatan Paper<br>(3 grams)                      | .2                | .2                | .2                | .2                | .2   |