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Effectiveness of Jackfruit Seeds *(Artocarpus Heterophyllus)* as Biodegradable Paper Plate

Matias, Emman Joshua D.[1], Lugtu, Jenny G.[2], Martin, John Gabriel D.[3], Reyes, Clark Ken G.[4], Soliman, Jens Nickel T.[5], Tabago, Ahriela B.[6], Tolentino, Khurt Dhavid S.[7] Guarin, Vi Briza E.[8]
[1,2,3,4,5,6,7] *Student-Researchers, Asian Pacific Christian School, Incorporated*
[8] *Senior High School Department, Asian Pacific Christian School, Incorporated, Block 2 Cristo Rey, Capas, Tarlac City, Philippines*

Abstract: ***The increasing environmental burden of plastic waste necessitates the development of sustainable alternatives, particularly in disposable tableware. This study explores the effectiveness of Jackfruit (Artocarpus Heterophyllus) Seeds as a biodegradable paper plate material. This study aimed to explore the characteristics of Jackfruit (Artocarpus Heterophyllus) Seeds' durability, appearance, and biodegradability—and compare its performance with traditional paper plates in terms of durability, resistance, absorption, and shelf life. Employing an experimental design, systematically processing jackfruit seeds into prototypes using natural and recycled materials. Findings revealed the jackfruit-based plates exhibited notable durability, withstanding weights up to 200 grams, and degraded within three weeks under natural conditions. Statistical comparisons indicated no significant difference in performance compared to traditional paper plates, supporting the potential viability of jackfruit seeds as a sustainable material for disposable tableware. This research highlights the environmental benefits of utilizing organic waste for product development, offering a viable alternative to reduce plastic pollution. Further refinements in production processes may enhance its commercial applicability.***
Keywords: Biodegradability, Durability, Jackfruit Seeds, Paper Plate, Sustainability.

I. INTRODUCTION

Plastic pollution is a pervasive environmental challenge, with disposable tableware significantly contributing to this problem (Moshood et al., 2022). As per the United Nations (n.d.), plastics persist in the environment for 20 to 500 years, harming ecosystems and human health. Consequently, researchers and environmental advocates are striving to develop sustainable alternatives. Jackfruit seeds *(Artocarpus heterophyllus)*, a tropical by-product often discarded as waste, offer a promising solution. These seeds are rich in starch, an essential component for biodegradable materials, and have been utilized in various sustainable applications, such as biodegradable films (Lubis et al., 2017). This study explores the feasibility of using jackfruit seeds to produce biodegradable paper plates, addressing the environmental hazards of non-biodegradable waste. Unlike traditional paper plates, which rely on cellulose from trees or recycled pulp, jackfruit seeds provide a renewable, low-cost alternative with better gel-forming and mechanical properties compared to other starch sources, such as tapioca or maize (Ao et al., 2022). This research evaluates the characteristics of jackfruit-seed-based plates, such as durability, appearance, and biodegradability, and compares their performance with conventional paper plates. By focusing on this innovative approach, the study aligns with efforts to mitigate plastic waste while promoting sustainable product development. Through rigorous experimentation and analysis, the findings aim to contribute to waste reduction, support local agricultural economies, and inspire further advancements in eco-friendly disposable products. Such initiatives have the potential to alleviate the environmental burden posed by traditional tableware while fostering a culture of sustainable consumption and innovation (Kalse & Swami, 2022).

II. METHODOLOGY

This study investigates the potential of Jackfruit (*Artocarpus Heterophyllus*) seeds as a key material for producing biodegradable paper plates. Conducted using a quantitative experimental research design, the study explores the effectiveness of these plates under specific conditions, aiming to establish them as an eco-friendly alternative to traditional paper plates. True experimental design is a highly structured research method valued for its ability to determine precise cause-and-effect relationships.

The production process involves jackfruit seeds as the primary component, supplemented by used paper for added strength, cornstarch to enhance dry strength, eggshells and egg whites as natural binding agents, non-toxic glue for cohesion, and water to soften the mixture. These ingredients were combined to form a soft mixture, shaped into plate forms, and air-dried until hardened for testing.

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The plates underwent evaluations for durability, appearance, and biodegradability. Various types of food, including cooked rice, mashed potatoes, and boiled bananas, were placed on the plates to assess their performance. Using an observational checklist, the researchers monitored and recorded characteristics such as durability, resistance, absorption, and shelf life. Descriptive statistics, one-sample t-tests, and ANOVA were employed to analyze the data, revealing durability as the most effective attribute of the plates. An observational checklist was a key tool for summarizing data on durability, appearance, and biodegradability, aligning with Nicolas (2023), who noted its utility in data collection. The one-sample t-test evaluated the plates' resistance, absorption, and shelf life against a predefined standard. Comparative analysis using one-way ANOVA and MANOVA highlighted differences between jackfruit seed plates and conventional paper plates across durability, resistance, absorption, and shelf life. These statistical methods, coupled with careful observation, underscored the advantages of jackfruit seed plates, reinforcing their potential as an environmentally friendly alternative.

III. RESULTS AND DISCUSSION

TABLE 1. DURABILITY OF JACKFRUIT SEEDS *(ARTOCARPUS HETEROPHYLLUS)* AS BIODEGRADABLE PAPER PLATE BASED ON THE OBSERVATIONAL CHECKLIST

Solid Foods	Weight	Results			Nothing Happened
		Splitting	Breaking	Shattering	
Cooked Rice	50-100 grams / 83 grams				✔
Mashed Potato	100-150 grams / 105 grams				✔
Boiled Bananas	150-200 grams / 184 grams				✔

Table 1 highlights the impressive durability of paper plates made from jackfruit seeds. These plates successfully endured various foods, including boiled bananas (83 grams), cooked rice (105 grams), and mashed potatoes (184 grams), without showing any damage or wear. This resilience demonstrates their ability to support different food textures and weights, particularly denser, softer foods. Such durability positions jackfruit seed plates as a sustainable alternative to conventional paper plates, capable of holding heavier foods while maintaining stability and integrity.

TABLE 2. ONE-SAMPLE T-TEST OF DURABILITY OF JACKFRUIT SEEDS *(ARTOCARPUS HETEROPHYLLUS)* AS BIODEGRADABLE PAPER PLATE IN TERMS OF EFFECTIVENESS

One-Sample Test

Test Value = 124

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Durability	.000	2	1.000	.000	-131.94	131.94

The table presents the t-value for the durability of jackfruit seeds paper plate as 0.000, with a 2-tailed significance of 1.000 ($p > 0.05$) and a mean difference of 0.000 within a wide confidence interval. These results indicate no significant deviation from the test value (124). Durability is a crucial factor in determining the practical effectiveness of these plates, as they must withstand regular use while decomposing more readily than plastic. Consequently, the findings support the null hypothesis (Ho1), concluding that jackfruit seeds paper plates do not significantly affect durability compared to the standard.

IV. DISCUSSION

The findings of this study highlight the potential of jackfruit seed-based paper plates as a strong, durable, and environmentally friendly alternative to conventional disposable plates. The results demonstrate the remarkable mechanical properties of these plates, which were tested under realistic conditions involving different food types and weights. Specifically, the jackfruit seed paper plates maintained their integrity under 83 grams of cooked rice, 105 grams of mashed potatoes, and 184 grams of boiled bananas, with the heaviest item causing no observable damage. This performance under varying loads underscores the suitability of jackfruit seed-based materials for typical food-serving applications.

The observed durability can be attributed primarily to the high starch content in jackfruit seeds, which constitutes approximately 40-50% of their composition. Starch is a natural biopolymer known for its mechanical strength and flexibility, making it an essential component in the production of biodegradable plastics (Nurhayati et al., 2021). The incorporation of jackfruit seed starch in the manufacturing process provides the plates with the tensile strength needed to withstand pressure and weight without breaking. Additionally, the fibrous structure of jackfruit seeds enhances the mechanical properties of the plates by forming a robust network capable of supporting significant loads (Tepung et al., 2018).

The research further emphasizes the role of additives and processing techniques in enhancing the mechanical properties of the plates. Studies have shown that combining jackfruit seed starch with plasticizers and other biopolymers improves tensile strength and flexibility, which are critical factors for the practical usability of such materials (Lestari et al., 2020). This bioplastic blend prevents breakage and provides the plates with the durability required for diverse food-serving scenarios, making them a competitive alternative to traditional paper plates.

The water resistance of jackfruit seed-based composites is another significant finding of this research. According to Van et al. (2023), starch-based materials exhibit strong resistance to moisture when combined with appropriate biopolymers and plasticizers. This property ensures that the plates remain durable even when exposed to moist or wet food items. The researchers' paper plates leverage the natural crystallinity of jackfruit seed starch to enhance tensile strength and resistance to breakage, as supported by Campos, Natália, et al. (2017).

In addition to this, the jackfruit seeds biodegradable paper plate's ability to withstand drop tests from 1 to 3 meters can be attributed to the combined strength and binding properties of its components. Jackfruit seed starch, which has high amylose content, contributes to the plate's structural integrity, while the addition of cornstarch enhances its tensile strength and durability (Santana et al., 2017). Eggshell powder, known for its calcium carbonate content, reinforces the material, improving impact resistance and reducing brittleness (Hussain et al., 2020). Additionally, the presence of egg white as a natural binder increases cohesion among fibers, preventing fragmentation upon impact (Liu et al., 2019). The integration of recycled paper pulp also enhances flexibility, allowing the plate to absorb shock without breaking (Fairuzdzah et al., 2018). These combined properties result in a sturdy and resilient biodegradable paper plate capable of withstanding significant drops.

Overall, the combination of jackfruit seed starch's inherent properties, the fibrous structure of the material, and the use of bioplastic blends has resulted in a biodegradable product with remarkable mechanical properties. These attributes suggest that jackfruit seed-based paper plates could serve as a viable and eco-friendly alternative to conventional disposable plates. By addressing both durability and environmental concerns, this innovation aligns with the growing demand for sustainable and biodegradable materials in everyday applications.

V. CONCLUSION

The study successfully highlighted the durability of jackfruit *(Artocarpus Heterophyllus)* seeds as a viable material for biodegradable paper plates. The experimental findings demonstrated that these plates could withstand substantial weight without tearing, affirming their mechanical resilience. Comparatively, the durability of jackfruit seed-based plates paralleled that of traditional paper plates, suggesting their potential to serve as a sustainable alternative. The incorporation of starch from jackfruit seeds and other organic materials contributed significantly to the structural integrity of the prototypes, ensuring a practical and reliable end product. Moreover, repeated experiments and refinements in the preparation and production methods enabled the researchers to improve the plates' thickness, texture, and overall functionality. Adjusting the proportions of binding agents, such as egg white and cornstarch, and optimizing drying conditions led to the creation of plates with enhanced durability. This iterative process underscored the adaptability of jackfruit seeds as a raw material for disposable tableware, especially in settings demanding robustness and longevity. While the results are promising, further research is needed to evaluate the plates' performance under varied conditions, such as exposure to heat, moisture, and prolonged storage. Additionally, exploring cost-effective production methods and scaling up the process would be essential for commercial viability. By addressing these factors, jackfruit seed-based plates could emerge as a practical and environmentally friendly solution to reducing plastic waste in everyday consumer products.

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VI. LIMITATION

Despite the promising durability of the jackfruit seed-based biodegradable paper plate, several limitations were observed in this study. While the plate successfully withstood drop tests from heights ranging from 1 to 3 meters, its structural integrity may still be affected by external factors such as prolonged exposure to extreme moisture, pressure, or temperature variations. Although these conditions were not the primary focus of this study, future research should explore their potential effects on the long-term durability of the plate.

Additionally, while the friability of the plate was successfully refined and removed, the overall durability may still differ based on variations in production techniques, ingredient ratios, or environmental conditions during drying. The handcrafted nature of the plates, along with potential inconsistencies in material distribution, could result in slight variations in strength and resilience across different batches. This highlights the need for standardized manufacturing processes to ensure uniform durability in larger-scale production.

The study also introduced larger plate sizes to assess durability under practical usage scenarios. However, the increased surface area and weight distribution may have influenced the plate's overall strength, particularly when holding heavier food items for prolonged periods. While the plates performed well under standard usage conditions, further studies could evaluate how different plate sizes impact durability, especially when subjected to repeated handling or stress.

Lastly, the application of natural coatings enhanced resistance to common condiments such as soy sauce, ketchup, fish sauce, and vinegar, with no observable effects on the plate's structure. However, durability against other liquid-based foods, prolonged soaking, or high-temperature foods was not extensively examined. Future studies should investigate how the coated plates perform under extreme food conditions, such as exposure to hot soups or oily dishes, to determine their full durability potential in real-world dining scenarios.

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Authors' Profile

Lugtu, Jenny G. resides at Block 90 Lot 91 Cristo Rey, Capas, Tarlac. She can be contacted at 0950 213 4404 or via email at lugtujenny44@gmail.com. Jenny graduated from Holy Spirit Elementary School and Cristo Rey High School for junior high, and took her senior high school at Asian Pacific Christian School, Inc. Her skills include listening, time management, teamwork, problem-solving, and adaptability. Jenny has received honors, Gawad Pagkilala, and perfect attendance awards and has participated in youth camps.

Martin, John Gabriel D., resides at Brgy Sta. Lucia, Capas, Tarlac, Transmitter Street. He can be reached at 0949 953 6646 or via email at gabrieldumlao47@gmail.com. He finished elementary and junior high at Multiple Intelligence Development, Assessment and Simulation Institute (MIDAS Institute), and took his senior high studies at Asian Pacific Christian School, Inc. John Gabriel is skilled in communication, teamwork, adaptability, and hard work. He has earned academic excellence awards and actively participated in youth camps and medical missions.

Matias, Emman Joshua D., served as the research leader and resides at Block 11 Lot 49 Phase 1 Suba Street, Cristo Rey, Capas, Tarlac. He can be contacted at 0948 774 9076 or via email at joshuadm0507@gmail.com. He graduated elementary and junior high school at Asian Pacific Christian School, Inc. (APCSI) and studied senior high school at the same institution. Emman excels in public speaking, graphic designing, writing, leadership, and event management. His achievements include consistent academic excellence awards, leadership awards, overall best research paper and recognition as the Best Male Oral Research Presenter. He has participated in various leadership training, youth camps, and international conferences, notably as a delegate at the 2024 Global Conference held in Gwangju, South Korea.

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Reyes, Clark Ken G., lives in Sitio Calumpit, Aranguren, Capas, Tarlac. He can be reached at 0910 800 081 or via email at clarkkenreyes19@gmail.com. He completed elementary and junior high at Aranguren Integrated School and studied senior high at Asian Pacific Christian School, Inc. Clark is skilled in critical thinking, adaptability, and multitasking. His achievements include academic excellence and perfect attendance awards. He has attended journalism training, leadership training, and medical seminars.

Soliman, Jens Nickel T., lives at Block 32 Lot 15 Phase 2 Cristo Rey, Capas, Tarlac. He can be contacted at 0946 264 7432 or via email at jensnickelsoliman@gmail.com. Jens completed elementary at Lipayran Integrated School and junior high at Cristo Rey High School. He took his senior high at Asian Pacific Christian School, Inc. Jens is talented in listening, artistry, multitasking, and strategic thinking. His achievements include academic awards, sports victories, and participation in youth camps and medical missions. He also works as an engine mechanic, fitness coach, and cycling race organizer.

Tabago, Ahriela B., resides at Parang St. O'Donnell, Capas, Tarlac. She can be contacted at 0928 546 7814 or via email at tabagoahriela@gmail.com. She attended Capas West Central Elementary School and Anao Elementary School for her elementary education, completed junior high at Asian Pacific Christian School, Inc., and graduated there for senior high. Ahriela is proficient in teamwork, time management, adaptability, and multitasking. She has consistently been awarded an academic excellence award and has participated in youth camps.

Tolentino, Khurt Dhavid S., lives at Block 13 Lot 21 Phase 2 Christian Street, Cristo Rey, Capas, Tarlac. He can be reached at 0969 540 9355 or via email at kdtolentino53@gmil.com. He completed his elementary and junior high school education at Asian Pacific Christian School, Inc. and graduated senior high school there. Khurt is skilled in listening, artistry, and multi-tasking. He has consistently earned academic excellence awards, excelled in basketball, and achieved recognition in Filipino literary competitions. His experiences include participating in youth camps and journalism training.

Guarin, Vi Briza E., served as the research adviser for the student-researchers. A nurse by profession and an educator at the same time, she is the Senior High School Academic Coordinator at Asian Pacific Christian School, Incorporated (APCSI) in Capas, Tarlac. With twelve years of teaching experience in a private institution, she holds a Master's degree in Science Education from Pangasinan State University, Philippines. She is currently pursuing her Doctor of Philosophy in Science Education at Don Mariano Marcos Memorial State University in La Union, Philippines. For inquiries, she can be contacted via email at vibrizaguarin.apcsi@gmail.com.

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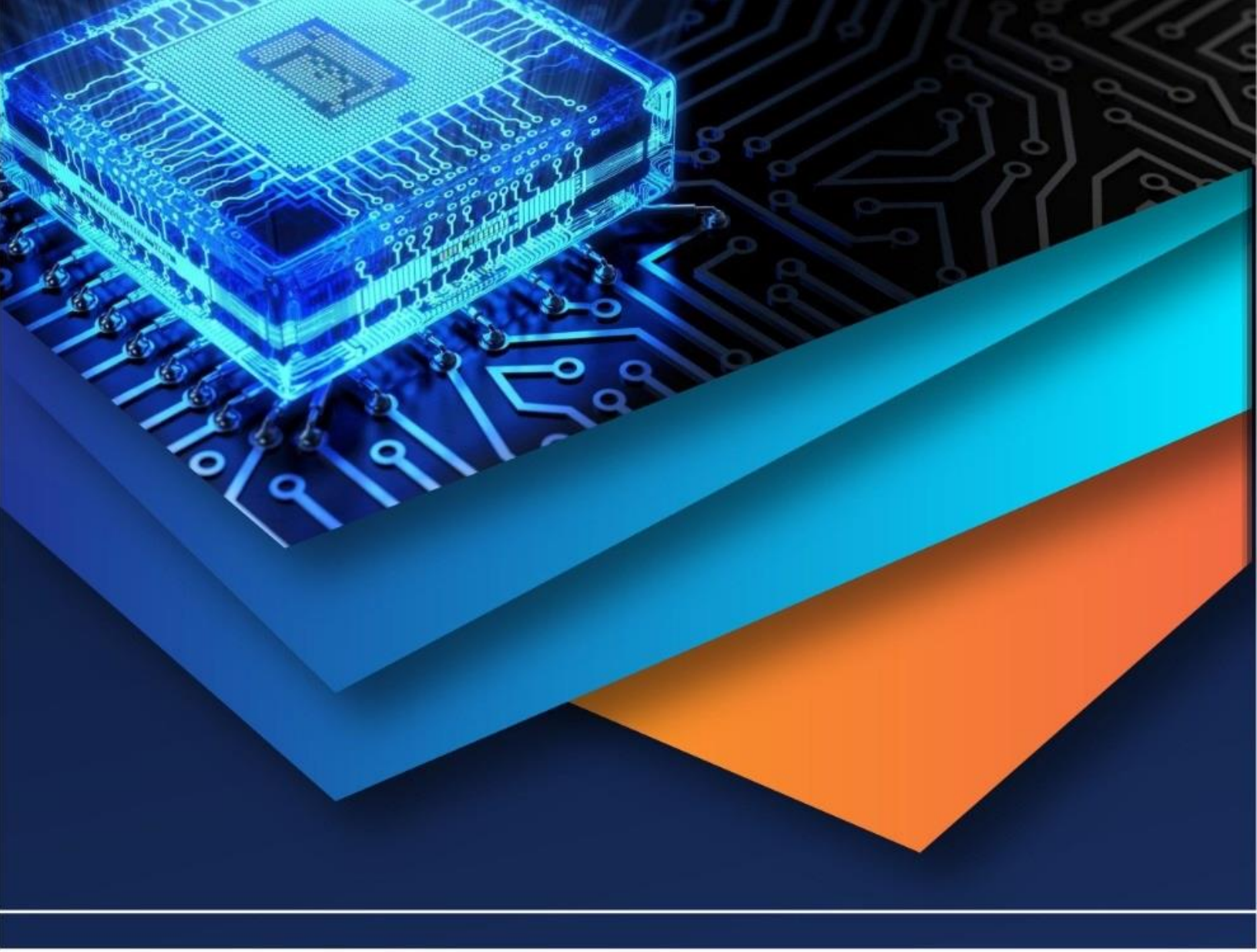

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