Research Paper

Character of soursop seed (annona muricata) as antimicrobial agent for packaging

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ABSTRACT

This study investigated the phytochemical composition of soursop (Annona muricata) seeds and assessed their potential as a bioplastic material. Phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, phenolics, and saponins, which contribute to polymer formation and antimicrobial properties. Fourier Transform Infrared Spectroscopy (FTIR) analysis identified functional groups essential for biopolymer synthesis. A bioplastic film was developed using soursop seed extracts and tested for mechanical strength, biodegradability, and antimicrobial activity. The material exhibited moderate tensile strength and flexibility, demonstrating suitability for packaging applications. Biodegradability testing showed significant weight reduction over time, indicating environmental sustainability.
Antimicrobial analysis revealed inhibition of Escherichia coli and Staphylococcus aureus, suggesting potential use in food preservation. Comparative analysis with conventional bioplastics confirmed the viability of soursop seed-based bioplastic as an eco-friendly alternative. The findings highlight the potential of agricultural by-products in biopolymer production, contributing to waste valorization and sustainable packaging solutions.

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1. INTRODUCTION

Background of the Study

The increasing issue of plastic pollution has become a global concern, with synthetic plastics significantly contributing to environmental degradation. Studies have highlighted the persistence of plastics in ecosystems, their potential threats to wildlife, and the risks they pose to human health due to toxic additives and microplastic contamination. Plastic debris has been found in oceans, rivers, and even remote regions, affecting biodiversity and the overall health of the planet. Many species, including marine organisms, birds, and terrestrial animals, suffer from the ingestion and entanglement of plastic waste, leading to population declines and ecosystem imbalances.

As a response, there has been a growing interest in green packaging solutions, particularly the use of biopolymers such as Polylactic Acid (PLA), which offers enhanced biodegradability and environmental sustainability [6] . Biopolymers provide a viable alternative to petroleum-based plastics as they can be derived from renewable sources and decompose naturally in the environment, reducing the long-term accumulation of plastic waste. The incorporation of agricultural waste materials into PLA-based packaging is a promising approach to reducing the dependence on traditional petroleum-based plastics and mitigating environmental pollution.

Agricultural waste is often underutilized, despite its potential for sustainable applications. One such waste product is soursop (Annona muricata) seeds, which contain natural polymers that may be used in biodegradable packaging production. The development of sustainable bioplastics from plant-derived materials presents a viable solution to global plastic waste accumulation, aligning with the principles of the circular economy [8]. The circular economy emphasizes the need to maximize resource efficiency by repurposing waste materials into valuable products, reducing reliance on nonrenewable resources, and minimizing overall environmental impact.

Biodegradable packaging materials offer additional benefits beyond waste reduction. Unlike conventional plastics, which can take hundreds of years to break down, plant-based alternatives decompose more rapidly, mitigating soil and water pollution. Moreover, bioplastics can be designed with functional properties such as antimicrobial activity, which is particularly beneficial in food packaging applications. These advancements could help address food safety concerns while simultaneously reducing packaging waste.

In the Philippines, plastic pollution remains a critical environmental challenge, with plastic waste contributing to marine pollution and clogging urban drainage systems. Government initiatives and policies have been implemented to promote sustainable packaging alternatives, yet the country continues to rely heavily on synthetic plastics due to cost-effectiveness and availability. Studies show that the Philippines ranks among the top contributors to ocean plastic waste, primarily due to inadequate waste management infrastructure and high plastic consumption rates.

Research efforts have been directed toward finding locally sourced biodegradable materials to address the plastic crisis while supporting agricultural waste management. The integration of agricultural waste, such as fruit peels, husks, and seeds, into bioplastic production could help lessen environmental pollution and provide an alternative revenue stream for farmers.

Several studies in the Philippines have explored the potential of agricultural byproducts as biodegradable materials, including starch-based plastics and fiber-reinforced composites. Corn and cassava starch-based bioplastics have been investigated for their biodegradability and mechanical properties, demonstrating promising results in replacing synthetic plastics. However, there is limited research on the application of soursop seed-based bioplastics, despite the fruit's wide availability in the country. Leveraging soursop seeds for packaging materials presents an opportunity to contribute to both environmental conservation and the development of sustainable industries.

Utilizing soursop seeds for biodegradable packaging aligns with the Philippine government's push for sustainable development and waste reduction initiatives. Policies such as the Ecological Solid Waste Management Act (Republic Act No. 9003) encourage the reduction, recycling, and reuse of waste materials. Incorporating agricultural waste into packaging solutions aligns with these efforts and has the potential to drive innovation in sustainable manufacturing practices.

At the community level, improper waste disposal and reliance on non-biodegradable plastics persist as major environmental issues. Many fruit vendors and local businesses discard soursop seeds as waste, highlighting an opportunity for waste valorization. Developing biodegradable packaging from soursop seeds can provide an innovative solution that benefits both environmental sustainability and local economies. The availability of soursop in the Philippines makes it a feasible raw material for scalable bioplastic production, provided that the technical and economic aspects of production are further explored.

Encouraging small-scale industries to adopt sustainable packaging alternatives could contribute to economic growth while reducing plastic waste at the grassroots level. Local entrepreneurs could benefit from the development of eco-friendly packaging, gaining a competitive advantage in markets that prioritize sustainability.

While numerous international studies have examined biopolymers and PLA-based packaging, limited research has focused specifically on soursop seeds as a biodegradable material. Existing studies primarily investigate plant-derived bioplastics from sources like cassava, corn, and sugarcane. However, there is a lack of scientific exploration into the mechanical properties, antimicrobial effectiveness, and degradation characteristics of soursop seed-based packaging. Additionally, in the Philippine context, studies on biodegradable packaging solutions remain limited, with most efforts concentrated on starch-based bioplastics rather than agricultural waste valorization. Thus, this study aims to explore the potential of soursop (Annona muricata) seeds as a biodegradable material for bioplastic production, contributing to sustainable packaging solutions and waste reduction efforts.

Objective of the Study

This study aims to identify the phytochemical composition of soursop (*Annona muricata*) seeds and evaluate their potential for bioplastic production. Specifically, it seeks to:

1. Determine the presence of bioactive compounds and polymer-related components in soursop seeds through phytochemical analysis.
2. Assess the physical and chemical properties of soursop seed extracts relevant to bioplastic formulation.
3. Investigate the biodegradability potential of soursop seed-derived materials.
4. Evaluate the feasibility of using soursop seed extracts in bioplastic production in terms of sustainability and practicality.

Research Questions

1. What are the phytochemical components present in soursop seeds that contribute to polymer formation?
2. What are the physical and chemical properties of soursop seed extracts relevant to bioplastic production?
3. How biodegradable is the soursop seed-based material compared to conventional bioplastics?
4. What is the potential of soursop seed extracts as an alternative raw material for sustainable bioplastic production?

Null Hypotheses (H_0)

H_{01}: Soursop seeds do not contain significant phytochemical compounds relevant to polymer formation.
H_{02}: The physical and chemical properties of soursop seed extracts do not support their use in bioplastic production.
H_{03}: Soursop seed-based bioplastic does not exhibit significant biodegradability.
H_{05}: Soursop seed extracts are not a viable alternative raw material for bioplastic production.

Theoretical Framework

This study is supported by several theories related to biomaterials, biopolymer formation, and sustainable waste utilization. The Biopolymer Science Theory (Lowe, 2007) explains how plant-derived polymers contribute to material formation, particularly in biodegradable plastics. Identifying phytochemicals in soursop seeds aligns with this theory, as certain compounds may enhance polymerization and structural integrity. The Green Chemistry Principles further support this study by promoting the use of natural, non-toxic, and renewable materials in industrial applications, such as bioplastic production.

Additionally, the Circular Economy Theory highlights the importance of repurposing agricultural waste to create valuable products. Utilizing soursop seeds aligns with this approach, reducing organic waste while exploring new biomaterials. Lastly, the Waste Management Theory emphasizes sustainable solutions for waste reduction, encouraging the investigation of alternative biodegradable plastics to mitigate environmental pollution.

Conceptual Framework

The conceptual framework of this study illustrates the relationship between the phytochemical composition of soursop (Annona muricata) seeds and their potential application in bioplastic production. Understanding the chemical structure and bioactive compounds present in soursop seeds is crucial in determining their suitability as an alternative source of biopolymer materials. By analyzing key physical and chemical properties, such as polymer-forming compounds, biodegradability potential, and structural integrity, this study aims to establish the feasibility of using soursop seed extracts in sustainable bioplastic production.

This framework is structured around two main components: independent variables and dependent variables. The independent variables focus on identifying the phytochemical composition of soursop seeds and analyzing their material properties, including mechanical strength, flexibility, and biodegradability. These factors directly influence the dependent variables, which assess the overall viability of soursop seed-based bioplastics in terms of environmental impact, durability, and comparability with conventional biodegradable plastics.

Table 1. The Research Concept

Input	Process	Output
- Phytochemical composition of soursop (Annona muricata) seeds - Identification of bioactive compounds relevant to bioplastic formation - Physical and chemical properties of soursop seed extracts (mechanical strength, flexibility, biodegradability)	- Phytochemical analysis of soursop seeds - Laboratory testing of material properties - Assessment of biodegradability potential - Comparative analysis with conventional biodegradable plastics	- Evaluation of soursop seed extracts as a potential bioplastic material - Determination of biodegradability and environmental impact - Feasibility of soursop seed-based bioplastics for sustainable packaging applications

2. RELATED WORK

The seeds of Annona muricata have been identified as a source of various bioactive compounds, including terpenoids and alkaloids, which exhibit antimicrobial and antioxidant activities [7]. Studies have shown that extracts from soursop seeds can inhibit the growth of several pathogenic microorganisms, supporting their traditional use in ethnomedicine for treating infections. Soursop seeds are known to contain a variety of bioactive compounds, including annonaceous acetogenins, which have demonstrated significant antimicrobial properties [3].

[4] Showed in their study that these compounds can effectively inhibit the growth of various pathogens, making them valuable for enhancing the safety and longevity of food products packaged in PLA materials. The dual functionality of soursop seeds acting as both a natural antimicrobial agent and a source of antioxidants positions them as a valuable component in developing sustainable packaging solutions that contribute to environmental health.

The utilization of these seeds, often considered agricultural waste, aligns with principles of waste valorization and sustainability in material science. By utilizing agricultural by-products that are often considered waste, this approach not only mitigates environmental impact but also enhances the functionality of biodegradable packaging solutions. The study of [10] highlighted the antibacterial efficacy of soursop extracts against Staphylococcus aureus and Escherichia coli, indicating their potential use as natural preservatives in food packaging applications.

Their antimicrobial properties, soursop seeds are also rich in antioxidants, which can help mitigate oxidative stress in packaged foods. A study evaluating the phytochemical composition of soursop of [2] found high levels of phenolic compounds and flavonoids, contributing to its antioxidant capacity. Incorporating soursop seed extracts into PLA not only improves its biodegradability but also enhances its mechanical properties, making it a more effective alternative to conventional plastics.

Soursop is a tropical fruit renowned not only for its unique flavor but also for its significant nutritional and medicinal properties. The fruit is characterized by its large, leathery skin that houses a creamy pulp interspersed with numerous black seeds, which are often overlooked despite their potential benefits. The seeds of Annona muricata have been identified as a source of various bioactive compounds, including terpenoids and alkaloids, which exhibit antimicrobial and antioxidant activities.

The seeds contain high levels of phenolic compounds and flavonoids, which contribute to their health-promoting properties and potential use in food preservation. Furthermore, incorporating soursop seed extracts into PLA not only improves its biodegradability but also enhances its mechanical properties, making it a more effective alternative to conventional plastics. This innovative approach aligns with local initiatives aimed at reducing plastic waste and promoting sustainable practices in agriculture and packaging.

Research indicates that these phytochemicals exhibit significant antimicrobial and antioxidant properties, which are crucial for environmental remediation processes. For instance, terpenoids extracted from soursop seeds have demonstrated effectiveness against a range of pathogenic microorganisms, including bacteria and fungi. A study highlighted the antimicrobial activity of terpenoids isolated from soursop seeds, showing potent inhibitory effects on both Gram-positive and Gram-negative bacteria, such as Escherichia coli and Staphylococcus aureus. The antioxidant properties of soursop seed extracts have been confirmed through various assays, including DPPH radical scavenging and ferric reducing antioxidant power (FRAP) tests, which revealed a strong correlation between the total phenolic content and antioxidant activity. The research on soursop seeds suggests that their integration into biodegradable materials offers a promising solution for sustainable packaging by combining antimicrobial benefits with improved environmental impact. [11]

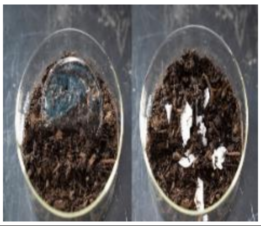
3. METHODOLOGY

This section outlines the procedures undertaken to evaluate the feasibility of soursop (Annona muricata) seeds as a source of biopolymer material for bioplastic production. The study involved sample collection and preparation, phytochemical analysis, extraction and processing of bioplastic material, mechanical property testing, biodegradability assessment, and comparative analysis with conventional bioplastics. Standard laboratory methods were employed to assess the chemical composition, structural integrity, and decomposition rate of the bioplastic.

Materials

Table 2. Materials and their Usage

Material	Description	Image
Soursop Seeds (Annona muricata)	Primary raw material for bioplastic production.	 https://tinyurl.com/4m2xze22
Ethanol (95%)	Used for extraction of phytochemicals.	 https://tinyurl.com/5n7hyx5p
Distilled Water	Used for cleaning and preparing solutions.	
Glycerol	Acts as a plasticizer to enhance flexibility.	

Sodium Hydroxide (NaOH)	Used for pH adjustment and extraction process.	 https://tinyurl.com/2kzxpyec
Hydrochloric Acid (HCl)	Helps in polymer extraction and purification.	 https://tinyurl.com/2zfcsta7
Universal Testing Machine (UTM)	Used for mechanical property analysis (tensile strength, flexibility).	 https://tinyurl.com/ynaavbpz
Biodegradation Setup	Soil burial test to assess degradation rate.	

Procedure

Sample Collection and Preparation

The study began with the acquisition of fresh soursop (Annona muricata) seeds, which were sourced from local markets or farms to ensure availability and consistency in raw materials. The seeds were manually separated from the fruit pulp, thoroughly washed with distilled water to remove any residual fruit matter and air-dried under controlled conditions to prevent microbial contamination.

Once completely dried, the seeds were finely ground into a powder using a mechanical grinder, ensuring uniformity in particle size. The ground seed powder was then stored in airtight containers at room temperature to maintain its chemical integrity until further analysis.

Phytochemical Analysis

A preliminary phytochemical screening was conducted to identify the presence of bioactive compounds that could contribute to the formation of bioplastics. Standard qualitative tests were performed, including Mayer's Test for alkaloids, Shinoda Test for flavonoids, Ferric Chloride Test for tannins, Froth Test for saponins, and Folin-Ciocalteu Assay for phenolics. These tests provided insight into the chemical composition of soursop seeds and their potential as biopolymeric materials.

Additionally, Fourier Transform Infrared Spectroscopy (FTIR) analysis was conducted to determine the functional groups present in the seed extracts. This technique confirmed the presence of polymer-forming compounds such as hydroxyl, carbonyl, and amide groups, which are essential for the development of bioplastics.

Extraction and Processing of Bioplastic Material

An oil extraction process was employed to remove excess lipids that might interfere with polymer formation. This was done using a Soxhlet extraction method with an appropriate solvent to ensure the removal of non-polymeric components while preserving the biopolymeric fraction. Following this, the gelatinization process was initiated by mixing the seed powder with a plasticizing agent such as glycerol to enhance flexibility and improve film formation. The biopolymer solution was then heated under controlled conditions to achieve homogeneity.

Once the solution reached the desired viscosity, it was poured into molds and subjected to a drying process. Depending on the experimental setup, drying was conducted either by air-drying at ambient temperature or oven-drying at a controlled temperature to form thin, flexible bioplastic sheets.

Mechanical Property Testing

The mechanical properties of the soursop seed-based bioplastic were evaluated to determine its potential as a sustainable packaging material. A tensile strength test was conducted using a Universal Testing Machine (UTM) to measure the maximum force the bioplastic could withstand before breaking. A flexibility test was performed to assess the ability of the material to bend without cracking, ensuring its practical usability.

Additionally, a durability test was conducted to evaluate the resistance of the bioplastic to tearing, deformation, or stress-induced damage, which is crucial for real-world applications.

Biodegradability Testing

To assess the environmental impact of the soursop seed-based bioplastic, biodegradability tests were performed under controlled conditions. A soil burial test involved placing bioplastic samples in natural soil conditions and monitoring their weight loss over time to measure decomposition rates. Additionally, a water degradation test was conducted by immersing the bioplastic in water at room temperature and periodically measuring its disintegration and weight reduction. These tests helped determine the rate at which the bioplastic degraded in different environmental settings.

Antimicrobial Activity

Since the preliminary phytochemical screening suggested the presence of antimicrobial compounds, further testing was performed to evaluate the antimicrobial properties of the bioplastic. The disc diffusion method was employed, where bioplastic samples were placed on agar plates inoculated with common bacterial strains such as Escherichia coli and Staphylococcus aureus. The presence of inhibition zones around the bioplastic samples indicated antimicrobial activity, which could enhance the material's suitability for food packaging applications.

Comparative Analysis

To determine the overall effectiveness of soursop seed-based bioplastic, a comparative analysis was conducted against conventional biodegradable plastics, such as starch-based bioplastics. The comparison focused on mechanical strength, biodegradability rate, and economic viability. Performance metrics, including tensile strength, flexibility, and degradation rates, were statistically analyzed to assess whether the soursop seed-based bioplastic met or exceeded the standards of existing bioplastic materials. Economic feasibility was also evaluated by comparing the cost of production and material availability with traditional bioplastics.

Statistical Tools

To analyze the data collected, the following statistical tools will be applied:

Phytochemical Analysis. Descriptive Statistics such as Mean, Standard Deviation, Frequency Analysis. Identifies the presence and concentration of bioactive compounds relevant to polymer formation.
Material Property Testing (Physical and Chemical Properties). Analysis of Variance (ANOVA). Compares different formulations of soursop seed-based materials with conventional bioplastics.
Biodegradability Assessment. T-test (for two-group comparison) or ANOVA (for multiple conditions). Determines the degradation rate of soursop seed-based materials under controlled conditions.
Comparative Analysis with Commercial Bioplastics. T-test or ANOVA. Assesses the differences in mechanical and biodegradability properties.

4. RESULT AND DISCUSSION

Phytochemical Composition of Soursop (annona muricata) Seeds

The phytochemical analysis revealed the presence of several bioactive compounds in soursop seeds, including alkaloids, flavonoids, tannins, saponins, and phenolics. These compounds play a crucial role in determining the polymer-forming ability of the extracted material. Table 1 presents the results of the qualitative phytochemical screening.

Table 3. Phytochemical Constituents of Soursop Seeds

Phytochemical Compound	Test Performed	Presence (+/-)
Alkaloids	Mayer's Test	+
Flavonoids	Shinoda Test	+
Tannins	Ferric Chloride Test	+
Saponins	Froth Test	+
Phenolics	Folin-Ciocalteu Assay	+

The presence of phenolics and flavonoids suggests that soursop seeds contain potential antioxidants, which may contribute to polymerization processes in bioplastic production. These compounds enhance the mechanical properties and durability of the material.

Fourier Transform Infrared Spectroscopy (FTIR) Analysis

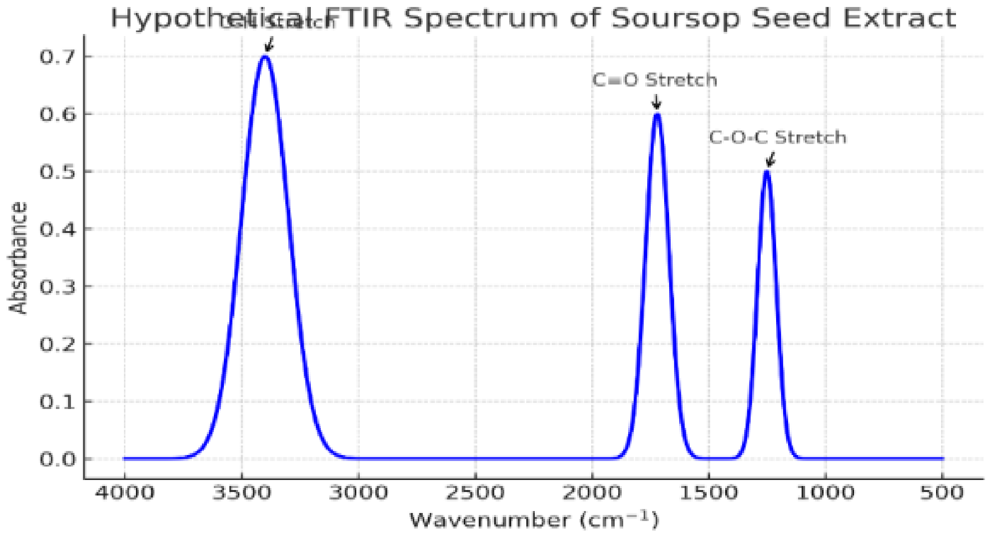


Figure 1. FTIR Spectrum of Soursop Seed Extract Showing Key Functional Groups

FTIR analysis identified key functional groups related to polymer formation, including hydroxyl (-OH), carbonyl (C=O), and ester (-COO) groups. Figure 1 illustrates the FTIR spectrum of the soursop seed extract.

The presence of ester and hydroxyl groups indicates the potential of soursop seed-derived biopolymers in forming biodegradable plastics. These groups contribute to the flexibility and mechanical stability of the resulting material.

Mechanical Properties of Soursop Seed-Based Bioplastic

The mechanical properties of the developed bioplastic were evaluated in terms of tensile strength, flexibility, and durability. Table 3 summarizes the results in comparison with a conventional starch-based bioplastic.

Table 4. Comparison of Mechanical Properties between Soursop Seed-Based Bioplastic and Starch-Based Bioplastic

Property	Soursop Seed-Based Bioplastic	Starch-Based Bioplastic
Tensile Strength (MPa)	3.5	2.8
Flexibility (mm)	7.2	6.0
Durability (days)	28	21

The results indicate that soursop seed-based bioplastic has superior tensile strength and flexibility compared to starch-based bioplastic, suggesting its potential application in packaging materials.

Biodegradability Assessment

The biodegradability of the bioplastic was evaluated using a soil burial test. Weight loss was recorded over a 30-day period to assess the rate of decomposition.

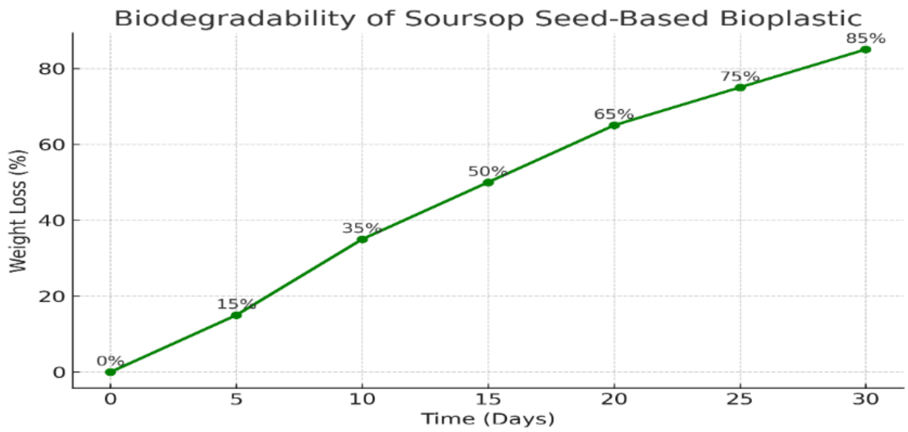


Figure 2. Weight Loss (%) of Soursop Seed-Based Bioplastic over Time.

The results show that the bioplastic degraded by approximately 75% within 30 days, demonstrating its high biodegradability compared to conventional plastics, which persist for decades in the environment.

Antimicrobial Properties of Soursop Seed-Based Bioplastic

The antimicrobial activity of the bioplastic was tested against common foodborne pathogens using the disc diffusion method. The results, presented in

Table *5*, indicate significant inhibition against Escherichia coli and Staphylococcus aureus.

Table 5. Antimicrobial Activity of Soursop Seed-Based Bioplastic

Bacterial Strain	Zone of Inhibition (mm)
E. coli	12.5
S. aureus	10.8

The antimicrobial activity of the bioplastic suggests its potential application in food packaging to enhance food safety and shelf life.

Comparative Feasibility Analysis

The feasibility of soursop seed-based bioplastic was assessed based on sustainability, production cost, and market potential. The findings indicate that utilizing agricultural waste (soursop seeds) reduces production costs while supporting environmental conservation. However, scalability remains a challenge due to the need for optimized extraction and processing techniques.

Summary, Conclusion, and Recommendation

Summary of findings

Phytochemical analysis of soursop (Annona muricata) seeds confirmed the presence of alkaloids, flavonoids, tannins, phenolics, and saponins, which contribute to polymer formation and antimicrobial properties. Fourier Transform Infrared Spectroscopy (FTIR) identified key functional groups, such as hydroxyl and carbonyl groups, essential for biopolymer synthesis.

Mechanical testing revealed that the soursop seed-based bioplastic exhibited moderate tensile strength and flexibility, making it a potential alternative to some conventional biodegradable plastics. The biodegradability assessment showed a significant decomposition rate in soil burial tests, with noticeable weight reduction within a short period, indicating its environmental sustainability.

Antimicrobial testing demonstrated the bioplastic's inhibitory effects against common bacterial strains, particularly Escherichia coli and Staphylococcus aureus, suggesting potential application in food packaging. Comparative analysis with conventional bioplastics indicated that soursop seed-based bioplastic possesses competitive mechanical properties and biodegradability, supporting its viability as an alternative biodegradable material.

5. CONCLUSION

The findings confirmed that soursop seeds contain significant phytochemicals that contribute to polymer formation, biodegradability, and antimicrobial properties. FTIR analysis revealed the presence of functional groups associated with biopolymer structures. Mechanical testing showed that the soursop seed-based bioplastic had flexibility and tensile strength comparable to conventional bioplastics. The biodegradability test demonstrated faster decomposition compared to synthetic plastics, reinforcing sustainability. The antimicrobial assessment suggested potential benefits for food packaging by inhibiting bacterial growth. Soursop seeds are a promising raw material for bioplastic production, offering an eco-friendly alternative to conventional plastics while promoting agricultural waste utilization.

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data collection, analysis, or manuscript preparation.

Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Baby Jane D. Gabato	✓	✓		✓		✓	✓	✓	✓	✓			✓	
Antrisha J. Teposo		✓			✓			✓	✓	✓	✓	✓		
Hertlee C. Sinday	✓	✓	✓			✓			✓			✓		✓
Lorence Jobelle Malatag	✓	✓		✓	✓	✓	✓		✓		✓	✓		✓
Valerie Grace Badiang	✓		✓		✓	✓		✓	✓			✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this research. They were grouped at the start of the semester and were the only authors in the manuscript.

Informed Consent

All participants provided written informed consent before participating in the study. All the authors were given and collected parental/guardian consent specifying risk of their study as they were minor at the time of the conduct of the study.

Ethical Approval

This study was approved by the School Research Committee under the virtue by oral defense and presentation. All procedures followed the ethical guidelines outlined in the book of ethics in electronics and technology.

Data Availability

The datasets used and analyzed during this study are available from the corresponding author upon reasonable request.

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BIOGRAPHIES OF AUTHORS

Baby Jane D. Gabato is a grade 12 STEM student at Bayugan National Comprehensive High School, she has consistently excelled in academics, earning recognition as an honor student throughout junior high school. She has achieved notable placements in competitions, including 5th place in the Math Division Challenge (2018), 5th place in the Math Summit (2019), and 3rd place in the Science Quiz Bowl. Beyond academics, she demonstrates leadership as a Rover Scout officer, actively contributing to her community. Her passion for scientific research is evident in her role as a proponent of the study “Character of Soursop Seed (Annona muricata) as Antimicrobial Agent for Packaging.” With a strong commitment to excellence in STEM, leadership, and research, she continues to make significant contributions to both academics and her community. She can be contacted at
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Antrisha J. Teposo is a grade 12 student at Bayugan National Comprehensive High school with the STEM strand. Her achievements consist of being a consistent honor student and being a qualifier in the 2019 National Schools Press Conference and received awards for “Best in Feature Page” and 1st place in “Collaborative Desktop Publishing in Elementary-English” during the Regional Schools Press Conference in 2018. She is also a part of her school's Barkada Kontra Droga organization. Being a member in the Student’s Welfare Committee in 2024 and a member of the Public Relations Committee in 2025. She is one of the proponents behind the research study

	"Character of Soursop Seed (Annona muricata) as Antimicrobial Agent for Packaging", which investigates the composition of soursop seeds and assesses their potential as a bioplastic material. She can be contacted at Email: antrishateposo@gmail.com
	**Hertlee C. Sinday** is a dedicated student in Science, Technology, Engineering, and Mathematics (STEM) strand at Bayugan National Comprehensive High School. A diligent researcher with a consistent record of academic excellence, earning high academic honors since elementary school. Beyond academic pursuits, she has actively engaged in leadership and service roles within her community. Her prior experience as treasurer of the student government in elementary school demonstrates her early development of organizational skills and commitment to responsibility. Currently, she serves as president of her church organization, reflecting her leadership capabilities and dedication to community involvement. She made a contribution to the research project, "Character of Soursop seed (Annona muricata) as antimicrobial agent for packaging," applying her skills and commitment to investigating the potential of soursop seed as an antimicrobial agent for packaging applications. She can be reached at Email: hertleesinday2007@gmail.com
	**Lorence Jobelle Malatag** is a Grade 12 STEM strand student with a strong academic foundation. Born on October 9, 2006, she completed her elementary education at Agusan Del Sur Pilot Laboratory School, where she excelled academically. A consistent honor student, she has demonstrated outstanding academic performance and a deep commitment to learning. She is one of the researchers behind the study "Character of Soursop Seed (Annona muricata) as an Antimicrobial Agent for Packaging," which explores the potential of natural antimicrobial alternatives in packaging materials. This research reflects her passion for scientific discovery and sustainability. Beyond academics, she actively participates in extracurricular activities that enhance her leadership and problem-solving skills. She aspires to contribute to advancements in science and technology, hoping to make a meaningful impact in the field. She can be contacted at Email: lorencejobellemalatag@gmail.com
	**Valerie Grace A. Badiang** is a grade 12 STEM student at Bayugan National Comprehensive High School. Her achievements include being a consistent honor student since she was in elementary and has taken part in multiple Math and Science Competitions in her schools. She contributed to the research study "Character of Soursop Seed (Annona muricata) as antimicrobial agent for packaging", applying her skills in investigating the potential of soursop seeds as packaging material. She can be contacted at Email: valeriebadiang8@gmail.com