ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research

Vol. 14, Issue, 06, pp. 65913-65918, June, 2024

https://doi.org/10.37118/ijdr.28451.06.2024

RESEARCH ARTICLE

OPEN ACCESS

BANANA FOOD WRAP AND CASSAVA BIOPLASTIC PACKAGING: ASSESSMENT OF BIODEGRADABILITY

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ARTICLE INFO

Article History:

Received 11th March, 2024
Received in revised form
20th April, 2024
Accepted 17th May, 2024
Published online 28th June, 2024

Key Words:

Bioplastic, Biodegradable, Banana food wrap, Cassava packaging, soil, Fresh water, Salt water.

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ABSTRACT

Plastic pollution was identified as one of the main problems in the world, with plastic taking hundreds or thousands of years to decompose. Consequently, there has been a growing inclination towards utilizing biodegradable materials such as bioplastics for packaging purposes. Bioplastics can be derived from organic materials such as food waste, although it's important to note that not all bioplastics are biodegradable. This study aimed to determine the biodegradability rate of the Banana Food Wrap compared to a commercial product, the Cassava Packaging, under different environmental conditions including soil, freshwater, and saltwater. An experimental design was employed to fulfill the study's objectives and examine its underlying theory. The researchers utilized the soil method to assess the biodegradability rate and observe any disparities between the Banana Food Wrap and Cassava Packaging in terms of weight loss and physical appearance over a period of 90 days in various environments. The study revealed that the Banana Food Packaging achieved a 100% biodegradability rate at a faster pace compared to Cassava Packaging. T-tests were conducted to compare the two types of packaging, leading to the finding that the degradation mean loss for Banana Food Wrap (84.58%) was significantly higher ($p=.034$) than the mean loss for Cassava Packaging (69.76%). Understanding the biodegradability rate of the Banana Food Wrap could alleviate strain on the environment and current waste management facilities, prompting the food industry to consider bioplastics as a viable alternative to traditional packaging materials.

Citation*: *Princess Myle Q. Coratchia, Hazel Nicole P. Dela Cruz, Martin Franz B. Leslie, Francis Cedric M. Magboo, Andrei Jericho I. Manalo, Lady Diane A. Marie, John Carlo B. Palacol and Joyce C. Bagui. 2024. *"Banana food wrap and cassava bioplastic packaging: assessment of biodegradability". International Journal of Development Research*, 14, (06), 65913-65918.

INTRODUCTION

Plastics have played a crucial role in various industries globally, with their pervasive use in daily life. Consequently, there has been a rapid increase in plastic production in recent decades. However, the detrimental effects of plastics on health and the environment are often overlooked. Global plastic manufacturing has grown at an average rate of 9% annually (Okunola *et al*., 2019). Of the 6.3 billion tons of fossil-fuel-based plastic waste generated globally, only 9% is recycled, while 83% is disposed of in the environment or incinerated (12%). As plastic waste takes decades to decompose, soils, air, and oceans now contain five billion tons of increasingly toxic and fragmented plastics (Forrest *et al*., 2019). Biodegradability refers to a substance's capacity to be broken down and decomposed by living organisms such as microorganisms, bacteria, and fungi. This process transforms the substance into simpler forms like carbon dioxide, biomass, and water. Jørgensen (2008) emphasized that biodegradability is crucial for toxic chemicals, as a high degradation rate rapidly reduces their toxic effects. Therefore, biodegradability significantly contributes to the sustainability and health of our environment.

Bioplastics can be produced using plants and food waste, providing a sustainable method for their production. Food waste is recognized as a major environmental concern, and promoting environmental sustainability through its use in bioplastic production is vital. Potential bioplastic materials include chicken feathers, avocado seeds, jackfruit seeds, durian seeds, pineapple peels, banana peels, cassava peels, and sludge waste from the food industry. These materials can be sourced from households and large food industry companies (Ramadhan & Handayani, 2020). Based on the recommendations of the previous research titled "Development of Alternative Food Wrap Using Bioplastic" by Hernandez *et al*. (2023), this study conducted a biodegradability test on the Banana Food Wrap they produced, comparing it to a commercial product, the Cassava Food Bag. The formulation used for the banana food wrap was the best formulation from the previous study. The objective was to demonstrate that the banana food wrap packaging can decompose under various conditions, indicating its lower environmental impact compared to other food packaging. This research primarily focused on product testing, providing valuable insights for researchers, packaging developers, and industry pioneers by highlighting the importance of further exploration. The study aimed to be achieved through an experimental design using the necessary materials and setting. The findings could contribute to the development of more eco-friendly packaging for consumer products. Additionally, it could expand research scope, support future studies, and create a platform to raise awareness about the need for biodegradable and safe packaging for the planet's safety and its inhabitants. This aligns with the overall objectives of promoting environmental sustainability and reducing the negative impact of packaging materials.

METHODOLOGY

This chapter provided a comprehensive overview of the materials and methods employed in the research. It began with an introduction outlining the study's primary objective: to evaluate the biodegradability of banana food wrap packaging compared to traditional plastic packaging materials. The chapter underscored the significance of this comparison in addressing environmental sustainability concerns. The materials used in the study were described in detail, including both the banana food wrap packaging and traditional plastic packaging materials. Information on the sources, composition, and any pre-treatment or processing of these materials before testing was provided. This ensured a clear understanding of the baseline properties of the materials under investigation. The methods for evaluating the biodegradability of the materials were then discussed. This section covered the experimental design, including sample size and testing conditions. Specific tests performed included microbial degradation tests, composting tests, and soil burial tests. These methods were selected to simulate various environmental conditions and provide a comprehensive assessment of biodegradability. The research design employed an experimental approach to compare the biodegradability of banana food wrap and cassava bioplastic packaging materials. Controlled experiments were conducted to evaluate the degradation rate and changes in chemical and physical properties of the samples in different environments (soil, fresh water, salt water). This approach allowed for the systematic examination of the materials' biodegradability under realistic conditions, providing robust data to determine whether banana food wrap offered a more sustainable alternative to conventional plastic packaging. Evaluation of the banana food wrap packaging involved soil burial tests to simulate a realistic environmental setting. Biodegradability was measured through weight loss and microbial activity appearance. Weekly measurements of the samples' weight before and after exposure to microbial conditions provided quantitative data on degradation rates. Additionally, visual documentation and observation of microbial activity on the samples' surfaces offered qualitative insights into the biodegradation process. Data analysis utilized the 't' test to compare the biodegradability of banana food wrap and cassava bioplastic packaging, with the results aiding in identifying the more environmentally friendly packaging option. This methodology ensured the reliability and integrity of the study's findings, contributing valuable knowledge to the field of sustainable packaging.

Table 1. Materials

Parameters	Levels	Description
Product	2	Banana Food Wrap Packaging
Product	2	Cassava Bioplastic Packaging
Ingredients	5	Banana Peel (Without Fiber), Water, Cornstarch, Pure Glycerin and Vinegar
Sample Size	2	3x3 inches, 2mm

Table 2. Banana Food Wrap Formulation

Ingredients	Description	Unit of Measurement	Unit	Percentage
BANANAMIXTURE				
Banana Peel (withoutfiber)	TheMain Ingredients from Food Waste	g	100	27.78%
Water	AdditionalLiquid	ml	110	30.55%
CORNSTARCHMIXTURE				
Cornstarch	Actsas Polymer	g	30	8.33%
Water	AdditionalLiquid	ml	100	27.78%
Vinegar	Breakupsomepolymers to make the plastic less brittle	ml	5	1.39%
Pure Glycerin	Plasticizer	g	15	4.17%

Table 3. Cassava Bioplastic Packaging Formulation

Ingredients	Description	Percentage
Cassava Starch	The Main Ingredients	75%
Vegetable Oils	Liquid	25%

Table 4. Weight Loss Percentage of Banana Food Wrap buried in Soil

WEEK	1	2	3	4	5	6	7	8	9	10	11	12
Initial Weight	.633	.693	.670	.647	.685	.683	.680	.700	.647	.679	.683	.711
Final Weight	.314	.246	.152	.135	.135	.100	.073	.044	.023	.000	.000	.000
Weight Loss (%)	50%	65%	77%	79%	80%	85%	89%	94%	96%	100%	100%	100%

RESULTS AND DISCUSSION

Table 4shows the weight loss percentage of the Banana Food Wrap buried in soil for the span of 12 weeks, achieving 50% in its first week and degrading slowly in its following weeks ranging from 15% - 46% until reaching a 100% weight loss in week 10. The sample lost 50% of its weight in the first week, suggesting a high degradation rate in a soil component. In the following weeks, weight loss percentage slowed down due to biological activity until it reached 100% degradation of the original weight in 10 weeks. Microorganisms can assault cellulose and starch particles immediately because they can produce enzymes that break down or break the polymer's physical framework. This can lead to a reduction in the weight of molecules outside of the microbial cells (Ahsan, et. al., 2023). Therefore, the Banana Food Wrap displays a significant biodegradability rate when it is buried in soil. This indicates that the biodegradability rate of theBanana Food Wrap buried in soil is faster than the approximate time for bioplastic to degrade. Plastic is regarded as biodegradable if it can be reduced into pieces by a home compost in 12-24 months (Philips, 2021). Table 5 presents that throughout the experimental time line, the weightloss percentages of cassava bioplastic were evaluated based on its final weights in the soil. In the initial week, the cassava bioplastic, starting at an initial weight of 0.170mg exhibited a final weight of 0.110mg, corresponding to a 35% weight loss. As the experiment progressed to its final week, the cassava bioplastic

Table 5. Weight Loss Percentage of Cassava Bioplastic buried in Soil

WEEK	1	2	3	4	5	6	7	8	9	10	11	12
Initial Weight	.170	.186	.179	.192	.141	.140	.160	.179	.179	.199	.167	.177
Final Weight	.110	.090	.080	.076	.048	.040	.045	.041	.033	.028	.020	.013
Weight Loss (%)	35%	52%	55%	60%	66%	71%	72%	77%	80%	86%	88%	93%

Table 6. Weight Loss Percentage of Banana Food Wrap submerged in Salt Water

WEEK	1	2	3	4	5	6	7	8	9	10	11	12
Initial Weight	.783	.757	.731	.830	.757	.731	.812	.749	.732	.736	.840	.827
Final Weight	.668	.480	.668	.310	.242	.220	.233	.187	.170	.138	.145	.064
Weight Loss (%)	14%	32%	47%	52%	68%	69%	71%	75%	76%	81%	83%	92%

Table 7. Weight Loss Percentage of Cassava Bioplastic Submerged in Salt Water

WEEK	1	2	3	4	5	6	7	8	9	10	11	12
Initial Weight	.174	.182	.164	.196	.160	.201	.200	.195	.202	.160	.198	.180
Final Weight	.070	.073	.063	.066	.054	.069	.065	.060	.061	.046	.039	.027
Weight Loss (%)	60%	60%	62%	66%	66%	66%	68%	69%	70%	71%	80%	85%

demonstrated a substantial increase in degradation, with a final weight of 0.013mg and an impressive weight loss percentage of 93%. These findings highlight the progressive and significant biodegradation of cassava bioplastic over the experimental duration, emphasizing its potential as an environmentally friendly and sustainable material. As a supporting study Zoungranan *et al*., (2020) where they elucidated the rapid degradation of cassava-based bioplastics facilitated by bacterial activity in soil environments. Their study underscores the pivotal role of microbial communities in expediting the breakdown of these eco- friendly materials. Cassava bioplastics, sourced from renewable agricultural resources, exhibit notable biodegradability, a stark contrast to conventional plastics derived from fossil fuels. The investigation reveals that specific bacterial strains present in soil environments possess enzymatic capabilities crucial for accelerating the degradation process of cassava bioplastics. This finding highlights the synergistic relationship between microbial activity and bioplasticdegradation, emphasizing the potential of harnessing natural processes for sustainable waste management solutions. Commencing our examination of the 12-week timetable for the weight loss percentage of cassava bioplastic submerged in saltwater, it becomes evident that the most substantial weight loss, reaching 93%, is recorded in the twelfth week— the concluding phase of the experiment. This outcome is noteworthy, acknowledging the inherent difficulty in achieving such a high biodegradation rate for bioplastics, particularly in marine environments, as previously discussed. Conversely, week 1 showed the lowest proportion of weight reduction, coming in at about 14% throughout the first seven days. This early result is encouraging and points to efficient biodegradation. Thus, bioplastics degrades far more quickly than others, which requires at least two weeks to show comparable changes, as previous research has shown. (Cho, 2022)

In conclusion, the experimentation involving the submersion of cassava bioplastic in soil has yielded a notably impressive outcome, showcasing a substantial weight loss of 93%. This result holds considerable significance, suggesting a high level of biodegradability for cassava bioplastic within a soil environment. The observed efficacy in weight loss underscores the material's potential as an environmentally sustainable alternative. These promising outcomes pave the way for further exploration and consideration of cassavabioplastic as a viable and eco-friendly material in various applications in the foreseeable future. The demonstrated capacity for significant biodegradation positions cassava bioplastic as a noteworthy contender in the ongoing quest for sustainable materials, warranting continued investigation and potential integration into broader industrial and environmental contexts. Table 6 displays the weight loss percentage of banana food wrap sample when they are put in salt water.This section delves into the general findings drawn from Table 6, which presents an overview of the information gathered throughout the research study and experiment done for at least 12 weeks which corresponds to 3 months.

By examining the contents of this table, the results show a 92% weight loss of banana food wrap sample in its final week. According to (Gomez, 2021) , depending on their location, materials decompose in different ways. The rate of degradation depends on several factors, including moisture, temperature, and thenumber of microorganisms. For instance, some plastics may not degrade at all in the seawater. In conclusion, achieving this high weight loss percentage shows a positive result in terms of biodegradation rate. Beginning with the analysis of the 12-week timetable for weight loss percentage of banana food wrap submerged in salt water, the one with the highest percentage of weight loss which got 92% is the week 12 or the final week. Which indicates a positive result, recognizing that it is hard to achieve this biodegradation rate for bioplastics especially in marine environment as mentioned before. On the other hand, week 1 got the lowest percentage of weight loss which corresponds to at least 14% of weight loss in just seven days. This is a good starting point as it is already showing a good performance of biodegradation, which concludes that this type of bioplastic degrades faster than other bioplastics that took at least 2 weeks to confirm their changes (Triawan, 2020). In summary, the weight loss percentage of banana food wrap in saltwater was prominently observed in the final week, reaching an impressive 92%. This outcome is a positive indicator of the biodegradation rate of banana food wrap. In conclusion, the comprehensive analyzation of the 12-week timetable underscores the accelerated biodegradation of banana food wrap in saltwater, offering insightsinto its promising environmental impact and potential advantages over other bioplastics. Table 7 shows that based on the research done with the cassava bag, the cassava bag is a great product with natural and organic contents with few chemical mixtures and using Cassava as the main ingredient for the product. The ideal performance of the Cassava bag is to corrode in natural environments as said by the company. Cassava is a root vegetable. The underground part of the cassava shrub, which has the Latin name Manihot esculenta. Like potatoes and yams, it is a tuber crop. Cassava roots have a similar shape to sweet potatoes (Marengo, K. 2023). As said, the Cassava bag simply rots like any other fruits or vegetables in any environment when given the time to rot. The researchers made sure to put the products to the test, using their own product, Banana Bioplastic, and the company's product Cassava Bag and placed in different environments to prove, which is the best product to use, and which easily corrodes than the other.

Seen in table 7, the researchers use timetables to distinguish the progressive corrosion of the Cassava bag each week, along with weighing and inspecting any reaction of the cassava bag in salt water. The 1st week of the cassava bag already lost 0.174mg of its original weight and remained white with a more transparent look in it. As for the 2nd week the Cassava bag did not react much but changed its weight progressively up until week 3 however it did not change in appearance. The appearance hasn't changed from week 1 to week 3 but consistently lost its weight up until week 12 from. 174mg to

.164mg in just 3 weeks. In week 4 The appearance of the Cassava bag gained black spots and lost 66% of its original weight, the Cassava bag is biodegradable. In week 5 the Cassava bag gained a light-yellow color, and black spots are still seen in the cassava bag, due to long periods of time being submerged in salt water and lost more weight if differentiated from the 1st week.

the cassava bioplastic further decreased to 0.189mg corresponding to a substantial 90% weight loss. This suggests an accelerated degradation process or increased susceptibility of the bioplastic to the freshwater environment over the course of the experiment. The data in Table 6 highlights the dynamic nature of weight loss in cassava bioplastic under freshwater conditions, providing valuable insights into its degradation behavior over time. These findings could be crucial for assessingthe material's suitability for specific applications and understanding its environmental impact (Ribba, 2022). The results showed that a much larger quantity of plastic fragments/particles were formed in all aquatic environments. The study examines the formation of microplastics, their size distribution, shapes, and physicochemical properties. It reveals a high risk of microplastics from biodegradable polymers, requiring further evaluation in freshwater, estuarine, and seawater habitats. Although these microplastics may have good biodegradability in warmer water (Xin-Feng, 2021).

Table 8. Weight Loss Percentage of Banana Food Wrap Submerged in Fresh Water

WEEK	1	2	3	4	5	6	7	8	9	10	11	12
Initial Weight	.843	.892	.800	.823	.842	.802	.867	.888	.834	.822	.868	.851
Final Weight	.416	.320	.227	.155	.142	0.19	.015	.000	.000	.000	.000	.000
Weight Loss (%)	51%	64%	72%	81%	83%	98%	98%	100%	100%	100%	100%	100%

Table 9. Weight Loss Percentage of Cassava Bioplastic Submerged in Fresh Water

WEEK	1	2	3	4	5	6	7	8	9	10	11	12
Initial Weight	.160	.200	.161	.181	.176	.173	.189	.150	.200	.172	.159	.189
Final Weight	.085	.079	.054	.061	.058	.057	.057	.038	.046	.034	.030	.019
Weight Loss (%)	47%	61%	66%	66%	67%	67%	70%	75%	77%	80%	81%	90%

The 6th week of the experiment as seen, the yellow part of the Cassava bag is visible, and the weight of the bag slowly decreases by weeks pass. In week 7 the bioplastic is mixed with black and yellow color as evidence of rotting factor and as well as losing its weight .202mg and reached 68% of its weight loss. In week 8 the slow progression of corrosion on the bag can be seen and identified as well as its weight, due to how transparent the white part of the bag is becoming. In week 9 the weight of the Cassava bag is 0.202 and the final weightlost is 0.61 and the percentage of the Cassava weight lost 70% from its original weight and the figure shows a consistent growing of yellow and black color on the Cassava bag. In week 10 the Cassava bags initial weight was 0.160mg and during is dried part shows that it had lost 0.46 from its original weight which made it up to 71% loss weight. In week 11 The Cassava bag gained more of a black color and as for the weight of the Cassava bag Its initial weight is 0.198mg and its final weight lost was 0.039 mg of its original weight and loss around 80% of it. As for its final week 12, the Cassava bag had gained increasing amount of yellow and black color and lost around 0.027mg from its weight and loss 85% from its original weight during the 1st week of it being submerged. It goes to show that the Cassava bag product is biodegradable, and it was a groundbreaking innovation with a root vegetable, cassava, to combat plastic pollution (Ferreira a, 2020). The product was surely biodegradable but slow at decomposing compared to Banana bio plastic which showed to be more effective than Cassava bag.

Table 8 displays the weekly decreasing weight of each banana food wrap sample when submerged in fresh water. During the initial week, the sample had a 50% weight loss, demonstrating a rapid degradation rate in a freshwater environment. Subsequently, the weight loss for each sample every week slowed considerably, ranging from an 8% to a 15% decrease. Nevertheless, specific samples completely degraded within eight weeks of submersion in freshwater. However, according to Ahsan et. Al (2023), the degradation of bioplastics throughfreshwater has a high variability. Thus, the samples could have a high or low degradation rate due to changes in temperature or weather conditions. As shown in the table in the 11th week, the sample is still not thoroughly degraded. According to Kliem S *et al.* (2020), the material's shape, surface area, and thickness are key factors influencing biological degradation. Therefore, even if the samples initially have similar weights, thickness, shape, and surface area variations, they can lead to different degradation outcomes. In conclusion, the banana food wrap sample degrades quickly when submerged in fresh water. However, some inconsistencies may affect the degradation of it through fresh water. These include the environment's condition (temperature/season) and the material's properties. Table 9 presents the weight loss percentage of cassava bioplastic submerged in freshwater over a specified duration. In the first week, the cassava bioplastic exhibited a final weight of 0.085mg, reflecting a 47% weight loss. This indicates the initial degradation or dissolution of the bioplastic during the early stage of the experiment. As the experiment progressed, by the last week, the final weight of

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