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Bastefia Bag (Banana Stem Fiber Tea Bag) as Innovative Tea Bag Environmentally Friendly Non-Microplastic

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Keywords

Microplastics; Sea; Banana Stem Fiber; Tea Bags.

Abstract

Microplastics have become a major threat to humans. Indonesians are estimated to consume 15 grams of microplastic per capita per month, equivalent to three ATM cards, one source of which is tea bags. Unknowingly, these tea bags release or produce microplastics, which can become toxic if they pollute the environment. This microplastic waste can be channeled into the ocean through waterways. Researchers conducted a study aimed at determining how to make Bastefia Bag using banana stem fiber as the raw material and its efficiency as a substitute for commercial tea bags. The research method used was an experiment, namely conducting organoleptic tests, comparing Bastefia Bag with ordinary tea bags in terms of solubility in water at 100°C, and biodegradability tests. The results of this study indicate that banana stem fiber is effective as a raw material for Bastefia Bag without altering the function of commercial tea bags.

INTRODUCTION

One of the environmental issues currently receiving serious global attention is plastic waste. According to Rezi and Rahayu (2025), Indonesia is among the largest contributors to plastic waste worldwide, generating approximately 3.2 million tons of inadequately managed plastic waste annually. Since the onset of mass production in the 1950s, plastic has become one of the most widely utilized materials for packaging (Maulana, 2023). This is attributed not only to its practicality but also to its capacity to support the development of attractive packaging designs, which provide economic advantages for producers. The use of plastic generates a strong visual appeal for products. Nevertheless, plastic constitutes a significant environmental problem due to its non-biodegradable nature and its widespread consumption in society, despite the considerable hazards it poses.

Without widespread awareness, the issue of plastic waste is not solely a consequence of consumptive human behavior that prioritizes practicality, leading to the accumulation of plastic debris. This accumulation also gives rise to another critical issue, namely the formation of microplastics. Microplastics are defined as plastic polymer particles measuring less than 5 mm (Maulana, 2023). Their formation results from physical and chemical degradation processes, including exposure to solar radiation, thermal oxidation, and microbial activity (Fachrul & Rianti, 2018). Although such processes may suggest that plastics gradually decompose in the environment, this is not entirely accurate. Instead of fully degrading, plastics fragment into microplastics, which persist in the environment and pose significant ecological risks due to their ability to adsorb toxic pollutants.

The accumulation of plastic waste derived from human consumption has detrimental impacts on the environment. This is primarily because plastic is a hazardous pollutant characterized by its resistance to degradation (Cahyaningrum & Sari, 2024). In recent decades, research

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and understanding of the impacts of plastic waste on aquatic pollution have increased significantly, revealing serious consequences for aquatic ecosystems, biodiversity sustainability, and human health (Aqilla et al., 2023). Furthermore, improperly managed plastic waste can enter aquatic environments, either through direct disposal or passive transport driven by wind and other environmental factors. Among the vast quantities of waste that ultimately end up in the ocean, plastic waste is one of the most dominant types found in aquatic environments (Wati et al., 2023). The intentional disposal of waste into the sea is often driven by a prevailing societal perception that the ocean serves as the final sink for waste, based on the assumption that its large volume of water can dilute various pollutants and environmentally harmful substances (Akbar & Maghfira, 2023).

Microplastics have been identified in several products widely consumed by Indonesian society, one of which is tea bags. Tea bags consist of ground tea enclosed in a porous, heat-resistant material. The bag functions as both a container and a filter for tea leaves, allowing it to be conveniently discarded after use without leaving residue in the beverage. The Badan Pengawas Obat dan Makanan (BPOM) has reported that tea bags are generally composed of a combination of paper and plastic materials. The plastic component, typically polyethylene, serves as a binding agent and provides heat resistance, preventing the bag from opening, tearing, or melting when immersed in hot water. Despite these functional advantages, the presence of plastic in tea bags also poses potential risks to human health. During the brewing process, exposure to heat can cause tea bags to release microplastic particles into the beverage. Therefore, this study seeks to preserve the cultural practice of tea consumption ("ngeteh") while minimizing or eliminating microplastic contamination.

Referring to several studies conducted by researchers from Ecological Observation and Wetlands Conservation (ECOTON), at least five commonly consumed tea bag brands in Indonesia have been found to release microplastic particles from their packaging. Indonesian society is estimated to consume approximately 15 grams of microplastics per capita per month, equivalent to the size of three ATM cards, with one of the sources originating from tea bags. Therefore, this study proposes an alternative solution to reduce microplastic exposure, particularly in tea consumption, where contamination arises from tea bag materials that release such particles. The proposed solution is an environmentally friendly product known as Bastefia Bag (Banana Stem Fiber Tea Bag). This product is a tea bag made from fibers derived from banana stems (Musa paradisiaca L.).

The banana plant is a highly versatile plant, as nearly all of its parts (from roots to leaves) can be utilized (Cindarbumi et al., 2020). It is widely cultivated in tropical regions, as it thrives in warm climates and requires abundant sunlight (Mutmainnah et al., 2023). Bananas are considered a priority horticultural commodity for research and development due to their strong potential to meet both domestic demand and export needs (Nugraha, et al., 2024). In Indonesia, however, the banana plant is predominantly utilized only for its fruit. In fact, every part of the plant can be processed and transformed into products with significant functional value. This has attracted the interest of researchers to utilize banana plants as raw materials for product development. In addition to their wide availability, favorable material characteristics, and low cost, consideration is also given to the environmental aspect, particularly the ability of the resulting product waste to biodegrade effectively.

Banana stem (Musa paradisiaca) is one of the parts of the banana plant that is still underutilized by the community (Ridwan et al., 2022). Referring to several craft applications, banana stems are utilized for their fibers to produce various products. These fibers possess characteristics that make them suitable as an alternative material for textile production and offer relatively high durability (Kusna & Anam, 2021). Banana stem exhibits porous, hollow, and fibrous properties, resulting in a relatively high density value (Amilia & Hidayanti, 2022). Based on these characteristics, banana stem fiber is considered a suitable raw material for the development of the Bastefia Bag. The researchers hypothesize that processing banana stem fibers into an innovative tea bag product will yield favorable results, particularly due to the fiber's capability to effectively filter tea leaves or particles.

Bastefia Bag represents a continuation of the bioplastic concept applied in this innovative tea bag product. The researchers drew inspiration from bioplastics in terms of their components, methods, and procedural steps in the development of the Bastefia Bag. In general, bioplastics are materials that can be naturally degraded by microorganisms, making them more environmentally friendly. Bioplastics also offer additional advantages, as their raw materials can be derived from renewable natural resources. They can be synthesized from renewable organic sources such as starch, proteins, and microorganisms (Salsabila et al., 2022). In this study, the researchers utilize banana stem fibers, which are often underutilized and have the potential to become organic waste, and subsequently synthesize them with starch to produce a biodegradable material.

This study was conducted to evaluate the effectiveness of the non-microplastic Bastefia Bag as a substitute for commercial tea bags, particularly in terms of its solubility performance, which reflects its resistance to hot water. In addition, the study aims to determine whether the Bastefia Bag is truly environmentally friendly, as indicated by its waste being naturally biodegradable.

The transition from commercial tea bags to the Bastefia Bag is expected to generate several positive impacts, including reducing the potential for human ingestion of microplastics and minimizing the release of microplastics into the environment. Furthermore, this innovation promotes the utilization of banana stem waste, which is often underused and discarded, thereby adding value to organic waste materials. As a biodegradable product, the Bastefia Bag can also contribute to reducing household waste generated from single-use tea bags. Ultimately, this initiative supports environmental sustainability and encourages the adoption of eco-friendly, plastic-free consumption habits within society.

RESEARCH METHODS

The research method employed in this study is an experimental method, which involves conducting controlled trials to investigate a particular problem in order to obtain empirical results. The data collected consist of primary data, defined as data obtained directly from the research object. In this study, primary data were gathered through organoleptic testing questionnaires, solubility tests, and biodegradability assessments. In addition, secondary data were also utilized, referring to data that are not obtained directly by the researcher but are collected through intermediaries such as documents or existing literature. The data analysis technique applied in this study is quantitative, involving hypothesis testing through experimental procedures in the production of the Bastefia Bag. Measurement instruments were employed as research tools, and statistical methods were used to derive valid and reliable research conclusions.

This study was conducted from August 6, 2025, to September 25, 2025. The experimental phase began with the preparation of the required tools and materials. The tools used in the production of the Bastefia Bag included a knife, scissors, sewing needle, strainer, containers, gauze cloth, oven, blender, spoon, ruler, dropper pipette, and digital scale. The materials consisted of banana stems, 2000 ml of water, 9 g of tapioca flour, 5 ml of glycerin, and sewing thread. After all tools and materials were prepared, the researchers conducted four experimental trials to determine the optimal composition of banana stem fiber, tapioca flour, and glycerin. The most effective composition was found to be in a ratio of 5:2:1. The procedure for producing the Bastefia Bag began by blending banana stems with 1000 ml of water until a coarse fiber pulp was obtained. The pulp was then filtered, yielding a mass of approximately 62.3 g. Subsequently, the pulp was cooked with 500 ml of water, followed by the addition of 9 g of tapioca flour and 5 ml of glycerin, and stirred until it reached a boiling state. After cooking, the mixture was poured onto a flat surface lined with gauze cloth and spread evenly. The pulp layer was then oven-dried until completely dry. This process produced a paper-like material that served as the base for forming the Bastefia Bag. The dried material was then cut into two rectangular pieces measuring 6 cm × 5 cm. Both pieces were stacked and sewn along the left, right, and bottom edges to form a pouch. Tea leaves were then inserted through the top opening, which was subsequently sewn shut. Finally, a string was attached to the tea bag to enhance the practical functionality of the Bastefia Bag.

Organoleptic (sensory) testing is a method that utilizes human senses as the primary instrument to evaluate the quality of a product, including parameters such as appearance, aroma, taste, and texture /consistency, as well as other relevant factors required for quality assessment. This test was conducted to determine whether the use of banana stem (Musa paradisiaca L.), tapioca flour, and glycerin would cause any changes in the color, taste, and aroma of the brewed tea. This approach is in accordance with Ismanto, who stated that the determination of food quality generally depends on several factors, including flavor, color, texture, and nutritional value.

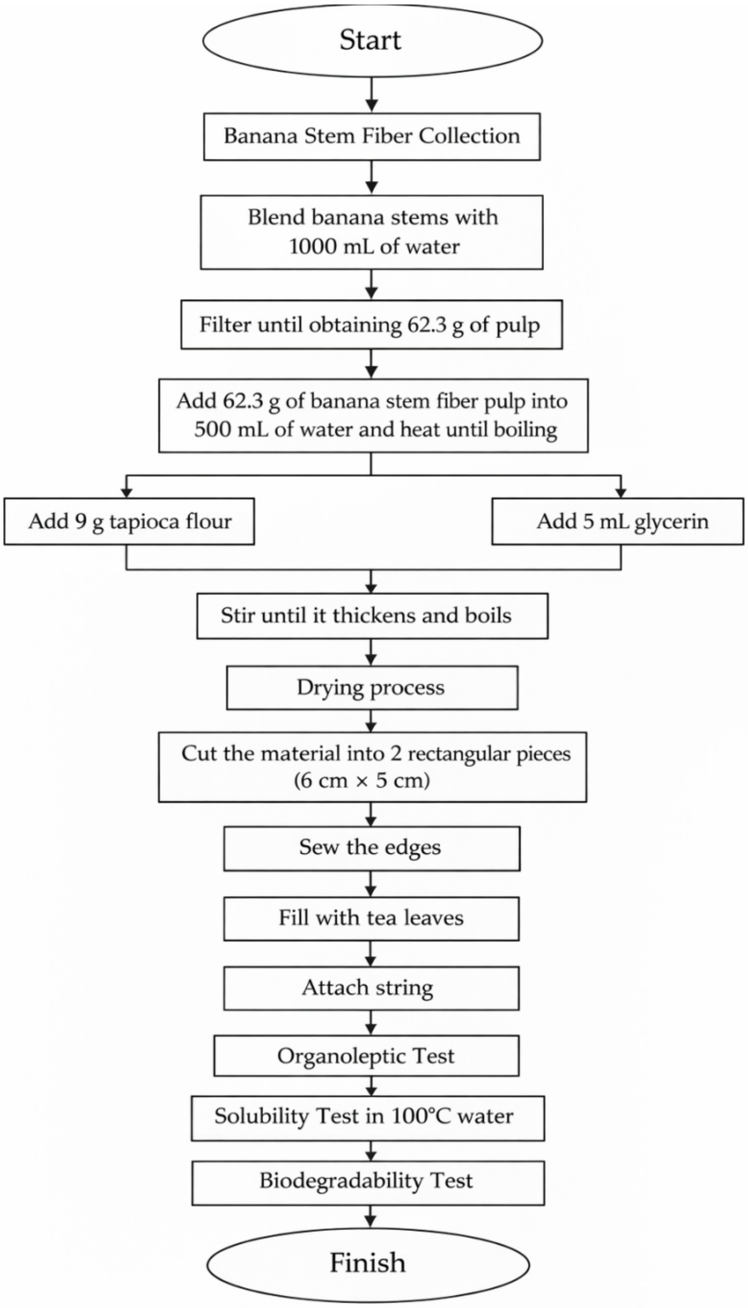
Subsequently, a solubility analysis of the tea was conducted. This analysis involved testing the resistance and solubility of both the Bastefia Bag and commercial tea bags in water at a temperature of 100°C, as well as comparing the performance of the two. The selection of 100°C was based on the common practice of tea brewing within the community. This analysis was also intended to evaluate the effectiveness of the Bastefia Bag as a heat-resistant tea bag. The test samples were prepared in a rectangular shape measuring 5 × 6 cm, consistent with the standard size of commercial tea bags, and each contained tea leaves. This approach was adopted to ensure comparability under identical conditions. Observations of solubility and structural integrity were conducted at the initial 5 minutes and continued up to 24 hours (1 day).

Subsequently, a biodegradability analysis was conducted by burying the Bastefia Bag, with an initial mass of 0.6 g, at a depth of 3 cm in loose soil to determine the time required for the material to degrade after use.Observations were carried out at two-day intervals following burial. This analysis was conducted over a period of 7 days (one week), from September 18 to September 25, 2025.

RESULTS AND DISCUSSION

Based on the results of the study, the researchers successfully developed the Bastefia Bag, an environmentally friendly and non-microplastic tea bag made from banana stem fiber as its primary raw material.

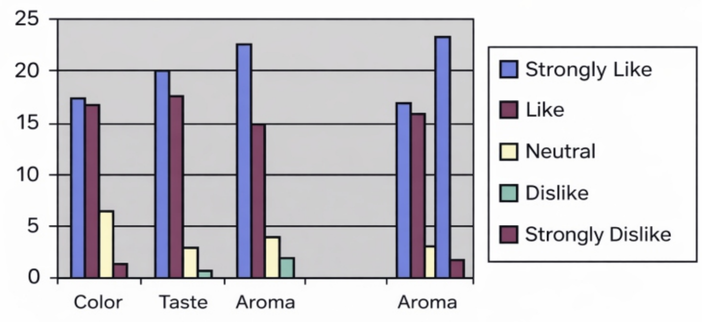
The issue of microplastic contamination in commercial tea bags necessitates a viable solution to enable consumers to enjoy tea without exposure to microplastics. To address this problem, the researchers developed the Bastefia Bag as an environmentally friendly, non-microplastic alternative to conventional tea bags.



Sumber: Processed Primary Data, (2025)
Figure 1
Flowchart of Bastefia Bag Production Procedure

Organoleptic Analysis

Organoleptic analysis was conducted involving 39 respondents to evaluate the Bastefia Bag product based on human sensory perception. The visual sense was used to assess color, the gustatory sense to evaluate taste, and the olfactory sense to assess the aroma of the brewed tea, as as illustrated in Figure 2. This approach is consistent with previous studies indicating that sensory perception forms the basis of consumer impressions, which subsequently determine the evaluation of a product according to the stimuli received by the senses (Gusnadi et al. 2021). Based on this framework,the researchers categorized respondents' evaluations into five levels: (1) strongly like, (2) like, (3) neutral, (4) dislike, and (5) strongly dislike. The organoleptic analysis through respondents was conducted to assess the effectiveness of the Bastefia Bag when applied to the broader community. Therefore, this analysis provides insight



Sumber: Processed Primary Data, (2025)
Figure 2
Diagram of the Results of the Organoleptic Test from 39 Respondents

into whether the Bastefia Bag is capable of producing tea that meets consumer preferences in terms of color, taste, and aroma.

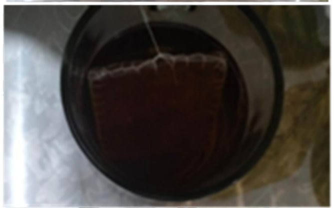
Based on Figure 2, it can be observed that the majority of respondents selected the "strongly like" category, followed by those who selected "like," while only a small proportion chose "neutral." For the color parameter, 17 respondents selected "strongly like," 16 selected "like," and 6 selected "neutral," with no respondents choosing "dislike" or "strongly dislike." For the taste parameter, 20 respondents selected "strongly like," 17 selected "like," and 2 selected "neutral," with no negative responses recorded. For the aroma parameter, 23 respondents selected "strongly like," 13 selected "like," and 3 selected "neutral," with no respondents indicating "dislike" or "strongly dislike." The taste of a food or beverage is influenced by its raw materials and the processing methods applied. Thermal processing, positioning during heating, and additional ingredients can significantly affect the resulting taste. This is consistent with literature stating that taste is a response to chemical stimuli perceived by the gustatory senses, particularly the basic taste modalities: sweet, salty, sour, and bitter (Rahmadiana & Farapti, 2024). When consuming food or beverages, the sensory system recognizes these taste components. Several factors contribute to taste perception, including

Sumber: Processed Primary Data, (2025)
Figure 3
Bastefia Bag Product

aroma, the composition of ingredients, texture or level of doneness, and the temperature of the food or beverage.

Differences in category selection are influenced by variations in individual perceptions and evaluation approaches. Each individual tends to interpret and assess the same object differently. Therefore, the researchers focused on general trends by identifying the categories most frequently selected by respondents. Overall, no respondents expressed negative evaluations, as none selected the "dislike" or "strongly dislike" categories in the Bastefia Bag testing. Based on these responses, it can be concluded that there were no significant changes in the color, taste, and aroma of tea compared to conventional tea. This indicates that the use of banana stem fiber, tapioca flour, and the application of the Bastefia Bag does not adversely affect tea quality and demonstrates its potential effectiveness when implemented in wider community use.

Table 1
Solubility in Water at 100°C

Time	Bastefia Bag	Commersial Tea Bag
September 22, 2025 07.30 p.m UTC+8 5 Minutes		
September 22, 2025 07.35 p.m UTC+8 10 Minutes		
September 22, 2025 07.45 p.m UTC+8 20 Minutes		
September 22, 2025 07.55 p.m UTC+8 30 Minutes		
September 22, 2025 08.05 p.m UTC+8 40 Minutes		
September 22, 2025 08.15 p.m UTC+8 50 Minutes		
September 22, 2025 08.25 p.m UTC+8 1 hour		

Source: Processed Primary Data, 2025

Solubility Analysis

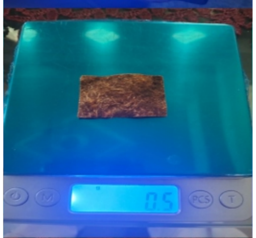
Based on Table 1, it can be observed that there was no change in the solubility performance of the Bastefia Bag from the first 5 minutes up to 1 hour. During the initial 5 minutes, the Bastefia Bag remained intact, similar to the commercial tea bag. Likewise, within the 10-minute to 1-hour interval, both the Bastefia Bag and the commercial tea bag maintained their structural integrity without any observable damage. After 24 hours (1 day), both the Bastefia Bag and the commercial tea bag remained intact; however, the Bastefia Bag, which was initially firm, became softer in texture. In contrast, the commercial tea bag, which was initially white, changed color to light brown. Overall, the Bastefia Bag and commercial tea bags exhibited a similar level of resistance to dissolution in hot water.

Based on this analysis, the Bastefia Bag does not lose its function as a tea bag, as it demonstrates a level of solubility resistance comparable to that of commercially available tea bags widely used by the community. However, the Bastefia Bag exhibits a distinct advantage over commercial tea bags, as it does not release microplastics during the brewing process.

Biodegradable Test

Based on Table 2, it can be observed that the Bastefia Bag experienced a reduction in mass at two-day intervals. On the first day prior to burial (September 18, 2025), the Bastefia Bag had an initial mass of 0.6 g. Two days after burial (September 20, 2025), it began to show physical changes, with a mass reduction of 0.1 g, resulting in a mass of 0.5 g. At this stage, the structure remained intact, although small holes appeared on the surface. Two days later, on September 22, 2025, the

Table 2
Biodegradable Test of Bastefia Bag

Time	Bastefia Bag	Weight	Notes
September 18, 2025		0,6 grams	Bastefia Bag remained intact.
September 20, 2025		0,5 grams	Bastefia Bag developed small holes.
September 22, 2025		0,3 grams	Bastefia Bag exhibited small fragments.
September 25, 2025		0,0 grams	The small fragments had begun to decompose, and the number of small fragments from the Bastefia Bag increased.

Source: Processed Primary Data, 2025

Bastefia Bag exhibited a further mass reduction of 0.2 g, reaching a mass of 0.3 g. The structure began to tear at certain parts, leading to the formation of small fragments. On the final observation day, September 25, 2025, the Bastefia Bag showed continued degradation, with previously torn sections and small fragments undergoing further decomposition, accompanied by additional structural damage. The degradation process of biodegradable plastics can be identified through physical changes such as the appearance of small holes on the surface, fragmentation into smaller pieces, and a reduction in mass (Wahyuningtyas & Suryanto, 2017). Therefore, the Bastefia Bag can be classified as a biodegradable and environmentally friendly material.

The rate of degradation can be influenced by several factors, including environmental conditions, temperature, humidity, and microbial activity in the soil. In addition to these factors, the degradation rate may also be affected by the material composition of the Bastefia Bag, particularly the presence of glycerin. This is consistent with the findings of Nurhidayah et al., who stated that glycerol possesses hygroscopic properties, enabling it to absorb water easily; thus, its addition can accelerate the degradation of bioplastics. The rate of degradation can be influenced by several factors, including environmental conditions, temperature, humidity, and microbial activity in the soil. In addition to these factors, the degradation rate may also be affected by the material composition of the Bastefia Bag, particularly the presence of glycerin. This is consistent with the findings of Nurhidayah et al. (2023) who stated that glycerol possesses hygroscopic properties, enabling it to absorb water easily; thus, its addition can accelerate the degradation of bioplastics. Soil consists of various components such as microorganisms, bacteria, and water. A higher moisture content contributes to faster degradation, as it facilitates the breakdown of materials. An increased glycerol content allows more water to penetrate the bioplastic structure, thereby enhancing microbial activity and accelerating the decomposition process.

CONCLUSION

Based on the results of the conducted experiments, it can be concluded that the Bastefia Bag has the potential to serve as an environmentally friendly and microplastic-free alternative to commercial tea bags, which have been shown to contain microplastics. The findings indicate that banana stem fiber demonstrates effective performance as the primary raw material for the Bastefia Bag, as it does not alter the sensory qualities of tea in terms of aroma, taste, and color. In addition, the product exhibits high resistance to hot water (above 100°C), ensuring its practical functionality during the tea brewing process. Furthermore, its biodegradable nature enhances its environmental sustainability. For future researchers interested in further developing the Bastefia Bag, it is recommended to explore more innovative ideas to improve the product's commercial appeal without compromising its fundamental characteristics as an environmentally friendly and non-microplastic material.

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