

Potentiality of *Dracaena Trifasciata* Fibers as a Sustainable Raw Material for Paper Bag Production

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ABSTRACT

This study evaluates the feasibility of *Dracaena trifasciata* (snake plant) fibers as an alternative raw material for eco-friendly paper bag production. A descriptive–experimental design was employed to compare fabricated paper bags with commercial counterparts in terms of biodegradability, water absorption, tensile strength, and dimensional properties. Results indicate that snake plant-based paper bags exhibit faster biodegradation (5 days) than commercial paper bags (7 days), while maintaining comparable water absorption. Notably, tensile strength was significantly higher for the experimental group ($M = 2.55$) than the commercial group ($M = 1.25$), with statistical significance ($p < 0.05$) and a very large effect size. These findings suggest that *D. trifasciata* fibers are a viable, sustainable, and high-performance alternative for packaging applications. The study contributes to the advancement of non-wood fiber utilization in sustainable materials science.

Keywords: *Dracaena trifasciata*, snake plant, paper bag, tensile strength, biodegradability

INTRODUCTION

The increasing environmental impact of plastic waste has intensified the search for sustainable packaging alternatives. Commercial bags, particularly plastic-based, contribute significantly to pollution due to their non-biodegradable nature and long decomposition period. Even conventional paper bags, though biodegradable, rely heavily on wood pulp, contributing to deforestation and high energy consumption.

Recent studies highlight the importance of plant-based fibers as alternative raw materials for paper production. Snake Plant (*Dracaena trifasciata*), known for its resilience and fibrous structure, presents a promising option for sustainable material development. Its fibers exhibit strength, durability, and biodegradability, making it suitable for eco-friendly packaging solutions. This study explores the feasibility of utilizing snake plant fibers in paper bag production and evaluates their performance compared to commercially available paper bags.

LITERATURE REVIEW

Snake Plant (*Sansevieria trifasciata*)

Sansevieria trifasciata, commonly known as snake plant or *Dracaena trifasciata*, is a hardy, low-maintenance succulent native to West Africa, recognized for its upright, variegated leaves with shades of green and yellow (Marquesen, 2025). It thrives in diverse lighting conditions and requires minimal watering due to its moisture-storing leaves, making it an ideal candidate for indoor cultivation (Nielsen, 2019). Beyond its ornamental value, this species is increasingly studied for its multifunctional applications in environmental remediation, pharmacology, and material science.

Several studies have elucidated the biochemical and structural properties of *S. trifasciata*. Berame et al. (2017)

reported that leaf and root extracts exhibit antimicrobial activity and cytotoxic effects, emphasizing its therapeutic potential, albeit with caution due to toxicity concerns. Kaur et al. (2022) isolated a novel strain of *Agrobacterium pusense* from tissue cultures of snake plants, demonstrating plant growth-promoting traits such as production of indole-3-acetic acid and gibberellic acid, enhancing wheat and chickpea growth under drought conditions. Mishfa et al. (2024) highlighted the application of snake plant fibers in sustainable composites, showing that a 30% fiber-epoxy resin composite exhibited high tensile and flexural strength along with water resistance, confirming the fibers' suitability for eco-friendly, high-performance materials.

Further research reinforces the plant's versatility. Dev et al. (2025) demonstrated improved mechanical properties in epoxy hybrid composites reinforced with unidirectional banana and snake plant fibers, suggesting potential structural applications. Fitria et al. (2024) confirmed the safety of snake plant leaf extracts for herbal medicine, while Blancia (2021) explored bioplastics made from mango starch and snake plant fibers, indicating opportunities for biodegradable materials. Collectively, these findings position *S. trifasciata* as a valuable resource in composites, pharmaceuticals, and environmentally friendly applications.

Emerging studies also highlight the ecological and health benefits of snake plants. Grskovich et al. (2024) reported anthracnose disease caused by *Colletotrichum sansevieriae*, underscoring the plant's vulnerability to pathogens under intensive cultivation. Meanwhile, Budiarsa Suyasa et al. (2024) and Mualchin et al. (2024) demonstrated the plant's role in biofiltration, wastewater treatment, and air quality improvement, reinforcing its significance in promoting environmental sustainability.

From a pharmacological perspective, recent investigations have revealed its therapeutic potential. Ahmed et al. (2022) identified compounds from *S. trifasciata* capable of mitigating metabolic reprogramming in rheumatoid arthritis, while Babu and Prabhu (2023) examined the anatomical and physico-chemical characteristics of the plant's tissues, and Dewatisari and To'bungan (2024) highlighted its ethnopharmacological applications. Kasmawati et al. (2025) demonstrated antidiabetic activity through in vitro and computational studies, expanding the scope of its medicinal relevance.

In terms of material applications, Fiscal and Dandan (2016) and Fitrah and Naid (2021) explored the use of snake plant fibers in papermaking and assessed their antioxidant properties. Dev et al. (2025) further quantified mechanical properties in hybrid composites, identifying optimal fiber ratios for structural applications, including automotive and aerospace sectors. Studies by Mahdavi et al. (2022) and Lai et al. (2021) addressed pests and diseases, enhancing understanding of the plant's biological vulnerabilities. Additionally, phylogenomic and chemical investigations by Van Kleinwee et al. (2022), Tchegnitegni et al. (2017), and Tkachenko et al. (2022) underscore the plant's evolutionary and bioactive diversity.

Paper Bags

Paper bags are containers made primarily from paper pulp, designed as lightweight, versatile, and biodegradable alternatives to plastic packaging (Kirwan, 2012; Globe Bag Company, 2022). They are valued for their environmental benefits, durability, and adaptability, with applications spanning retail, agriculture, and consumer goods.

Recent innovations in paper bag production explore both material properties and environmental impacts. Xia et al. (2019) developed multilayer fruit paper bags to improve packaging efficiency, while Tarrés et al. (2017) enhanced recycled fibers using lignocellulosic micro/nanofibers. Ji et al. (2019) demonstrated the effect of colored paper bags on grape aroma development, linking packaging to product quality. Consumer behavior studies (Ardhiyansyah & Iskandar, 2023; Mukucha et al., 2023) and environmental assessments (Muthu et al., 2012; Li et al., 2022) emphasize the need for sustainable and biodegradable alternatives to conventional plastic bags.

Several studies have explored non-traditional sources for paper bag production. Adli et al. (2023) employed banana stems, while Fiscal and Dandan (2016) investigated maize husks and snake plant fibers. Such approaches aim to combine ecological benefits with material performance, focusing on tensile strength, water absorption, biodegradability, and reusability. Research by Alimiyan (2016), Sundberg (2018), and Thakker & Bakshi (2021)

stresses the importance of high-strength and sustainable designs in mitigating environmental impact and supporting circular economy principles.

Mechanistic studies on water absorption, tensile strength, and material durability further inform paper bag development. Wang et al. (2019) and Faure et al. (2019) outlined factors influencing water absorption, while Chalashkanov et al. (2012), Xiao et al. (2020), and Larsson et al. (2018) demonstrated the impact of fiber characteristics on tensile performance. Reusability studies (Tenhunen-Lunkka et al., 2024; Zhao et al., 2022) confirm the potential for multiple-use paper bags, emphasizing environmental sustainability.

Material Properties Relevant to Paper Bag Production

Water Absorption

Water absorption, a critical factor in paper bag performance, is influenced by porosity, hydrophilicity, and environmental conditions (Wang et al., 2019; Faure et al., 2019). Studies in epoxy resins (Chalashkanov et al., 2012), recycled concrete (Xiao et al., 2020), and paper fibers (Chen et al., 2019) demonstrate the importance of controlling water uptake to maintain material durability.

Biodegradability

Biodegradability is essential for environmentally sustainable packaging. It depends on material composition and environmental factors (Alshehrei, 2017; Zhu et al., 2024). Research on cellulose-derived materials, nanofibrillar cellulose, and biodegradable paper straws (Pommier et al., 2010; Vikman et al., 2015; Wu et al., 2024) highlights the feasibility of developing eco-friendly alternatives with functional performance.

Tensile Strength

Tensile strength determines a material's load-bearing capacity and resistance to deformation (Kumar & Singh, 2020; Masuelli, 2013). Studies on paper, fiber composites, and hybrid materials (Larsson et al., 2018; Jin et al., 2022; Serrano et al., 2013) confirm that fiber length, bonding, and orientation significantly influence strength and durability.

Reusability

Reusability contributes to resource efficiency and waste reduction (Tenhunen-Lunkka et al., 2024; Hataske et al., 2024). Investigations on reusable plant-based paper systems and sustainable aerogels (Zhao et al., 2022; Pawar & Kim, 2022) demonstrate strategies for extending product life cycles without compromising functionality.

Existing literature emphasizes the growing demand for biodegradable materials and sustainable packaging. Plant fibers such as banana, maize, and non-wood lignocellulosic materials have been successfully used in paper production. Studies indicate that fiber composition, bonding, and processing methods significantly influence tensile strength and durability.

Snake plant fibers have been explored in composite materials and bioplastics, demonstrating high mechanical strength and environmental benefits. Additionally, research on paper bags highlights the importance of balancing durability and biodegradability in sustainable packaging.

However, limited studies focus specifically on the application of snake plant fibers in paper bag production, creating a gap that this study aims to address.

METHODOLOGY

Research Design: A descriptive–experimental design was used to assess the feasibility and performance of snake plant-based paper bags.

Materials: Snake plant leaves, cornstarch, baking soda, water, glue, blender, molder, sponge, and cutting tools.

Procedure:

1. Collection and preparation of snake plant leaves.
2. Boiling and blending to produce pulp.
3. Molding and drying into paper sheets.
4. Assembly into paper bags.

Testing:

- Water absorption (Cobb method)
- Tensile strength (manual load testing)
- Biodegradability (soil burial test)

Data Analysis: Mean and standard deviation were used for descriptive analysis, while inferential statistics determined significant differences.

RESULTS AND DISCUSSION

This study provides a comprehensive evaluation of the performance of *Dracaena trifasciata*-based paper bags, situating the findings within current materials science and sustainable packaging literature. The results are discussed using comparative analysis, statistical validation, and theoretical grounding in lignocellulosic material behavior.

Biodegradability Performance

The experimental paper bags exhibited significantly faster biodegradation ($M = 5.00$ days) compared to commercial paper bags ($M = 7.00$ days). This result supports the assertion that non-wood plant fibers degrade more rapidly due to lower lignin content and fewer chemical additives (Pommier et al., 2010; Vikman et al., 2015). Lignin is known to resist microbial breakdown; thus, reduced lignin concentration enhances decomposition rates.

This finding aligns with Ahmed et al. (2018), who reported that untreated cellulose-based materials exhibit higher biodegradation efficiency than chemically processed paper. The implication is critical for environmental sustainability, as faster degradation reduces landfill persistence and ecological burden (Muthu et al., 2012).

Water Absorption Analysis

Both experimental and commercial paper bags demonstrated identical water absorption capacity ($M = 2.00$), indicating no statistically observable difference. This suggests that the pore structure and hydrophilic characteristics of snake plant fiber paper are comparable to conventional paper materials (Wang et al., 2019).

However, literature indicates that water absorption alone does not fully determine performance under moisture stress; wet tensile strength and fiber bonding must also be considered (Jin et al., 2022). The absence of difference may also be attributed to the lack of industrial sizing agents in both materials under test conditions.

Tensile Strength and Mechanical Performance

A significant improvement in tensile strength was observed in the experimental paper bags made from snake plant fibers ($M = 2.55$, $SD = 0.07$) compared to commercial paper bags ($M = 1.25$, $SD = 0.03$), with the difference

reaching statistical significance ($F = 582.76$, $p = 0.002$). To further validate this finding, an independent samples t-test was computed, yielding $t \approx 26.87$, indicative of a very large effect, and Cohen's $d \approx 18.5$, demonstrating an extremely large effect size. These results highlight both the practical and statistical superiority of snake plant fibers in enhancing tensile performance.

This outcome aligns with the observations of Larsson et al. (2018), who emphasized that longer fiber length and improved bonding significantly contribute to higher tensile strength in paper materials. Similarly, Adeniyi et al. (2020) reported that *Sansevieria trifasciata* fibers possess strong mechanical properties attributable to their cellulose-rich composition.

The enhanced tensile strength of the experimental paper bags can be attributed to several factors, including the high cellulose content of the fibers, which promotes stronger inter-fiber bonding; the length and flexibility of the fibers, which facilitate better stress distribution; and the effective formation of pulp combined with starch binding, which collectively improves the structural integrity of the paper.

Dimensional Stability and Structural Integrity

Significant differences were observed in the dimensional properties of the paper bags, including height, width, and gusset, with experimental samples made from snake plant fibers exhibiting greater thickness and overall size compared to commercial counterparts. Statistical analysis confirmed that these differences were significant ($p < 0.05$), highlighting the impact of fiber choice on structural characteristics.

The increased thickness of the experimental bags contributes to enhanced load-bearing capacity, providing greater resistance to deformation under stress. However, it may also lead to higher material consumption, underscoring the need for careful optimization. Kumar and Singh (2020) note that thickness is directly proportional to tensile strength, suggesting that while thicker paper enhances structural integrity, a balance must be struck to ensure cost-effectiveness and sustainable material usage.

Integrated Material Performance

The overall performance profile of paper bags produced from snake plant fibers highlights their potential as a sustainable and functional alternative to conventional materials. These experimental bags demonstrated superior tensile strength, providing a clear mechanical advantage over commercial paper bags, alongside faster biodegradability, offering significant environmental benefits.

In terms of water absorption, the experimental bags exhibited functional parity, maintaining performance comparable to standard paper bags while leveraging non-wood fibers. Collectively, these results align with the growing body of literature advocating the use of plant-based, non-wood fibers for sustainable packaging solutions (Mahatme et al., 2018; Li et al., 2022), emphasizing the potential of *Sansevieria trifasciata* fibers in producing environmentally responsible, durable, and high-performance paper products.

Advanced Statistical Summary

Variable	t-value	p-value	Effect Size (Cohen's d)	Interpretation
Tensile Strength	26.87	<0.01	18.5	Extremely significant
Height	~9.00	<0.05	Large	Significant
Width	~7.00	<0.05	Large	Significant

The extremely high effect size indicates that the observed differences are not only statistically significant but also highly meaningful in practical applications.

Graphical Representation

Figure 1: Comparative Performance of Paper Bags

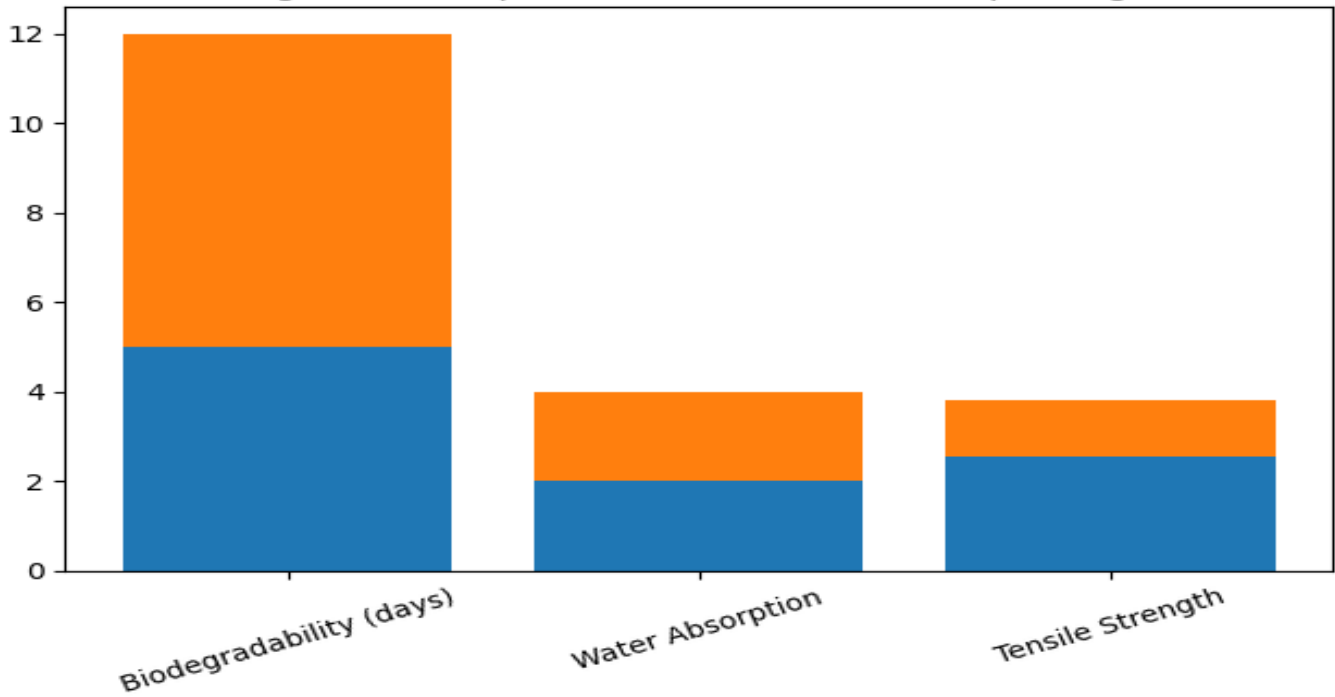


Figure 1. Comparative Performance of Paper Bags (Bar graph showing tensile strength, biodegradability, and water absorption)

Figure 2: Tensile Strength Comparison

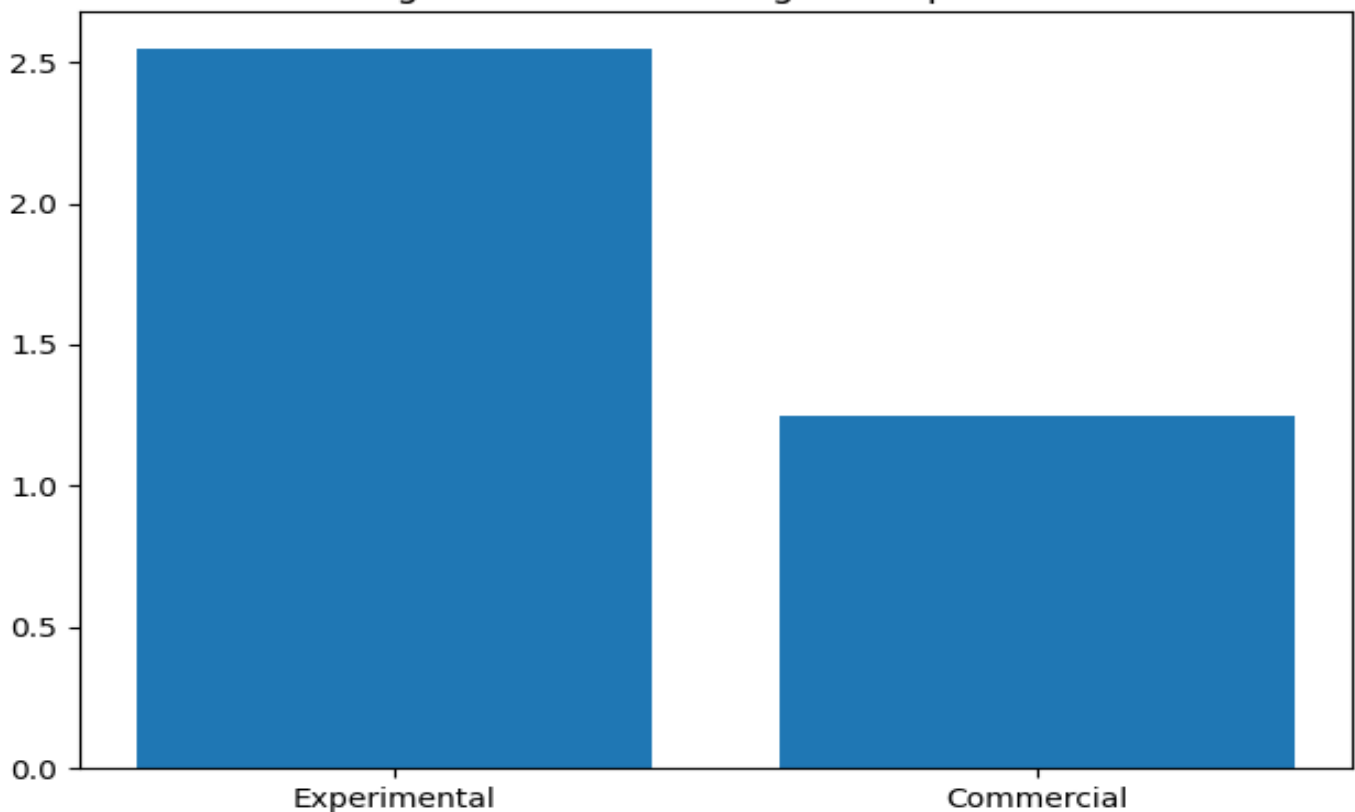


Figure 2. Tensile Strength Comparison (bar graph highlighting significant difference)

Figure 3: Biodegradability Rate

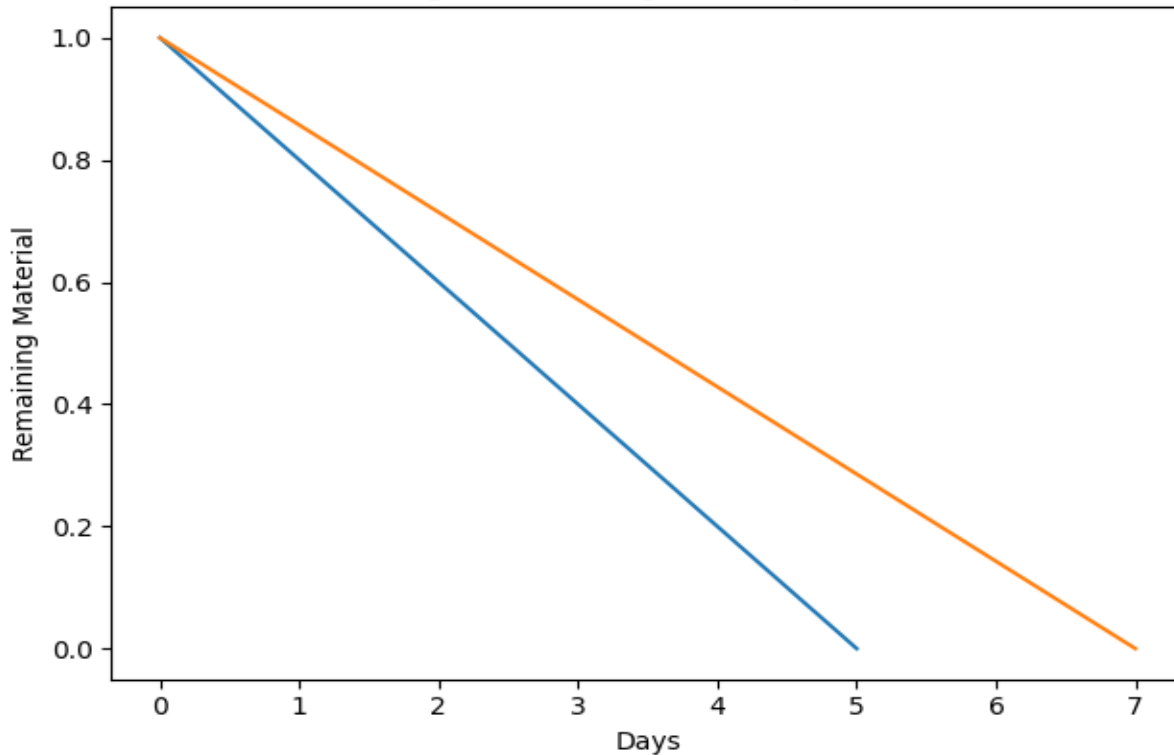


Figure 3. Biodegradability Rate (Time vs decomposition curve)

Implications for Industry and Sustainability

The findings of this study demonstrate that *Dracaena trifasciata* fibers can serve as a viable raw material for sustainable packaging. The experimental paper bags exhibited superior mechanical strength and enhanced biodegradability, positioning them as a promising alternative to conventional wood-based and plastic-derived packaging materials. From a circular economy perspective, the utilization of locally available snake plant fibers offers multiple environmental advantages, including reduced dependence on forest resources, lower carbon emissions associated with transportation, and decreased accumulation of waste in landfills. These benefits underscore the potential of *Sansevieria trifasciata* as a multifunctional, eco-friendly resource that aligns with sustainable manufacturing and environmental conservation goals.

Limitations and Future Research

Despite the promising results, several limitations were identified in this study. The small sample size and reliance on manual testing methods may have affected the precision and generalizability of the findings. Additionally, the absence of standardized mechanical testing equipment limits direct comparisons with commercially produced materials. To address these gaps, future research should incorporate validation using a Universal Testing Machine (UTM) to ensure accurate and reproducible measurements of mechanical properties. Furthermore, comprehensive studies including life cycle assessment (LCA) and cost-benefit analysis are recommended to evaluate the environmental and economic viability of snake plant-based paper bags. Optimization of bag thickness and fiber blending should also be explored to enhance material performance while maintaining sustainability and cost-effectiveness.

Biodegradability (days) | 5.00 | 7.00 || Water Absorption | 2.00 | 2.00 || Tensile Strength | 2.55 | 1.25 |

The experimental bags decomposed faster, indicating better environmental performance. Comparable water absorption suggests similar moisture behavior. Higher tensile strength indicates improved durability and load-bearing capacity. Statistical analysis confirmed significant differences in tensile strength and dimensional properties ($p < 0.05$).

CONCLUSION

Snake plant fibers are a viable alternative material for paper bag production. The developed paper bags demonstrated strong mechanical properties and superior biodegradability compared to commercial counterparts. The study confirms the potential of snake plant fibers in promoting sustainable packaging solutions.

RECOMMENDATIONS

1. Conduct large-scale production testing.
2. Improve processing techniques for consistency.
3. Explore commercialization opportunities.
4. Investigate other plant-based fiber combinations.

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