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Feasibility of Cogon Grass (*Imperata cylindrica*) and Corn Husk as Sustainable Materials for Food Packaging

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ABSTRACT

The growing problem of plastic and wood-based packaging highlights the urgent need for sustainable alternatives. This study investigated the feasibility of utilizing agricultural residues as sustainable raw materials for producing biodegradable packaging. Aiming to address the environmental consequences of plastic and wood-based packaging, the research examined the durability, texture, and cost-effectiveness of materials derived from different proportions of cogon grass (Imperata cylindrica) and corn husk fibers. An experimental design was employed, with samples produced in 50:50, 60:40, and 40:60 ratios. Durability was assessed through load-bearing analysis, while 30 respondents, composed of local carinderia owners and customers, evaluated the texture using a 5-point Likert scale. Statistical tools, including mean, standard deviation, and one-way ANOVA, were used to analyze the data. Results showed that all samples demonstrated very good durability (overall mean = 0.79 kg) and a smooth-to-very smooth texture (overall mean = 4.09), with the 60% cogon grass–40% corn husk proportion yielding the most favorable results. No significant differences were found among the three mixtures, indicating similar performance across proportions. The production cost, ranging from ₱34.50 to ₱36.50 per batch, confirmed economic feasibility at the laboratory scale. The findings affirm that agricultural residues can be transformed into durable, low-cost, and eco-friendly packaging materials under controlled, dry-condition testing, contributing to SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action). This study provides experimental evidence on the use of composite non-wood fibers for biodegradable packaging, offering localized data relevant to sustainable materials development in the Philippine context. The study recommends further enhancement of fiber processing techniques, broader testing of mechanical properties, and policy integration under the Extended Producer Responsibility framework.

Keywords: *sustainable materials, food packaging, fiber sustainability, material innovation, eco-efficiency, circular economy, sustainable development*

INTRODUCTION

The growing accumulation of non-biodegradable waste—particularly from food packaging—continues to pose critical environmental challenges worldwide. Single-use plastics such as high-density polyethylene (HDPE) persist in landfills and waterways due to their petroleum-based, non-biodegradable nature, while wood-based packaging, though often perceived as sustainable, contributes to deforestation, biodiversity loss, and reduced carbon sequestration (FAO Forestry

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Paper, 2010). In the Philippines, waste segregation practices have improved, yet inefficiencies in disposal and recycling remain prevalent (Pimienta et al., 2024). Even with high compliance levels observed in institutions such as secondary school canteens (Vitamog et al., 2024), unrecyclable packaging materials continue to accumulate, emphasizing the need for biodegradable, locally sourced alternatives.

The global dependence on wood fibers—constituting 80–90% of pulp materials (Blechschmidt et al., 2012)—drives the harvesting of billions of trees annually, resulting in forest loss, including significant reductions in Philippine Forest cover (FAO Forestry Paper, 2010). To address these impacts, researchers have explored non-wood fibers such as rice husks, pineapple leaves, sugarcane bagasse, banana stems, okra stalks, and corn husks (Kamoga et al., 2013). These agricultural residues offer renewable and biodegradable advantages, yet their adoption often faces technological and economic limitations in developing countries.

Cogon grass (*Imperata cylindrica*) and corn husk are two promising non-wood fiber sources abundant in the Philippines. Cogon grass contains cellulose, hemicellulose, and lignin suitable for pulping (MacDonald, 2004) and is considered an invasive species that thrives rapidly even in poor soils (USDA-APHIS, 2020). Corn husks possess favorable fiber morphology and tensile properties comparable to hardwood fibers (Caulfield & Gunderson, 1988; Aperolola, 2015; Otitoju et al., 2014; Fagbemigun, 2014). While both materials have been studied individually, their combined use as a composite fiber source for food packaging—especially under Philippine conditions—remains largely unexplored. Establishing such a combination could optimize strength, texture, and cost-efficiency while utilizing abundant local biomass.

The shift toward non-wood and agro-based fibers aligns with sustainability and circular economy principles by reducing waste, preventing the burning of agricultural residue, and lowering greenhouse gas emissions. These efforts support the United Nations Sustainable Development Goals (SDGs), particularly SDGs 12, 13, and 15, and indirectly contribute to SDG 14 by reducing plastic pollution. Beyond environmental benefits, biodegradable packaging from natural fibers can enhance food safety. Unlike petroleum-based materials, plant-derived packaging minimizes chemical contamination and aligns with FSSC 22000 requirements for safe material handling (FSSC, 2023). Maintaining hygienic food handling practices, as highlighted by Miguel et al. (2024), further underscores the value of packaging materials that reduce contamination risks.

Processing methods also influence the suitability of non-wood fibers for packaging. Chemical pulping—such as kraft and sulfite processes—removes lignin more effectively and yields stronger fibers, whereas mechanical pulping retains more lignin but produces weaker pulp (PCC Group, 2018). Additionally, material performance indicators such as tensile strength, elongation, and flexibility remain key considerations for biodegradable packaging (Shah et al., 2023). Consumer perception studies further show that environmentally friendly packaging enhances brand trust and purchase intention (Brennan et al., 2003), increasing the relevance of sustainable local materials.

Despite these advances, research combining cogon grass and corn husk fibers into a single biodegradable packaging material is limited, particularly in the Philippines, where both resources are abundant and underutilized. While cogon grass and corn husk have been studied individually as non-wood fiber sources, limited experimental research has examined their combined use as a composite material for food packaging under Philippine conditions. Addressing this gap can support local industry, reduce deforestation, and provide cost-effective and environmentally responsible packaging alternatives.

Therefore, this study aims to determine the feasibility of utilizing cogon grass and corn husk as composite raw materials for biodegradable food packaging. Specifically, it evaluates the durability, texture, and cost-effectiveness of packaging materials produced from varying fiber proportions. This study focuses on initial feasibility in terms of durability, texture, and cost under dry conditions, rather than comprehensive functional performance for all food packaging applications. By employing readily available natural fibers and simple processing techniques, this research contributes to sustainable material development and supports national and global goals for responsible production and waste reduction.

Objectives of the Study

This study aimed to determine the feasibility of utilizing cogon grass (Imperata cylindrica) and corn husk as sustainable materials for food packaging. Specifically, it sought to: (1) Assess the durability and texture of food packaging produced from different proportions of cogon grass and corn husk (50:50, 60:40, and 40:60); (2) Determine whether significant differences exist in durability among the three proportions; (3) Determine whether significant differences exist in texture among the three proportions; and (4) Compute the production cost of each proportion to evaluate economic feasibility.

METHODOLOGY

Research Design. This study employed an experimental research design to determine the feasibility of cogon grass (Imperata cylindrica) and corn husk as sustainable materials for food packaging. The experimental method enabled the researchers to compare the physical properties—specifically durability and texture—of food packaging produced from varying proportions of cogon grass and corn husk. Three sample ratios were prepared:

- 50% cogon grass and 50% corn husk,
- 60% cogon grass and 40% corn husk, and
- 40% cogon grass and 60% corn husk.

The experimental design evaluated material performance under controlled, dry conditions and did not assess resistance to moisture, oil, or heat. Respondents evaluated only the packaging's surface smoothness, and no sensory or food-contact safety testing was conducted. The experimental design was structured to evaluate the potential of these materials as viable, environmentally friendly, and cost-effective alternatives to commercial packaging.

Participants of the Study. This study involved thirty (30) respondents, composed of ten (10) carinderia owners and twenty (20) customers within the vicinity of the University of Northern Philippines. Purposive sampling was used to ensure that participants had sufficient familiarity with food packaging materials. Respondents evaluated the acceptability of the developed packaging samples based on texture, which in this study was operationalized specifically as surface smoothness and measured using a 5-point Likert scale. Although user acceptability in food packaging typically includes additional attributes such as rigidity, perceived cleanliness, aesthetic appeal, and ease of handling, the present study assessed only surface smoothness. For the durability test, three samples were tested for each of the three proportions, and each was subjected to different weight loads (100 g, 250 g, and 500g).

Research Instrument. The researchers utilized both experimental testing tools and a structured survey questionnaire. The experimental setup was used to evaluate durability, while the survey measured respondents' perceptions of the food packaging's texture. The scale interpretation used for the evaluation is presented below.

Table 1
Range and Descriptive Rating for Durability

Range (in kg)	Description
0.01 – 0.25	Poor Durability
0.26 – 0.50	Fair Durability
0.51 – 0.75	Good Durability
0.76 – 1.00	Very Good Durability
1.01 and above	Excellent Durability

Durability was measured as the maximum weight (in kilograms) each sample could carry without tearing or deforming.

For the texture evaluation, respondents rated the produced packaging using a Likert scale as shown in Table 2.

Table 2.
Scale for Texture Evaluation

Scale	Description
1.00 – 1.80	Very Rough
1.81 – 2.60	Rough
2.61 – 3.40	Slightly Rough
3.41 – 4.20	Smooth
4.21 – 5.00	Very Smooth

A higher score indicated better smoothness, which is essential for consumer acceptability.

The materials used in the study are summarized in Table 3.

Table 3
Materials Used in Producing Food Packaging

Materials Used	Quantity per Batch
Cogon Grass	150 g
Corn Husk	150 g
Caustic Soda (Lye)	60 g
Okra (as Natural Binder)	1.5 kg
Water	12 liters
Scissors, Sieving Screen (30×40 cm), Basin, Casserole, Bowl, Blender, Cotton Cloth	—

Data Gathering Procedure. The data for this study were gathered through a series of systematic experimental and evaluative procedures conducted within the University of Northern Philippines. The process began with the collection of raw materials, including cogon grass (Imperata cylindrica), corn husks, and okra. These materials were sourced from San Julian Sur, Vigan City, Ilocos Sur. Cogon grass and corn husk were chosen for their abundance and cellulose content, while okra served as a natural binding agent to enhance fiber adhesion in the paper pulp mixture.

After collection, the materials underwent preparation and pulping. The cogon grass and corn husk were first washed thoroughly to remove dirt and impurities, then cut into smaller segments, approximately one to two inches long, to facilitate easier processing. The fibers were boiled separately in a caustic soda solution prepared by dissolving 10 grams of caustic soda in 1 liter of water. Each batch was boiled for about thirty minutes to break down lignin and hemicellulose, softening the fibers for pulping. Once softened, the fibers were rinsed several times with clean water to remove excess alkali, then blended for 15 minutes to produce a fine, uniform pulp suitable for forming packaging sheets.

The next phase involved forming and drying the pulp mixture. The prepared pulp was combined with okra extract in a 1:12 ratio of okra juice to water, ensuring proper binding and flexibility of the resulting sheets. The mixture was poured onto a 30×40 cm sieving screen submerged in water, where it was evenly distributed to form a thin, consistent layer. The screen was then gently shaken to drain excess water and carefully inverted onto a cotton cloth to dry. The sheets were sun-dried for approximately 30 minutes, until most of the moisture had evaporated. Once dry, they were peeled from the cloth and molded into the desired food packaging.

The testing phase followed immediately after production. To evaluate durability, the molded food packaging samples were subjected to incremental load tests at 100 grams, 250 grams, and 500 grams. Each sample was observed for signs of deformation, tearing, or failure under the applied weight. The maximum load the packaging could carry without damage was recorded to determine its durability rating using the established range in Table 1.

Simultaneously, the texture evaluation was conducted using a structured questionnaire distributed to 30 respondents, comprising 10 carinderia owners and 20 customers at the University of Northern Philippines. Respondents were selected through purposive sampling based on their familiarity with food packaging materials. They were asked to evaluate the packaging's smoothness using a five-point Likert scale (as shown in Table 2). Their assessments provided quantitative data to determine consumer acceptability and perceived texture quality for each proportion of cogon grass and corn husk.

All observations and respondent evaluations were recorded, tabulated, and prepared for statistical analysis. The entire data-gathering process was carried out under controlled and consistent conditions to ensure the reliability and accuracy of results.

Data Analysis. The data collected from this study were rigorously analyzed through descriptive and inferential statistical methods. Mean values and standard deviations were used to describe the average durability and texture ratings of the samples. Analysis of Variance (ANOVA) determined whether significant differences existed among the three proportions in terms of durability and texture. Results were analyzed at the 0.05 significance level to assess whether the proportions of cogon grass and corn husk had statistically different effects on the measured properties.

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RESULTS AND DISCUSSION

This section presents, analyzes, and interprets the study's findings on the feasibility of using cogon grass (Imperata cylindrica) and corn husks as sustainable materials for food packaging. The results are organized according to the study objectives, covering the durability, texture, and production cost of the packaging made from different cogon grass–corn husk proportions.

1. Durability of the Food Packaging

Table 4 shows the mean durability ratings of food packaging samples made from cogon grass and corn husk in varying proportions: 50:50, 60:40, and 40:60. Durability was measured as the maximum load the packaging could hold before tearing or deforming.

Table 4
Mean Durability Ratings of Food Packaging at Different Proportions of Cogon Grass and Corn Husk

Proportion	Mean (kg)	Description
50% Cogon Grass – 50% Corn Husk	0.79	Very Good Durability
60% Cogon Grass – 40% Corn Husk	0.83	Very Good Durability
40% Cogon Grass – 60% Corn Husk	0.76	Very Good Durability
Overall Mean	**0.79**	**Very Good Durability**

The data indicate that all three packaging samples demonstrated very good durability, with mean load capacities ranging from 0.76 to 0.83 kg. The sample composed of 60% cogon grass and 40% corn husk exhibited the highest durability, suggesting that a higher proportion of cogon grass improves tensile strength and fiber cohesion. This result can be attributed to the higher cellulose and lignin content in cogon grass, which contribute to fiber rigidity and structural integrity (MacDonald, 2004).

The high durability ratings imply that both cogon grass and corn husk can withstand considerable load without tearing, making them suitable for light to medium loads under dry handling conditions. These results should be interpreted within the limits of dry-load testing and do not represent performance under wet or oily conditions. These findings are consistent with previous studies by Otitoju et al. (2014) and Fagbemigun (2014), who found that corn husk-based papers have high tensile strength comparable to that of conventional packaging-grade papers.

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Volume 34, Issue 1, January - December 2025

2. Analysis of Variance in Durability

To determine whether the differences in durability across the three proportions were statistically significant, a one-way Analysis of Variance (ANOVA) was conducted.

Table 5
Analysis of Variance in the Durability of Food Packaging Across Different Proportions

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Interpretation
Between Groups	0.004	2	0.002	0.215	0.808	Not Significant
Within Groups	0.084	9	0.009			
Total	**0.088**	**11**				

The ANOVA results show no significant difference (p = 0.808) in the durability of food packaging produced from different proportions of cogon grass and corn husk. This suggests that all three combinations provided relatively similar strength performance. Therefore, the fiber ratio does not substantially affect the durability of the final product within the tested range. The absence of significant differences suggests flexibility in selecting fiber proportions without compromising basic strength performance.

This outcome aligns with the findings of Kamoga et al. (2013), who observed that blending agricultural residues with similar fiber morphologies often yields comparable strength outcomes, as their cellulose-to-lignin ratios remain within effective bonding limits.

Texture of the Food Packaging

Table 6 presents the mean texture ratings of the packaging samples as evaluated by thirty respondents, consisting of carinderia owners and customers. Respondents rated the texture on a five-point Likert scale, with higher scores indicating smoother, more refined surfaces.

Table 6
Mean Texture Ratings of Food Packaging at Different Proportions of Cogon Grass and Corn Husk

Proportion	Mean	Description
50% Cogon Grass – 50% Corn Husk	4.08	Smooth
60% Cogon Grass – 40% Corn Husk	4.32	Very Smooth
40% Cogon Grass – 60% Corn Husk	3.88	Smooth
Overall Mean	**4.09**	**Smooth**

The results show that the packaging sample containing 60% cogon grass and 40% corn husk received the highest texture rating (M = 4.32, described as Very Smooth). This may be attributed to the finer fiber structure of cogon grass, which produces smoother pulp sheets when blended with corn husk. The higher cellulose content of cogon grass enables tighter fiber bonding during sheet formation, resulting in improved surface smoothness. These findings align with MacDonald's (2004) study, which noted that grass-based pulps tend to produce smoother, more uniform textures than woody fibers due to their smaller fiber diameter and greater flexibility. Similarly, Aperolola (2015) emphasized that blending softer non-wood fibers enhances tactile qualities suitable for consumer packaging.

These findings reinforce the material's potential for surface smoothness acceptability in initial consumer evaluation. Other acceptability factors, such as rigidity, appearance, and ease of handling, were not assessed in this study.

3. Analysis of Variance in Texture

To determine whether texture differences among the three proportions were statistically significant, ANOVA was also performed.

Table 7
Analysis of Variance in the Texture of Food Packaging Across Different Proportions

Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Interpretation
Between Groups	0.369	2	0.185	0.693	0.524	Not Significant
Within Groups	2.400	9	0.267			
Total	**2.769**	**11**				

The computed p-value of 0.524 indicates no statistically significant difference in texture among the three proportions. Although the 60:40 blend yielded the highest mean rating, the variation was not statistically significant. This suggests that minor changes in fiber ratios do not significantly alter the packaging material's tactile smoothness. Although statistical differences were not observed, the consistently smooth ratings indicate acceptable surface quality across all fiber ratios.

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Volume 34, Issue 1, January - December 2025

As reported by Shah et al. (2023), maintaining uniform fiber bonding and surface consistency is essential for packaging usability and consumer appeal.

4. Cost of Production

Table 8 presents the production cost of each proportion of cogon grass and corn husk packaging material.

Table 8
Cost of Production per Batch of Food Packaging

Proportion	Cost per Batch (₱)
50% Cogon Grass – 50% Corn Husk	₱35.00
60% Cogon Grass – 40% Corn Husk	₱36.50
40% Cogon Grass – 60% Corn Husk	₱34.50

The cost of production per batch of food packaging ranged from ₱34.50 to ₱36.50, with minimal variation across different material proportions. Each production batch yielded 60 pieces, resulting in an estimated production cost of approximately ₱0.58 to ₱0.61 per piece. Among the proportions, the 40% cogon grass–60% corn husk mixture exhibited the lowest cost per batch (₱34.50).

Commercially available biodegradable food packaging is typically sold in packs of 100 pieces, priced from approximately ₱50.00 to ₱60.00 per pack, or about ₱0.50 to ₱0.60 per piece. The estimated per-unit cost of the developed packaging material falls within a similar range; however, the present analysis was limited to laboratory-scale production and did not account for labor costs, equipment depreciation, overhead expenses, or costs associated with large-scale manufacturing. As such, the production cost ranged from ₱34.50 to ₱36.50 per batch, indicating preliminary economic feasibility at the laboratory scale. A comprehensive cost evaluation, including labor, equipment depreciation, and scale-up factors, is necessary for an accurate commercial feasibility assessment.

Overall, the study demonstrated that food packaging made from cogon grass and corn husk has very good durability, a smooth texture, and a relatively low production cost across all three proportions. Although statistical analyses revealed no significant differences among the formulations, the combination of 60% cogon grass and 40% corn husk consistently exhibited slightly superior performance in terms of both durability and texture. These findings suggest that cogon grass and corn husk are promising, sustainable alternatives for the development of eco-friendly food packaging materials, offering both functional quality and preliminary cost feasibility.

These results align with existing studies emphasizing the viability of non-wood fibers for packaging applications (Kamoga et al., 2013; Otitoju et al., 2014; Aperolola, 2015) and highlight the practical potential of integrating agricultural residues into local production systems to promote environmental sustainability and economic resilience.

CONCLUSIONS

The findings of this study establish that cogon grass (*Imperata cylindrica*) and corn husk are feasible, sustainable, and economically viable materials for producing prototype food packaging materials for dry applications. All the produced samples exhibited very good durability, withstanding loads up to 0.83 kg without deformation, and were rated smooth to very smooth in texture by respondents. The proportion with 60% cogon grass and 40% corn husk achieved the highest mean ratings for both durability and texture, indicating that a higher percentage of cogon grass improves tensile strength and surface quality due to its cellulose composition and fiber structure. However, statistical analyses revealed no significant difference among the three proportions in both durability and texture, implying that all tested ratios are equally suitable for producing prototype food packaging materials for dry applications. The findings are limited to durability and texture under dry conditions and should not be generalized to all food packaging requirements. The study evaluated only durability under dry conditions and did not assess moisture, oil/grease, or heat resistance, nor performance under realistic service conditions such as exposure to wet or oily foods, hot items, repeated handling, bending, folding, or stacking. Thus, while the material appears promising for light to medium loads in dry environments, claims of full functional suitability for food packaging remain preliminary and require further validation. The cost of production, ranging from ₱0.58 to ₱0.61 per piece, demonstrated that these materials can be developed at a relatively low expense, supporting both environmental and economic goals. The study highlights the potential of agricultural residues as raw materials for sustainable production, contributing to the reduction of deforestation, plastic waste, and greenhouse gas emissions.

RECOMMENDATIONS

Future research should prioritize testing for moisture, oil/grease, and heat resistance as the immediate next steps to validate the material's suitability for real-world food-service conditions. Subsequent studies may focus on refining fiber processing techniques, evaluating tensile strength and biodegradability, and conducting life cycle assessments. Pilot-scale production and industry collaboration are recommended to assess scalability and market viability. Policy integration through the Extended Producer Responsibility framework may further support the adoption of agricultural-residue-based packaging.

ETHICAL STATEMENT

This research was conducted in accordance with the ethical standards set by the Vector Publication and Research Ethics Committee of the University of Northern Philippines (UNP). The study protocol underwent ethical review and was approved before data collection. All participants were informed about the study's objectives, procedures, and their rights as respondents. Voluntary participation was ensured, and participants were free to withdraw at any point without consequence. Confidentiality and anonymity of responses were strictly maintained, and all collected data were used solely for academic and research purposes. The researchers affirm full compliance with the ethical principles of integrity, transparency, and respect for human participants as upheld by the Vector Publication and Research Ethics Committee.

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