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From Nuts to Bag: Peanuts (Arachis Hypogea) Shells as Sustainable Alternative Source in Making Eco-friendly Paper Bags

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Abstract
This study explored the potential of peanut shells (Arachis hypogea) as a sustainable material for eco-friendly paper bag production, addressing the environmental issues tied to traditional plastic and wood pulp-based bags. Using a quasi-experimental approach, 6 kg of peanut shells were processed into pulp and tested for strength, tear resistance, stiffness, durability, and biodegradability. The results showed that peanut shell-based paper bags were biodegradable, cost-effective, and suitable for carrying light to moderate loads. An optimal composition of 75% peanut shells was determined, balancing tensile strength, solubility, and biodegradability. The production process included collecting, cleaning, pulping, and papermaking, offering opportunities for further refinement. Although peanut shell paper bags were less robust than wood pulp alternatives, they provided substantial environmental benefits, such as reducing landfill waste and decreasing reliance on non-renewable resources. This study highlighted peanut shells as a promising sustainable alternative for the packaging industry, combining functionality with environmental responsibility. By repurposing agricultural waste, these paper bags contribute to waste reduction and sustainability goals. Further research and industry adoption are recommended to enhance the performance and scalability of peanut shell-based packaging, supporting both community needs and global efforts for environmental conservation.

Keywords: Arachis Hypogea, e-commerce, Biodegradability

Introduction

As of 2023, the Philippines produces an estimated 2.7 million tons of plastic waste, which we can almost see every day on the roads, the sea, and some places in the Philippines (Arowana, 2023) [1]. The biggest cause of this waste is a Lack of Awareness, where they only have limited resources on how plastics can have a huge impact and hinder our daily lives. On the other hand, Parayno (2023) stated that waste paper contributes to 19% of the total municipal solid waste in the Philippines.

Alternative paper bags using peanut shells (Arachis Hypogea) are an innovative tool that can help the marketing industry and the environment. This can be an alternative to plastics and paper bags as this is biodegradable. Peanut shells offer various benefits compared to other agricultural residues. The fibrous composition makes them ideal for soil improvement and erosion control.

The use of peanut shells as an alternative bag can help reduce plastic and paper waste by providing a sustainable and biodegradable option. Peanut shells are rich in nutrients like phosphorus and calcium, beneficial for plant growth. When bags made from peanut shells decompose, they release nutrients that can enrich the soil. Using bags made from peanut shells can provide a natural way to improve soil quality and reduce the need for synthetic fertilizers (Srija, 2021) [23].

According to Sohail and Drees (2023), using paper bags is environmentally friendly, unlike plastic bags and paper bags are biodegradable and recyclable. Also, the paper bag is made from recyclable resources. In addition, Arachis Hypogea is a vegetable from Central Brazil known for its nutritional needs. Also, according to Food Navigator Europe (2024), peanuts are widely consumed worldwide, in fact, 48 million metric tons of peanuts are produced worldwide.

Paper bags and sacks are widely used in the Philippines in various sectors such as food, retail, agriculture, and industry. The country's urbanization and expanding middle class are driving the demand for these products, which is expected to continue to increase over the next five years. The rise of e-commerce platforms further fuels the demand for paper bags among online shoppers. Between 2015 and 2020, sales of paper bags and sacks in the Philippines showed a Compound Annual Growth Rate

(CAGR) of 3.8%. (6Wresearch, 2024). In addition, the paper bag market value globally in 2017, and a forecasted figure for 2027, broken down by end-use. By 2022, the global market value of paper bags used by the food and beverage industry is expected to reach approximately 1.8 billion W.S. dollars. (Statistics Research Department, 2024).

Nowadays, as the world continues to turn, the increasing number of plastic and paper bags can be a big problem in the future. So, peanut shells can be an alternative bag that can be used daily and at the same time serve as fertilizer for the soil and plants. The researcher chose this topic to find a modern paper bag with quality and to help the marketing industry. It will also be a substitute for conventional plastic bags due to their non-toxicity, composability, and biodegradability.

By exploring here, paper made from peanut shells is one of the alternative paper bags that is traditionally used in the market. also, the paper bag made of peanut shells has the same characteristic structure as the traditional one but has different chemical and physical properties. According to Phil Musekiwa (2020) [12], the ground shell is perfect cellulose that can be used to synthesize fibers that can be converted into paper products. With the use of peanut shells in the industry, purpose of this paper bag made of peanut shells is to help the market industry become more eco-friendly.

Researchers are working on making a paper bag that can break down naturally using peanut shells. The researchers aim to meet the growing need for packaging that is good for the environment by using peanut-shell-based materials, which are both eco-friendly and cost-effective. By studying the ingredients, ways to improve the surface, and how it's made, we want to make sure our paper bag breaks down easily and lasts a long time. This new way of doing things not only helps reduce waste in packaging but also protects the environment and encourages using greener packaging methods. By exploring how peanut shells can be used in packaging, we hope to help make the industry eco-friendlier. This creative approach is not just about meeting the demand for sustainable packaging but also about leading the way towards more environmentally friendly packaging practices (Mandala *et al*., 2023).

Objectives of the Study

This study aims to quantitatively evaluate the perspective on the use of peanut (Arachis hypogea) shells as an alternative paper bag in our community. The study also wants to deeply understand how these paper bags might impact the environment and contribute to the market industry. Specifically, (1) How sure or effective is an Arachis hypogea (peanut) shell as a material to be used by the proponents in creating an eco-friendly paper bag that does not affect our environment? (2) What steps and procedures are required to convert arachis hypogea (peanut) shells into a usable material for making paper bags, and what process should be done to further optimize it? (3) How can the characteristics of paper bags made from Arachis hypogea (peanut) shells be better compared to traditional bag materials in terms of: Biodegradability,Tensile strength, and Solubility.

Methods and Materials

Quasi-experiments share similarities with randomized controlled trials in their aim to establish cause-and-effect relationships, the lack of random assignment poses significant challenges. The absence of randomization introduces internal validity threats, making it more difficult to confidently attribute observed outcomes to the independent variable. This necessitates careful design and execution to minimize these threats and ensure the reliability of the findings. Quantitative research designs fall into two main categories: Experimental and quasi-experimental. The defining characteristic of a quasi-experiment is the manipulation of the independent variable without the use of random assignment. When random assignment or the inclusion of a control group is impractical, researchers can employ a variety of quasi-experimental designs to investigate cause-and-effect relationships. (Krishnan, 2024) [10]. A quasi-experimental method is suitable for this inquiry since the materials (peanut shells) and members are chosen based on what is considered feasible to utilize or maybe then recording utilizing inspecting recording. This is about employing a quasi-experimental inquire plan to look at the shelled nutshell (Arachis hypogea) as a sustainable alternative raw material for the generation of eco-friendly paper bags. The reasonability of utilizing peanut shells (Arachis hypogea) as an economical crude material for the making of naturally inviting paper sacks is inspected in this chapter through the improvement of a quasi-experimental think-about plan. This ponders endeavors to find out the adequacy, adjust, and conceivable natural effect of the fabric by conducting a controlled comparison between peanut shells and conventional wood mash. The analysts will help in the creation of naturally inviting substitutes for bundling materials.

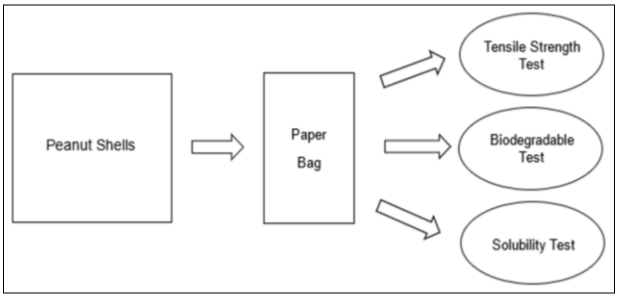

Fig 1: Conceptual Study Framework

This study explores the potential of peanut shells as a sustainable alternative for paper bag production. Driven by the urgent need to address environmental concerns and reduce waste, we are investigating the feasibility of transforming peanut shells into a practical and eco-friendly replacement for traditional paper bag materials.

A recent study conducted in Indonesia highlighted the significant environmental impact of peanut shell waste, motivating us to investigate its potential as a sustainable resource. This study revealed that Indonesia alone generates a substantial amount of peanut shell waste each year, posing a threat to environmental health.

Furthermore, the reliance on wood for traditional paper production contributes to deforestation and the depletion of natural resources. Peanut shells, however, offer a promising solution. They contain a high percentage of cellulose, the key ingredient in paper. By utilizing these discarded shells, we can reduce waste and minimize our reliance on trees for paper production.

To evaluate the viability of peanut shell paper bags, we will conduct tests to assess their tensile strength, biodegradability, and solubility. Tensile strength will measure the paper's resistance to tearing and its overall durability. Biodegradability will assess how quickly the paper decomposes in a natural environment, indicating its environmental impact. Solubility will determine how the paper reacts to water, which is important for disposal and recycling.

The research aims to demonstrate the feasibility of using peanut shells to create a sustainable and eco-friendly paper bag alternative. By exploring the potential of this readily available resource, we hope to contribute to a greener future where waste is minimized and natural resources are preserved (Maulana *et al*., 2022).

Results and Discussion

This presents the results and discusses the research From Nuts to Bag: Peanuts (Arachis Hypogea) Shells as a Sustainable Alternative Source in Making Eco-friendly Paper Bags. It will discuss how sustainable the making of peanut shell bags is and the results of each test conducted.

Table 1: Solubility/Water Test Table

Product	Percentage of Peanuts Used	State (Solid, Liquid, Powder)	Amount Used of Water	Reaction/Behavior	Dissolved Completely (Yes/No)	Time To Dissolved	Final Observation	Rank
A	25%	Solid	10 cups	When we put the bag of peanut shells in the water right away, it was damaged and torn.	NO	24 hours	After 24 hours, it just separated, there were still some clumps but eventually, it dissolved.	3
B	75%	Solid	10 cups	After 32 seconds, the bag was already damaged.	YES	24 hours	After 24 hours, there were remaining bags but it was already completely dissolved.	1
C	100%	Solid	10 cups	The paper was just floating around and was not damaged after 1 minute.	NO	24 hours	After 24 hours, a few clumps were left but dissolved.	2

The researchers experimented with peanut shell bags' capability when submerged in water. Solubility/Water Tests are performed to test the ability of compounds to dissolve in water (Sapkota, 2022) [17]. This test will serve as how peanut shell bags can do well in solubility tests. Each test was given an equivalent of 10 cups per peanut shell bag and 24 hours to dissolve.

In the first column, product A consists of 25% peanut shells. After being put in the water, the bag immediately broke down and tore apart, forming big and little holes. This suggests that the bag's structural integrity was compromised upon contact with water. However, despite the damage, the contents did not dissolve completely. The peanut shell bag was separated after giving it 24 hours to dissolve. There were still clumps left behind, and the other half of the bag was slowly dissolving. The incomplete dissolution of Product A may indicate that the lower peanut concentration, combined with other possibly water-resistant components, hindered its breakdown. Product A was rated 3rd in the rank list, its relatively poor performance in terms of dissolution efficiency.

On the other hand, product B consists of 75% peanut shells. Like product A, the researchers also used 10 cups of water in the peanut shell bag. Upon soaking the bag, it showed that after 32 seconds in the water, the bag broke down. However, after 24 hours, unlike product A which has still clumps left, product B already dissolved leaving a few clumps left. The complete dissolution suggests that the higher concentration of peanuts contributed to a more effective breakdown process, possibly due to increased water absorption and interaction. This quick and complete dissolution earned Product B the highest rank (Rank 1), suggesting that a 75% concentration might be the best for dissolving efficiently. It seems to have just the right balance of peanuts to break down effectively in water while still being fragile enough to dissolve completely.

Lastly, product C consists of the highest percentage of 100% peanut shells. This remained intact for about a minute without any signs of breaking. This floating behavior indicates some degree of initial water resistance, likely due to the high concentration of solid peanut material, which might have created a barrier to immediate water penetration. Even after 24 hours, there were still some clumps left, though they did dissolve over time. Despite having the highest concentration of peanuts, its dissolution was less effective compared to Product B, possibly due to the initial floating and resistance to water contact. This product was ranked 2nd because it took longer to break down completely compared to Product B but performed better than Product A.

Overall, the experiment suggests that product B which consists of 75% peanut shells, was the most effective, as it dissolved fully after 24 hours, earning it the highest rank. While, Product A (25% peanut shells) dissolved more slowly and left clumps behind, resulting in the lowest ranking. Product C (100% peanut shells) maintained its structure longer but took more time to dissolve fully, placing it second. How the products reacted when first placed in water, like floating or quickly breaking apart, also played a big role in how well they dissolved. In the case of Product B, its rapid breakdown and complete dissolution show that 75% peanuts are likely the ideal concentration for the best mix of dissolvability and reactivity, making it the most effective among the three products tested.

Table 2: Tensile Test Table

Product	Percentage of Peanuts Used	Initial Length (cm)	Sectional Area (cm2)	Initial Force Applied (N)	Maximum Force Before Breaking (N)	Calculated Tensile Strength (N/cm2)	Final Observation	Rank
A	25%	15.24cm	232.25	1 cup	300 g 3 N	3N/232.25 = 12.91 N	It was noticed that only part of the side to the bottom of the bag was punctured due to its heavy load.	3
B	75%	15.54 cm	241.50	1 cup	480 g 4.8 N	4.8N/241.50 = 19. 87 N	Only the bottom part was removed from its shape as a paper bag.	1
C	100%	15.54 cm	241.50	1 cup	390 g 3.9 N	39N/24.30 = 16.14 N	The bottom of the paper was damaged due to the weight that was placed on it.	2

The researchers tried an experiment called the tensile strength test in which the paper bag made of peanut shells was tested to see how strong it was (Sharma, 2023) [19]. The researchers made three products that each have a different percentage based on the thickness of the paper made of peanut shells, and the first product product A has 25% thickness, product B has 75%, and at the end is product C which has 100% thickness.

Product A, which has a 25% thickness and composition of peanut shells, shows a limited load capacity of the paper or strength and structural strength, and product A has a size or length of 15.24cm or 6.1 inches and a sectional area of 232.25 cm². In the experiment conducted on product A, it was filled with a cup of water weighing 300g or 3 Newtons, then, it was calculated and the tensile strength obtained by product A reached 12.9 N/cm², which is the lowest for the three products tested by the researcher, and the observations that the researcher noticed about the work done on product A were that the side and bottom were only damaged or punctured due to the weight of the water loaded on it, and the bag reached 50 sec while carrying a load of 300g or 3 Newtons before it completely broke. Overall, product A with 25% of the thickness and composition of a peanut shell shows the lack of strength required to load heavy objects, and this resulted in the lowest tensile strength of the three products tested.

Product B was made by the researcher with 75% of the thickness and composition of the peanut shell, and it was also tested in the same way as product A, and it resulted in the highest tensile strength of the three. Product B has a size or length of 15.54cm or 6.12 inches and has a section area of 241.5cm². In the process done here, a cup of water weighing 480g or 4.8 Newton was placed on it. When it was tested, product B was kept loaded with 480g or 4.8 Newton, and it took 1:09 minutes before it completely broke, it was calculated and the tensile strength obtained was 19.87 N/cm², which is product B that obtained the highest observed in the experiment conducted by the researcher. When the product B was observed, it was seen that only the body part and the bottom were damaged, almost losing its shape like a paper bag. Despite its damage, product B still has the highest tensile strength of the three. Overall, product B, which has 75% thickness and a peanut shell composition, shows the strongest and most flexible properties when it comes to carrying heavy objects.

Product C was made by the researcher with 100% thickness and a peanut shell composition, and product C only shows moderate tensile strength, being in the middle of product A and product B in terms of load capacity. Product C has a length of 15.54 cm or 6.12 inches and has the same sectional area as product B (241.5 cm²). In the process or experiment conducted here, product C was loaded with a cup of water with a weight of 390g or 3.9 Newton, and product C lasted 1:04 minutes while carrying a load of 390g or 3.9 Newton before it completely broke. This was calculated and the tensile strength obtained reached 16.14N/cm². When the researcher began to observe product C, it was seen that only the bottom part of the paper made of a peanut shell was damaged due to the weight loaded on it. Although product C had 100% of the thickness and composition of a peanut shell, it still exceeded it by 75% when it came to tensile strength. Overall, even though product C has a higher percentage, 75% is still better because of the results it showed in the experiment

Overall, it was found that 75% of product B has the strength and durability when it comes to tensile strength compared to the two products. Its ability to carry a heavy load for minutes before breaking, suggests that 75% or product B could be a good paper to make as a paper bag that can hold a heavy object. The idea that there is a balance between the peanut shell and the integrity of the paper structure strengthens it, especially in terms of tensile strength, so product B is the most effective option for carrying a heavy object.

Table 3: Biodegradability Test Table

Product	Percentage Of Peanuts Used	InitialWeight (g)	Initial Dimensions (cm)	Days in Soil/Compost	Weight After (g)	Dimension Change (cm)	Visual Change	Breakdown Level (Low/Medium/High)	Final Observation	Rank
A	25%	0.25 grams	2 cm	10 days	8 grams	4 cm	Covered by soil	High	Damaged	3
B	75%	0.69 grams	5 cm	10 days	3 grams	1 cm	Dirtier	Low	Partially damaged	1
C	100%	0.83 grams	1 cm	10 days	1 gram	3 cm	Moist and full of soil	Medium	Most of the paper is shredded	2

The researchers conduct a biodegradability test, biodegradability tests in soil and compost are tricky, expensive, and time-consuming. They need controlled conditions to mimic real-world environments, with careful tracking of things like temperature, moisture, and microbial activity over time (Pires *et al*., 2022) [16]. Product A, containing 25% peanut shell content, expanded significantly during the biodegradability test. Starting with a weight of 0.25 grams and a size of 2 cm, it increased to 0.8 grams and grew by 4 cm after 10 days in soil. The product became heavily covered in soil and was described as damaged, showing a high level of breakdown. It ranked 3rd in biodegradability, indicating that lower peanut shell content leads to faster decomposition but compromises durability.

Product B, with 75% peanut shell content, demonstrated the best biodegradability performance. Initially weighing 0.69 grams and measuring 5 cm, it decreased to 0.3 grams and shrank by 1 cm after 10 days. While the product became dirty, it was only partially damaged and showed a low level of breakdown. Ranking 1st in biodegradability, these results suggest that a higher peanut shell content enhances both durability and controlled decomposition.

Product C, composed entirely of peanut shells (100%), delivered moderate results. Starting with a weight of 0.83 grams and a size of 1 cm, it increased to 1 gram and grew by 3 cm after 10 days in soil. The product became moist and shredded, exhibiting a medium level of breakdown. It ranked 2nd in biodegradability, indicating that a 100% peanut shell composition offers a balanced approach to biodegradability and durability.

Among the three products, Product B, with 75% peanut shell content, emerged as the best overall performer. It degraded effectively while retaining partial durability. Product A broke down rapidly but expanded and lacked durability, whereas Product C expanded and degraded at a moderate rate. These findings suggest that a 75% peanut shell content strikes the ideal balance between biodegradability and strength.

The researchers conducted solubility, tensile strength, and biodegradability tests on three products made from peanut shells with compositions of 25%, 75%, and 100%. In the solubility test, Product B (75%) fully dissolved after 24 hours with minimal clumps, earning the top rank, while Product A (25%) dissolved partially and left clumps, and Product C (100%) floated initially and dissolved only partially, ranking 3rd and 2nd respectively. In the tensile strength test, Product B again outperformed the others with the highest tensile strength (19.87 N/cm^2), holding a 480g load before breaking, while Product C ranked 2nd with moderate strength (16.14 N/cm^2), and Product A ranked last with the weakest performance (12.9 N/cm^2), breaking under a 300g load. The biodegradability test revealed that Product B degraded effectively, shrinking in size and weight with the lowest breakdown level, ranking 1st. Product C expanded moderately and showed medium breakdown, ranking 2nd, while Product A expanded significantly, broke down rapidly, and lacked durability, placing it last. Overall, Product B consistently outperformed the others, demonstrating the best balance of solubility, tensile strength, and biodegradability. This indicates that a 75% peanut shell composition is optimal for strength, durability, and environmental performance, making it the most effective choice among the three products tested.

Conclusion

The study From Nuts to Bag: Peanuts (Arachis Hypogea) Shells as a Sustainable Alternative Source in Making Eco-friendly Paper Bags" is a research project that aimed to use peanut shells as a sustainable and viable alternative raw material for the production of paper bags. The following are some of the study's major findings, which established that Product B, made up of 75% peanut shell composition, is a successfully developed paper bag that offers the best mobility, durability, and ecological benefits. More generally, those study findings point initially towards possible avenues for applying peanut shells for paper bag production in terms of a greener future for packaging. Product B, for example, has an optimal property combination conducive to further research and development to maximize its production and market potential.

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