Garlic *(Allium Sativum)* Skin as an Alternative for Wood Pulp to Make Potential Paper

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ABSTRACT

This study explores the potential of garlic *(Allium sativum)* skin as an alternative raw material for wood pulp in the production of paper. With the growing demand for sustainable and eco-friendly resources, agricultural waste such as garlic skin offers a promising solution to help mitigate deforestation and promote waste utilization. The research investigates the physical, chemical, and mechanical properties of paper produced from garlic skin pulp compared to conventional wood pulp paper. The process involved collecting garlic skins, treating them with appropriate pulping methods, and forming paper sheets through traditional papermaking techniques. Preliminary results indicate that garlic skin-based paper exhibits acceptable durability, texture, and fiber quality, making it a viable alternative for non-commercial paper applications. This study highlights the environmental and economic advantages of using agricultural by-products in papermaking and encourages further research into optimizing production techniques and improving paper quality.

Keywords: Allium sativum, garlic skin pulp, paper, smoothness, tensile strength

INTRODUCTION

The growing concern over environmental degradation and deforestation has fueled the search for sustainable alternatives to traditional paper production. Conventional paper relies heavily on wood pulp, a resource-intensive process contributing to deforestation, biodiversity loss, and significant carbon emissions. As global demand for paper products continues to rise, it becomes crucial to explore alternative raw materials that minimize environmental impact [1].

Utilizing garlic peels in paper production offers a sustainable alternative to traditional wood pulp, mitigating environmental issues such as deforestation and waste generation [10]. By substituting wood pulp with this readily available agricultural waste, it may reduce the demand for trees, thereby conserving forests and their associated biodiversity [9]. Furthermore, diverting garlic peels from landfills minimizes waste and promotes a circular economy, aligning with sustainable resource management principles [4].

Garlic peels have emerged as a promising material for sustainable papermaking, offering an innovative solution to reduce agricultural waste while also preserving natural resources as the outer layers of garlic bulbs are typically discarded as waste, they can be repurposed into handmade paper due to their high cellulose, hemicellulose, and lignin content [7]. These compounds are essential for creating strong and durable paper products, making garlic peels a good substitute to wood-based materials. This approach may not only reduce environmental pollution from garlic waste but also contribute to the conservation of forests by decreasing the reliance on traditional wood pulp sources.

In regions like Tondo, and Manila, the transformation of garlic peels into handmade paper has become part of livelihood programs aimed at empowering local communities. This initiative also aligns with broader efforts to address waste management challenges and promote environmental sustainability [6]. By recycling organic waste, garlic peel paper production offers a dual benefit: mitigating environmental impact and fostering sustainable economic opportunities and addressing some of the sustainable development goals [3].

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METHODS AND EXPERIMENTAL DETAILS

1. Preparation of Garlic Skin

Cleaning of garlic skin was done by removing stains and other debris through washing with clean water. This process was repeated until water used to clean the garlic skin becomes clear and free from any visible dirt. Garlic skin was then air dried inside the laboratory until dehydrated. This is done to ensure that the garlic peels are clean and dry before chemical treatment.

Figure 1. Washing and Drying of Garlic Skin

2. Chemical Alkaline Treatment

The procedure of Raven Fly [5] on alkaline treatment was adopted for this process. 1.5 liters of water with 35 grams of NaOH was boiled for 15 minutes to make the white liquor. 100 grams of garlic skin was then submerged in the boiling white liquor for an hour. The alkaline solution broke down the lignin and hemicellulose of the garlic skin, loosening the fibers and making them more accessible for further processing.

Figure 2. Alkaline Treated Garlic Skin

3. Mechanical Pulping

Mechanical pulping is the process in which a fiber is defibrated mechanically into a soft, wet, shapeless mass of material called pulp. In this study, the garlic skin was ground and refined with a blender in order to produce garlic skin pulp.

Figure 3. Grinding of Garlic Skin

4. Paper Making Process

After pulping, the pulp was diluted in a container with 5 liters of water. Sheet formation was then done by double-dipping a mold. The formed pulp was air dried in the laboratory until the paper is solid and was slowly removed from the mold.

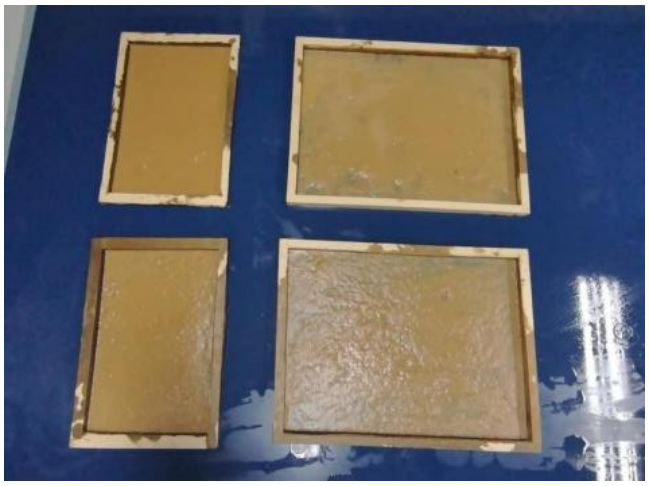

Figure 4. Washing and Drying of Garlic Skin

RESULTS AND DISCUSSION

5. Tensile Strength

The table below presents tensile strength data in MPa (Megapascals, a measure of force per unit area), for three garlic skin paper (GSP) samples and commercialized bond paper (CBP) samples. A t-test was used to compare their tensile strengths.

Table 1 Tensile Strength Group Analysis

	Tensile Strength (MPa)	Mean	Standard deviation
Garlic skin paper	6.676 8.073	8.1143	.07420

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	8.073		
Commercialized bond paper	6.178 8.434 5.786	5.9000	.23643

A tensile strength test was performed on three strips each of GSP and CBP paper. The results, shown in Table 1, are measured in megapascals (MPa). The GSP paper had an average tensile strength of 8.1143 MPa with a standard deviation of 0.07420. In comparison, the CBP paper had a lower average of 5.9000 MPa and a standard deviation of 0.23643. This means that GSP is stronger and has more consistent results, while CBP is weaker and has more variation in its strength.

7. Smoothness

Table 2 Smoothness Test Comparison of Garlic Paper and Commercialized Paper

	Garlic Skin Paper	Commercialized bond Paper
Pencil		
Line	✓	✓
Smudge	✗	✓
Erasure	✓	✓
Ballpen		
Line	✓	✓
Smudge	✓	✓
Correction Tape	✓	✓
Markers		
Line	✓	✓
Smudge	✗	✓
Absorption	✗	✓
Printer		
Color Value	✓	✓
Letter Clarity	✓	✓
Smudge	✓	✓

Note: ✓ - *Good performance;* ✗ - *Bad performance*

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For writing with a pencil, both garlic skin paper (GSP) and commercialized bond paper (CBP) made good lines and erased well. However, pencil smudges spread more easily on the GSP. All tests for line quality, smudging, and correction tapes with ballpens performed effectively. Smudges for both gel pens and fine pens perform well. Correction tapes stick well and do not easily remove on both papers. Marker writing lines performed well for both, but the smudges on GSP does not. We tested how well the paper absorbed ink by writing on two stacked sheets. If the ink didn't soak through to the bottom and caused smearing on the GSP, it means the GSP didn't absorb ink well. For printing, the color looked good, the letters were clear, and there were no smudges here, everything worked well.

The amount of soft pulp in paper affects how well it absorbs ink. Adding some softwood pulp reduces absorption due to a smooth surface blocking ink. Paper made entirely of hardwood pulp absorbs ink best because of its fiber structure [2]. Therefore, CBP showed better absorption in the absorption test because it was made from hardwood pulp, whereas GSP, made from the softer garlic skin pulp, had lower absorption.

The difference in ink absorption between CBP and GSP is due to their fiber structures and compositions. CBP, made from hardwood pulp, has shorter, finer fibers that create a porous surface ideal for absorbing ink. GSP, made from garlic skin soft pulp, has longer fibers and possible natural oils or waxes that make it smoother and less absorbent. As a result, CBP is more suitable for printing and writing applications.

8. Significant Difference

Table 3 Analysis of Variance on the Tensile Strength

T-value	Degrees of freedom (Df)	P-value	Mean difference
15.477	4	.000	2.21433

The t-test shows a p-value of .000 which is lower than the level of significance set at 0.05. This indicates strong statistical evidence to reject the null hypothesis, confirming that the difference in tensile strength is statistically significant. This means that the GSP has stronger tensile strength.

CONCLUSION

The garlic skin paper was found to be much stronger than regular commercialized bond paper when tested for tensile strength, which is the ability of a material to resist breaking when pulled. This means that garlic skin paper can handle more force without tearing compared to the usual paper we use. To confirm this, a T-test was done — a type of statistical test used to compare two sets of data. The result of the test showed a p-value of 0.000. Since this value is much lower than 0.05, which is the standard level used to check if results are meaningful, it clearly shows that the difference in strength between the two types of paper is significant and not just due to chance. Therefore, garlic skin paper is proven to be stronger and more durable than regular commercialized bond paper. This result is particularly promising, as it highlights garlic skin paper's potential as a strong, sustainable alternative to traditional commercial papers, despite being made from an organic material. This is supported by the study on pencil and ballpen tests conducted by Salim et al. [8] which states that garlic skin paper exhibited a smoother surface compared to commercialized bond paper, as it shows less smudging with these writing tools. However, garlic skin paper demonstrates poor absorption with markers. Therefore, while smoother in terms of resisting smudging with certain tools, its low absorption indicates a different surface texture compared to commercial paper.

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