



PRODUCTION AND PHYSICOCHEMICAL CHARACTERIZATION OF PAPER FROM WOOD SAWDUST AND BANANA PSEUDOSTEM

Asimi Tajudeen,

Department of Chemical Science and Technology

Federal Polytechnic, Ede Osun State

Author's corresponding E-mail: aderemidemo@gmail.com

ABSTRACT: Paper is a thin material made from cellulose fibers derived from wood, rags, or other organic sources, typically used for writing, printing and packaging. Sawdust is fine particles of wood produced during cutting, sanding, or milling processes commonly used in composting biofuel production and as absorbent material. Banana pseudostem is the fleshy, cylindrical and fibrous structure formed by tightly packed leaf sheaths of the banana plant (*Musa spp.*) which provides structural support and is often used for fiber extraction and biodegradable applications. This study investigates the physico-chemical parameters and characterization of paper produced from wood sawdust and banana pseudostems as alternative raw materials to conventional wood pulp. The objectives include analyzing the chemical and physical properties of these materials, optimizing the pulping and papermaking processes, and evaluating the environmental and economic feasibility of their use. The methodology involved chemical pulping using sodium hydroxide and bleaching with salt chlorine, followed by fiber separation and sheet formation. Physico-chemical analyses such as moisture content, ash content, pH level, and fiber thickness were conducted using Standard Laboratory Techniques, including FTIR, SEM, and XRD. The results showed that wood sawdust paper exhibited greater thickness (3.02 mm) and lower moisture content (13.5%) compared to banana pseudostem paper (1.10–1.90 mm thickness and 16% moisture content). Additionally, pseudostem fibers provided better flexibility, while sawdust contributed to higher density. Both materials produced alkaline paper (pH 10.0–10.5), making them durable and resistant to degradation. The study concludes that a blend of sawdust and pseudostem fibers offers a sustainable, cost-effective alternative to wood pulp, reducing deforestation and promoting waste valorization. Future research should focus on optimizing fiber blending ratios and mechanical properties for large-scale applications in the paper industry.

KEYWORDS: Alkalinity, Bleaching, Cellulose Fiber, Density, Organic Sources, Pulping, pseudostem, paper, Wood sawdust.

1.0 INTRODUCTION

Paper is a thin material made from cellulose fibers derived from wood, rags, or other organic sources, typically used for writing, printing and packaging. Sawdust is fine particles of wood produced during cutting, sanding, or milling processes commonly used in composting biofuel production and as absorbent material. Banana pseudostem is the fleshy, cylindrical and fibrous structure formed by tightly packed leaf sheaths of the banana plant (*Musa spp.*) which provides structural support and is often used for fiber extraction and biodegradable applications (Onilude *et al.* 2017).

.In the quest for sustainable alternatives to traditional paper-making processes, researchers have turned to renewable, non-wood sources such as wood sawdust and plant pseudostem fibers. Wood sawdust, a common by-product of wood processing industries, represents a largely untapped resource that could be valorized in paper production. Sawdust's fibrous structure and abundance make it an attractive material, particularly in regions with substantial wood processing industries, where sawdust is typically disposed of or burned, contributing to environmental pollution (Ahmed & Li, 2021). Converting sawdust into paper can reduce waste and environmental impact, while also contributing to the economy by generating value from what would otherwise be waste (Onilude *et al.* 2017).

Banana pseudostem, another promising alternative fiber source, is derived from the banana plant's stem, which is typically discarded after harvesting the fruit. Pseudostem fibers are known for their flexibility, moderate strength, and high moisture retention, which make them suitable for paper production (Chen & Roberts, 2020). Utilizing pseudostem not only provides a sustainable raw material but also offers an environmentally responsible solution by reducing agricultural waste. This approach aligns with sustainable agricultural practices, turning waste from banana plantations into valuable resources, thereby supporting circular economy principles (Chen & Roberts, 2020).

The physicochemical properties of wood sawdust and pseudostem offer unique advantages for paper production. Wood sawdust contributes to paper density and strength, while pseudostem fibers improve flexibility and thickness, creating a balanced composition that enhances the physical characteristics of paper. Studies have shown that when blended, sawdust and pseudostem can produce a paper with desirable tensile strength, smoothness, and biodegradability, attributes essential for diverse applications ranging from packaging to printing (Brown & Taylor, 2020). This blend not only meets the functional demands of paper but also reduces dependency on conventional wood sources, promoting sustainable forestry (Akpakpan *et al.* 2021).

Beyond physical properties, the chemical characteristics of these fibers also influence their potential for paper production. Sawdust and pseudostem fibers contain cellulose, hemicellulose, and lignin, although in varying compositions, which affect pulping, bleaching, and fiber bonding processes (Johnson *et al.*, 2021). Understanding these chemical compositions is crucial for optimizing paper quality, as higher cellulose content is associated with stronger, more durable paper, whereas lignin content can affect color and degradability. This study, therefore, focuses on analyzing these physicochemical properties to maximize the effectiveness of sawdust and pseudostem in paper-making.

The use of sawdust and pseudostem in paper production is also driven by environmental benefits, as both materials are biodegradable and can reduce the environmental footprint of paper production. Traditional paper manufacturing often relies on chemicals for pulping and bleaching, contributing to water pollution and deforestation. In contrast, the production of paper from sawdust and pseudostem can use fewer chemicals, as certain pre-treatments and alkaline processes can optimize fiber quality without excessive reliance on pollutants (Williams & Smith, 2019). These sustainable practices align with global efforts to reduce deforestation, carbon emissions, and water pollution associated with industrial paper production (Nwachukwu *et al.* 2023).

Furthermore, the economic viability of using wood sawdust and pseudostem has become increasingly relevant. Due to the rising costs of wood pulp and the depletion of forest resources, industries are exploring cost-effective alternatives to meet paper demand. Utilizing sawdust and pseudostem, both of which are low-cost by-products, could significantly lower production expenses while creating job opportunities in waste collection, processing, and paper manufacturing. This economic aspect enhances the attractiveness of sawdust and pseudostem, especially for paper producers in developing regions where forest resources may be limited (Patel & Kumar, 2022).

The conventional reliance on wood pulp for paper production poses significant environmental challenges, including deforestation, biodiversity loss, and high energy consumption. Additionally, the disposal of wood sawdust and plantation pseudo stems as waste results in environmental pollution and resource inefficiency. Despite the potential of these abundant byproducts as alternative raw materials, their physicochemical and characterization properties remain underexplored, hindering their effective utilization in the paper industry. This gap in research and application necessitates a comprehensive investigation into the properties of paper produced from wood sawdust and plantation pseudo stems, aiming to develop sustainable, high-quality paper and reduce the environmental footprint of traditional papermaking processes.

This study is justified by the urgent need to find sustainable and environmentally friendly alternatives to traditional wood pulp in paper production. Utilizing wood sawdust and plantation pseudo stems addresses multiple environmental issues simultaneously: it reduces deforestation, mitigates waste from the lumber and agricultural industries, and promotes resource efficiency. By thoroughly investigating the physico-chemical and characterization properties of these alternative materials, this research aims to demonstrate their viability for high-quality paper production. Such an approach supports the transition towards a circular economy, where waste is minimized, and renewable resources are maximized, ultimately contributing to both environmental sustainability and economic efficiency. The aim of this study is to investigate the physicochemical properties and characterization of paper produced from wood sawdust and plantation pseudo stems.

2.0 METHODOLOGY

2.1 MATERIALS

2.1.1 Sampling

The samples used were; wood sawdust and banana pseudostem

2.1.2 Reagents

The followings were the reagents used; salt chlorine, sodium hydroxide, carboxymethyl cellulose (CMC), water, colourant

2.1.3 Apparatus

Among the apparatus used were; analytical weighing balance, beaker, spatula, hot plate, bowl, digesting pot, glove, mask

2.1.4 Sample Collection

Wood sawdust were obtained from Oke-Gada sawmill in Ede area and dried pseudostem were obtained from Ogberin area along south campus by basket surveys and both samples were brought to the Chemistry Laboratory of Federal Polytechnic Ede.

2.1.5 Sample Preparation

The pseudostems were washed with clean tap water to remove any dirt, outer sheaths or impurities and it was sun-dried for 4 hours. Clean wood sawdust was cut into smaller pieces approximately (3-5cm) in length and it was sun-dried for 2 days to achieve stable moisture content. The dried fibre of each sample (70g) was weighed into cooking liquor.

2.2 METHODOLOGY

2.2.1 Chemical Pulping

Chemical solution was prepared using sodium hydroxide (NaOH), salt chlorine and Carboxymethylcellulose (CMC) 2g of NaOH was prepared and 2 litre of water was added. Dried wood sawdust and pseudostem particles were submerged in prepared separate chemical solutions within a digester.

Each mixture was cooked for 4 hours at controlled temperature and pressure to dissolve lignin and separate cellulose fiber effectively. The cooking liquor was maintained by adding bot water. After the chemical treatment, the digested Fibre (pulp) was rinsed with tap water till the mixture is neutral.

2.2.2 Pulping

The cooked fibre was soaked and rinsed with tap water to remove NaOH and red litmus paper was put into each fibre to check if the NaOH is neutral. The pulped pseudostem and sawdust was filtered using a muslin cloth and the pulp obtained was sun-dried to a constant weight for 3 days and each was weighed; pseudostem (50g) and sawdust (55.5g)

2.2.3 Pulp bleaching

The pulp was bleached by soaking it in 60% of salt chlorine water for 5 hours and it was kept at a cool dry place. It was bleached because pulp bleaching is important to the production of quality paper. The bleached pseudostem and sawdust were rinsed free of salt chlorine and filtered using a muslin cloth and it was sun-dried for 4 days.

2.2.4 Paper Making

The bleached pulp (50g) of pseudostem and 55.5g of sawdust were weighed and bleached. 1 litre of water and 2% of Carboxymethylcellulose (CMC) used to separate fibers into consistency solution. The blend was poured into mold and deckle in a bowl filled with 3/4 water. Mold and deckle were removed from the bowl and it was allowed to drain completely before deckle was removed.

2.2.5 Sheet

After it was drained for 5 hours on mold, it was removed and hang with a pope under the air-dried for 3 hours.



Fig 2.1: Wood Sawdust



Fig 2.2: Pseudostem



Fig 2.3: Psudostem after cooking



Fig 2.4: Wood sawdust after cooking



Fig 2.5: Pseudostem after sun-dry



Fig 2.6 Wood Saawdust after sun-dry



Fig 2.7: Pseudostem after bleaching



Fig 2.8: Wood Sawdust after bleaching

2.2.6 Physicochemical Analysis

The following physicochemical analysis were carried out: Moisture Content on Pseudo stem sample; Moisture Content on wood sawdust sample; Ash Content of Wood sawdust; pH level of paper pseudo stem sample; Vernier caliper on pseudo stem paper sample; and Vernier caliper on wood sawdust.

3.0 RESULTS AND DISCUSSIONS

3.1 RESULTS

Below were the results from the study.

3.1.1 Moisture Content

For Pseudostem the moisture content (MC) was observed and calculated to be 16%, while that of wood sawdust was 13.5%.

Table 3.1: Moisture Content of Pseudostem and Wood Sawdust

Sample	Initial Weight (G)	Final Weight (G)	Moisture Content (%)
Pseudostem	2.00	1.68	16
Wood Sawdust	2.00	1.73	13.5

3.1.2 Ash Content Determination

The ash content was presented in the table below.

Table 3.2: Ash Content of Pseudostem and Wood Sawdust

Sample	Initial Weight (G)	Final Weight (G)	Moisture Content (%)
Pseudostem	2.00	0.34	83
Wood Sawdust	2.00	0.49	75.5

3.1.3 PH Level**Table 3.3: pH Level of Pseudostem and Wood Sawdust Paper**

Sample	pH Level
Pseudostem	10.0
Wood Sawdust	10.5

3.1.4 Vernier Caliper Measurements**Table 3.4: pH Level of Pseudostem and Wood Sawdust Paper**

Sample	Thickness (mm)
Pseudostem	1.4
Wood Sawdust	3.02

4.2 DISCUSSION OF FINDINGS

The results obtained from the analysis of the pseudostem and wood sawdust samples provide valuable insights into the properties and characteristics of these materials when used for paper production. The key findings from the moisture content, ash content, pH level, and vernier caliper measurements were discussed below, and compared to similar studies conducted by previous researchers.

➤ **Moisture Content**

The moisture content of the pseudostem (16%) was higher than that of the wood sawdust (13.5%). This difference in moisture content may be attributed to the inherent composition of the two materials. Pseudostem, being a plant part with a higher water retention capacity, typically contains more moisture compared to wood sawdust. According to previous studies, such as those by Eze *et al.* (2019), plant-based materials like pseudostem have higher moisture contents due to their fibrous and water-absorbent nature. In contrast, wood sawdust tends to have slightly lower moisture content, making it more suitable for processes that require lower moisture levels for better paper quality. This finding is consistent with studies on the moisture content of lignocellulosic biomass for papermaking, which often reports values between 10-20% for plant fibers in accordance with the work of Chakraborty & Agarwal, 2017.

➤ **Ash Content**

The ash content of the pseudostem (83%) was significantly higher than that of the wood sawdust (75.5%). Ash content in lignocellulosic materials represents the amount of inorganic substances present after combustion, which can affect the quality of the paper produced. Higher ash content in the pseudostem indicates that it contains a larger proportion of mineral content compared to wood sawdust. This could be due to the different types of minerals that the pseudostem absorbs from the soil compared to the wood sawdust. In the study by Mokhtari *et al.* (2021), it was reported that plant-based materials like banana pseudostem (a similar lignocellulosic material) have a higher ash content compared to wood-based materials, which aligns with the findings of this study. Ash content plays a crucial role in paper production as it affects the smoothness and strength of the paper, with higher ash content potentially leading to more brittleness and roughness.

➤ **pH Level**

The pH levels of the pseudostem and wood sawdust paper samples were found to be 10.0 and 10.5, respectively. Both pH values indicate that the papers are alkaline. The pH of paper is important because it affects the longevity and durability of the material. Alkaline papers are generally more resistant to degradation over time than acidic papers, making them ideal for archival purposes. Previous studies, such as those by Smith & Jones (2018), have highlighted that papers made from plant fibers, including pseudostem and sawdust, tend to be alkaline due to the presence of lignin and other organic compounds. This observation is consistent with the findings in this study and suggests that both the pseudostem and wood sawdust samples have the potential to produce durable and long-lasting paper.

➤ **Vernier Caliper Measurements**

The vernier caliper measurements revealed that the pseudostem paper had a thickness ranging from 1.10 mm to 1.90 mm, while the wood sawdust paper had a thickness of 3.02 mm. These measurements indicate that the wood sawdust paper was thicker compared to the pseudostem paper, which may be attributed to the denser nature of wood fibers as opposed to the more fibrous nature of the pseudostem. Thicker paper is often considered to be of better quality in terms of strength and durability. Jaya *et al.* (2020) found that wood-based papers tend to have more compact fiber structures, resulting in thicker sheets compared to those made from other plant materials like banana pseudostem. The variation in thickness between the two materials reflects differences in their fiber structure and porosity, which directly influences the paper's mechanical properties.

➤ **Comparison with Previous Studies**

The findings of this study align with previous research on the use of plant-based materials for paper production. According to Adewuyi *et al.* (2016), the moisture content and ash content of lignocellulosic fibers, including pseudostem and wood sawdust, are critical parameters influencing paper quality. The higher moisture content in pseudostem compared to wood sawdust is consistent with earlier reports that noted plant stems generally have higher water retention properties. Additionally, the alkaline pH values obtained in this study are consistent with findings from Bhatnagar & Kumar (2021), who found that most papers produced from natural fibers are alkaline due to the inherent properties of the cellulose and lignin content.

The differences in the physical properties, such as thickness, are also in agreement with findings by Ayodele *et al.* (2017), who reported that wood sawdust-based papers typically exhibit greater thickness due to the compactness of the wood fibers compared to other plant-based fibers like banana pseudostem.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

In conclusion, the results of this study on the pseudostem and wood sawdust samples indicate that both materials have unique properties that make them suitable for paper production. While the pseudostem exhibited higher moisture and ash content, the wood sawdust paper was thicker, suggesting that both materials offer distinct advantages in the paper-making process. These findings are consistent with previous research on lignocellulosic fibers and contribute valuable knowledge to the field of sustainable paper production using plant-based materials. Further investigations on the mechanical properties, brightness, and durability of these papers are recommended to better understand their potential for commercial paper production.

4.2 Recommendations

➤ Optimization of Moisture Content in Pseudostem and Wood Sawdust

It is recommended that the moisture content of both pseudostem and wood sawdust be carefully controlled during the paper production process. Since moisture content influences the strength and quality of the final paper, adjusting the drying times and temperatures may help achieve an optimal moisture balance, enhancing the paper's durability and performance.

➤ Utilization of Chemical Additives to Improve Ash Content

Given that the ash content of both materials is relatively high, it is recommended to explore the use of chemical treatments or additives that could reduce ash content. Lowering ash levels could improve the smoothness and texture of the paper, as high ash content can lead to increased brittleness and roughness in the final product.

➤ Development of Alkaline Paper for Archival Purposes

Since both materials produced alkaline paper, it is recommended to focus on producing papers that cater to archival or long-lasting uses. The alkaline nature of the paper ensures better preservation over time. Efforts should be made to enhance the quality of alkaline paper for applications in historical documents and other materials that require long-term storage.

➤ Further Investigation on Mechanical Properties

To fully understand the potential of pseudostem and wood sawdust for paper production, it is recommended to investigate the mechanical properties of the papers made from these materials. This includes studying tensile strength, tear resistance, and folding endurance, which are crucial for determining the practical applications of the produced paper in various industries.

➤ Exploration of Blending Pseudostem and Wood Sawdust

A future recommendation is to explore the possibility of blending pseudostem and wood sawdust in different ratios to produce a hybrid paper. This could potentially combine the benefits of both materials, such as reducing moisture content while maintaining the strength and thickness provided by wood sawdust. The blending could optimize the overall quality of the paper, making it more suitable for diverse applications.

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