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EDITORIAL DESK

The Journal of Contemporary Issues in Nigerian Economy stands as a beacon of scholarly excellence, drawing upon a diverse spectrum of researchers hailing from the expansive West African region and beyond. This volume showcases 15 meticulously researched articles curated from contributors in Nigeria and the United States of America. The genesis of these scholarly endives can be traced back to the auspicious conference convened at the Lagos State University Mekanjuola Lecture Hall, held in December, 2023.

These articles, characterized by their depth and precision, underwent rigorous scrutiny during the conference, with over 90 participants actively engaging in critique. Subsequent to this extensive quality assurance regimen and plagiarism checks, only 15 articles successfully met the standards set forth by the esteemed guild of the editorial team, in strict adherence to international best practices.

It is with great pleasure that the Board of Editors announces the third edition of the publication schedule of the journal. Our heartfelt congratulations extend to the authors whose papers demonstrated exceptional merit and have successfully navigated the rigorous selection criteria. To future researchers, we extend our encouragement to strive for greater heights in their scholarly pursuits.

The Board of Editors appreciates the Vice Chancellor, Lagos State University, Prof. Ibiyemi Ibilola Olatunji-Bello, mni NPOM for providing the enabling environment for the conference and her directives to the editorial team for strong quality assurance measures. We believe in your leadership and concerted efforts at ensuring high standards for the journal publication.

Prof. M. O. B. Mohammed, FNAEAP
Editor in Chief

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AN INVESTIGATION FOR THE USE OF WASTES FROM FOUR PLANT MATERIALS IN PAPER PRODUCTION: *ANANAS COMOSUS* L, *MUSA PARADISIACA* L, *SACCHARUM OFFICINARUM* L AND *ZEAMAYS* L.

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Abstract

Plants are of numerous uses to mankind and the society. The pulp and paper industries are not left out of these uses. The global demand for wood fiber is increasing with world population and new applications for wood fiber. Therefore, to supplement the limited wood fiber resources, non-wood fibers from wastes of some plant materials have been introduced as alternatives in pulp and paper-based industries. This study aims to use wastes from four plant materials: *Ananas comosus*, *Musa paradisaca*, *Saccharum officinarum* and *Zea mays* as alternative raw material in pulp and paper-making industry to promote the concept of waste to wealth and recyclable materials. Physical properties of the wastes and mechanical properties of the handmade paper produced from the waste materials were performed in line with the procedures of TAPPI. Results from the physical properties showed that stalk of *M. paradisica* have the highest fiber length of 2.83 mm and husk of *Zea mays* have the least fiber length of 1.34mm. Runkel ratio of the four plant materials: *A. comosus*, *M. paradisaca*, *S. officinarum* and *Z. mays* are 0.75, 0.82, 0.95 and 0.98 respectively ($RK < 1$); making them suitable for pulping and paper making. The mechanical properties of the bleached and unbleached paper sheet revealed that the bleaching agent have mild effects on the properties investigated in the study. This study revealed that the four wastes from plant materials used in this study have a promising potential as fiber alternatives for pulp and paper production with less environmental threat.

Keywords: Fiber, Paper, Plant wastes, *Ananas* sp., *Musa* sp., *Saccharum* sp., *Zea mays*

Introduction

The manufacture of pulp and paper is important to education, printing, publishing and numerous packaging industries. Paper is widely used in the offices for writing, printing documents, and photocopying. At home, paper is used to clean, to dry things, and for many other purposes. Paper remains the dominant and essential vehicle of modern communication (MBendi, 2001). In summary, paper is one of the most versatile and common products of modern societies (El-Sakhawy *et al.*, 1996). The pulp and paper industry is much diversified, using many types of raw materials to produce different kinds of paper by different methods (Gullichsen, 2000). Historically, non-woody plants were major resources for pulp and paper production compared to woody plants. In the 19th century, an insufficient supply of the traditional raw materials of cotton and linen rags made it necessary to use wood to make paper (Bajpai *et al.*, 2004). Today, wood fibre either hardwood or softwood are the main raw materials used for the production of pulp and paper. About 90 – 92% of the pulp and paper in the world are produced from wood, mostly in the developed countries (Bajpai *et al.*, 2004; Jiménez *et al.*, 2009). Pulp and paper production from woody trees generates a considerable quantities of pollutants ranging from waste water, waste gases and solid wastes (Mladenov and Pelovski, 2010). According to the United Nations Food and Agriculture Organization, an estimated 18 million acres (7.3 million hectares) of forests are lost each year because of rapid consumption of timber trees for producing forest products such as paper (FOA, 2010). Owing to these environmental concerns and wood resource depletion, more attention is being paid to renewable materials such as non-wood. The increase demand of paper

consumption is the main cause for the usage of wood species as the main raw material leading to massive deforestation and replantation. Agriculture is an important sector in Nigeria economy. The sector generates substantial volume of agricultural waste in all ecological zones of the nation (Ogunwusi, 2014). The non-wood materials such as agricultural food crop residues, grasses and trees leaves which do not have immediate beneficial applications have been proposed to be potential sources of pulp. Since all these plant materials contain cellulose in form of fibre, they stand to be potential sources of raw materials for pulp production with less environmental threats (Tran, 2006; McCloskey, 1995). Hence, the use of wastes from four (4) plants: *Ananas comosus* L., *Musa paradisiaca* L., *Saccharum officinarum* L., and *Zea mays* L. (pineapple leaves, plantain stalk, sugarcane bagasse and corn husk) are investigated in this study to serve as alternative to the woody resources.

Materials and Methods

Plants Waste Collection

Fresh wastes from plant materials such as pineapple leaves, plantain stalk and corn husk used in this research were collected from Iyana-Iba market in Ojo Local Government Area and Ikotun market of Alimosho Local Government Area of Lagos State from various vendors of these plant materials. Collection was done in the morning with the aid of gloves. The plant materials were carefully packed inside polythene bags, thereafter taken to the laboratory for further processing.

Sample Preparation

Plant wastes including pineapple leaf, plantain stalk and corn husk were washed with water to remove debris and unwanted particles. Only sugarcane bagasse was not washed as it does not contain any unwanted particles. The samples were thereafter chipped into small sizes using cutting tools like scissors and knife. The chipped samples were then oven-dried at 60°C until absolute dryness was achieved. The dried plant materials samples after dryness were preserved in Aluminium foil and kept in the laboratory for later use.

Physical Properties Characterization

Physical properties such as Fibre Length (FL), Fibre Diameter (FD), Cell Wall Thickness (CWT) and Lumen Width (LW) were determined. This was achieved by weighing and soaking preserved samples of the plant materials separately in a mixture of 1:1 solution of glacial acetic acid (CH_3COOH) and hydrogen peroxide (H_2O_2) in test tubes. The hydrogen peroxide acts as an oxidizing agent that bleaches the raw materials colour to complete white, while the glacial acetic acid acts as cooking medium, which softens the plant materials. The solution was put in the oven for over 2 hours at about 100°C for maceration. The mixture was thereafter decanted and macerated fibres were washed in cold water and further disintegrated to release individual fibres. Each representative fibres were mounted on the slide and examined microscopically in accordance with TAPPI Standards (T 233 os 75) (Tappi, 2008).

Pulping Process

Pulping of the chipped samples were performed in an electrically-heated autoclave using chemical pulping process (Soda pulping). The preserved plant materials were loaded separately into a 1000ml conical flask with 7% caustic soda (NaOH) solution placed in the autoclave with sufficient amount of water. The ratio of volume of water to raw material was 3:1 in accordance with the TAPPI Standards (T 258 os 76) (Tappi, 2008).

Pulp Washing

The pulp obtained was thoroughly washed under running water to remove the residual chemicals still present. The pulp was oven-dried at 60°C until absolute dryness was attained and the Pulp yield was determined. After pulp yield was determined, the pulp was also preserved using Aluminium foil in the laboratory for further usage.

Pulp Bleaching

A weighed amount of dried pulp from each plant material was introduced into a beaker, and a measured amount of Hydrogen peroxide (H_2O_2) was added. The beaker was then heated on a heating mantle for about 20 minutes at 60°C after which it was observed that the pulp colour had changed to white. This process is line with TAPPI Standards (T 236 om 299) (Tappi, 2009).

Production of Handmade Paper

The pulps from the bleached and unbleached plant materials samples were de-fiberized in the laboratory using blender for about 5 – 10 minutes. Starch was added to it to serve as binding force for the fibre before the sheet formation process. Handmade paper sheets were produced using deckle and mould. The paper mould with the fibres was then air dried. After absolute drying of the handmade paper was attained, the paper samples were then pressed with an electric hot iron to improve the smoothness of the paper.

Results and Discussion

Table 1 shows the pulp yield of the waste from plant materials.

Table I: Pulp yield of the wastes from Plant materials

Botanical Name	Plant materials used	Pulp Yield (%)
<i>Ananas comosus</i> L.	Pineapple leaf	40.67
<i>Musa paradisiaca</i> L.	Plantain stalk	35.47
<i>Saccharum officinarum</i> L.	Sugarcane bagasse	68.50
<i>Zea mays</i> L.	Corn husk	38.63

$$\text{Pulp Yield} = \frac{\text{Dry weight of pulp}}{\text{Dry weight of chip samples}} \times 100\%$$

Pulp Yield

The pulp yield of the plant materials used in pineapple leaf, plantain stalk, sugarcane bagasse and corn husk are 40.67%, 35.47%, 68.50% and 38.63% respectively. The percentage pulp yield recorded in the literature of corn husk and plantain stalk are 23.00% and 35.96% respectively by (Aremu *et al.*, 2015) which are low compared to those studied. Sugarcane bagasse have the highest pulp yield with 68.50% in this study. All the samples used in this study have moderate pulp yield which makes them suitable raw materials for pulp and paper industries (Table 1).

Physical Properties of the Samples

Physical properties such as Fibre Length (FL), Fibre Diameter (FD), Cell Wall Thickness

(CWT) and Lumen width (LW) were determined for the four (4) wastes from plant materials samples: pineapple leaf, plantain stalk, sugarcane bagasse and corn husk (Table II).

Fibre Length

Fibre length is one of the most important physical features of any potential material for pulp and paper making. Of the four (4) examined materials, plantain stalk has the highest fibre length of 2.83mm, followed by pineapple leaf with 2.47mm, sugarcane bagasse with 1.57mm and corn husk with the shortest fibre length of 1.34mm. Fibres with length $\geq 2\text{mm}$ are classified as long fibre and are preferred in pulp and paper production (Omotoso, and Owolabi, 2014). However, it has been found that both short and long fibres are essential for papermaking. From the result of this research, plantain stalk and pineapple leaf are long fibres because they have fibre length greater than 2mm while sugarcane bagasse and corn husk are short fibres having length below 2mm. Long fibres from softwoods or from non-woody species form a strong matrix in the paper sheet leading to sheets of high tensile strength, while shorter hardwood fibres or grass fibres contribute to the properties of pulp blends, especially opacity, printability and stiffness (Makinde *et al.*, 2019). Hence, fibres from the studied materials have usefulness in pulp and paper industry.

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Fibre Diameter and Lumen Width

Fibre diameter and Lumen width are vital to paper strength especially during beating operations (Fagbemigun *et al.*, 2014). From the results obtained, the fibre diameter of pineapple leaf, plantain stalk, sugarcane bagasse and corn husk are 15.81 μm , 37.50 μm , 21.40 μm and 30.19 μm respectively. These fall within the range of values reported for plantain stalk by (Ekhuemelo *et al.*, 2006) and kenaf core by (Shakhes *et al.*, 2011). A small fibre diameter indicates less fibre flexibility (Aremu *et al.*, 2015). Coupled with its fibre diameter, plantain stalk has the highest lumen width, 20.6 μm out of the four (4) plant materials studied. Corn husk, pineapple leaf and

sugarcane bagasse have lumen width of 13.83µm, 9.16µm and 9.72µm respectively. It is therefore expected to form better pulp than the others. Lumen width affects the beating of the pulping. The larger the lumen width, the better the beating of the pulp because of the penetration of liquids into empty spaces of the fibres (Omotoso *et al.*, 2014).

Cell Wall Thickness

The values of the cell wall thickness of the samples: pineapple leaf, plantain stalk, sugarcane bagasse and corn husk used in this studies are 3.48µm, 8.45µm, 4.64µm and 6.82µm respectively. The values are compatible with that reported by (Shakhes *et al.*, 2011) for kenaf core by (Omotoso *et al.*, 2014). for pineapple leaf and coconut husk. These values are low and therefore will allow easy collapse of the fibres resulting in good surface contact and inter fibre bonding during paper formation. This implies that the four samples studied have potential for paper making based on their cell wall thickness. Thick cell-walled fibres forms bulky paper sheets of low tensile, burst and folding endurance but with high tearing strength.

Table II: Physical properties of the wastes from Plant materials

Sample	Fibre length (mm)	Fibre diameter (µm)	Cell wall thickness (µm)	Lumen width (µm)
Pineapple leaf	2.47	15.81	3.48	9.16
Plantain stalk	2.83	37.50	8.45	20.60
Sugarcane bagasse	1.57	21.40	4.64	9.72
Corn husk	1.34	30.19	6.82	13.83

Derived Fibre Dimensional Values

The following morphological indices (derived values) were also determined according to (Kırcı, 2006). (Table III).

$$\text{RunkelRatio} = \frac{2 \times \text{Cell Wall Thickness (CWT)}}{\text{Lumen Width (LW)}}$$

$$\text{FeltingRatio(Slenderness)} = \frac{\text{FibreLength(FL)}}{\text{FibreDiameter(FD)}}$$

$$\text{ElasticityCoefficient(\%)} = \frac{\text{Lumen Width (LW)}}{\text{Fibre Diameter(FD)}} \times 100\%$$

$$\text{RigidityCoefficient(\%)} = \frac{\text{CellWallThickness(CWT)}}{\text{FibreDiameter(FD)}} \times 100\%$$

Runkel Ratio

Runkel ratio is an important parameter for the measurement of biomass suitability for pulp and

papermaking (Runkle, 1952). According to (Eroglu, 1980), when runkel ratio is less than 1, it means the fibres obtained from the material is most suitable for paper making. When runkel ratio equals 1, it means the cell wall of the material have medium thickness and cellulose obtained from such material are suitable for paper making. When runkel ratio is greater than 1, it is assessed as fibre having thick wall and cellulose obtained from this type of fibre is not suitable for paper making. Results from this study showed that all the plant materials have runkel ratio less than Pineapple leaf, plantain stalk, sugarcane bagasse and corn husk have runkel ratio of 0.75, 0.82, 0.95 and 0.98 respectively. Runkel ratio value of corn husk is higher (1.23) as reported by (Ekhuemelo and Tor, 2013). This means the plant materials are highly pulpable i.e. suitable for paper production.

Felting ratio or Slenderness

High felting ratio or Slenderness is imperative for paper resistance to tear and burst. The felting ratio for the plant materials: pineapple leaf, plantain stalk, sugarcane bagasse and corn husk from this study are 156.23, 75.46, 73.36 and 44.38 respectively. These values are greater than the benchmark of 33 considered being good for pulp and paper production (Bektas *et al.*, 1999). Paper from these samples are expected to have sufficient tear strength suitable for packaging purposes.

Elasticity Coefficient

Elasticity coefficient is a function of lumen width and fibre diameter. It determines the degree of fibre bonding in paper sheet. Elasticity coefficient are classified into four (4) groups of fibres (Bektas *et al.*, 1999). High elastic fibres having elasticity coefficient greater than 75% are the first group. The second group are elastic fibres having elasticity coefficient between 50% - 75%. Rigid fibres having elasticity ratio between 30% - 50% makes up the third group. The fourth group are the highly rigid fibres with elasticity ratio below 30%. From the results obtained from this study, pineapple and plantain stalk have elastic fibres having an elasticity coefficient of 57.93% and 54.93% respectively. Corn husk and sugarcane bagasse falls under the third group of rigid fibres with elasticity coefficient of 45.80% and 45.42% respectively. Elastic fibres are indicative of acceptance burst and tensile strength (Akpabio and Akpakpan, 2012).

Rigidity Coefficient

Rigidity coefficient is a function of Cell Wall Thickness (CWT) and Fibre Diameter (FD). High rate of rigidity affects tensile, tear, burst and double fold resistance of paper negatively (Ekhuemelo, *et al.*, 2006). In this study, the rigidity coefficient of the samples: pineapple leaf, plantain stalk, sugarcane bagasse and corn husk are 22.01%, 22.53%, 21.68% and 22.59% respectively.

Table III: Derived fibre dimensional indices for the wastes from Plant materials

Sample	Derived Fibre Dimensional Indices			
	Runkel ratio	Felting ratio	Elasticity coefficient (%)	Rigidity coefficient (%)
Pineapple leaf	0.75	156.23	57.93	22.01
Plantain stalk	0.82	75.46	54.93	22.53
Sugarcane bagasse	0.95	73.36	45.42	21.68
Corn husk	0.98	44.38	45.80	22.59

Conclusion

This study revealed that wastes from the studied plant materials such as pineapple leaf, plantain stalk, sugarcane bagasse and corn husk have impressive fibres characteristics; which make them promising potentials as fibre alternative for pulp and paper production. This will be useful for various applications; thereby reducing depletion of forest and environmental pollution caused by the conventional woody plants. However, more research should be conducted on other wastes from plant materials to promote the concept of recyclable materials.

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