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PULP EXTRACTION AND PAPER PRODUCTION FROM BANANA PSEUDOSTEM AND ITS CHARACTERIZATION

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Abstract: Banana *(Musaceae sp.)* is one of the popular plants foods and is widely cultivated in Africa due to its health benefit to animal and human body. Extraction and utilization of banana fiber for the production of paper and its equivalent is an effective and economics means of reducing biomass in the society, reducing deforestation and prevention of environment hazards resulting from paper making industries. In this paper, extracted pulp from banana pseudostem was characterized and the Lady Finger paper type has the highest paper strength and folding endurance with 20 g/mm^2 and 1.68 respectively. FTIR analysis of the paper types and extracted pulp indicated the presence of different functional groups: hydroxyl (3352 -3437), Amide (1630-1631), Carboxylate (1317-1371) and Transition metal carbonyl group (2009-2044). This innovation would reduce deforestation by paper making industry, boost small and scale industry and thus, generating employment.

Keywords: Pulpextract, Paper, Non-convectional fibre, FT-IR characterization

1.0 Introduction

The paper products industry is big business generating over $200 billion, Global paper use hasincreased by 400 % in the last 40 years [1]. The global demand for paper products is significant as evidenced by the more than 350 million tons produced annually. The papermaking process is complex method and has far-reaching environmental impacts creating major health issues and environment degradation [2].

Although, non-woods are originally used for paper making in early 1970s, the conventional paper is derived from wood, a forest resource and the paper industry is mainly depending upon forest resources. It was reported that 70 % of global wood fibres were obtained from roundwood and chips in 2004 while non-wood pulp was said to have 5 % capacity of the total paper making capacity [3]. Deforestation is rampaging the world causing global warming, climate change, desertification and loss of biodiversity [4]. A combination of convergence of environmental concerns and shortage constraints has led to an increase in non-wood fibre production for pulp and paper industry [5].

It is therefore important to search for alternative cellulose containing resources as raw material for paper making using environment friendly technology.The usage of non-wood fibre materials for pulp, paper and cellulose based is a way of reducing the deforestation and protection of the environment. The technology of renewed interest in non-wood fibre sources offers several advantages in the pulp and paper industry:

i. it offers a renewable source (annual) of raw material compared to the long growth cycles for wood;
ii. the lower lignin content in non-wood fibre implies that chemical pulping process will require relative environment friendly approach compared to the wood pulping; and
iii. non-woodfibre can be used in making every grade of paper and fibre-board and composite materials.

However, non-wood fibre sources have its own challenges which include:

i. seasonal availability;
ii. handling problem resulting from their high-volume-low-density; and
iii. large amount of dirt and earth materials (silica) which have to be removed during processing.

Banana fruit fiber can be an alternative raw material for paper making such as paper board, tissue, bloating, tracing and writing printing paper [6]. Banana plant (*Musa sp.*) is planted for its highly nutritious fruits [7] and is more easily digestible than many other fruits including apple [8]. Banana is a major fruit crop of the tropical and sub-tropical regions of the world grown on about 8.8million hectares [8]. Fiber is extracted from the leaf sheath or pseudostem of the banana plant and the use of "Banana" fiber for textile and other purpose as cheap natural material is a new concept. In the recent past, banana fibre had very limited applications and was primarily used for making items like ropes, mats and some other composite materials. With the increasing environmental awareness and growing importance of unfriendly fabrics, banana fibre has also been recognized for all its good qualities and now its application is increasing in other fields including garment making and home furnishings [9].

The physical morphological and chemical characteristics of different *musa*species were studied by [10]. In spite of the various uses of banana plants, large portion of its biomass are dumped as wastes on the farms and in the neighborhood causing environmental hazards and ecosystem imbalance. The extraction and utilization of banana fibers as a new technology for paper making is an effective and economic means of reducing this wasted biomass and reduce de-forestation activity resulting from papermaking industry. Therefore, the aim of the study was to extract pulp from banana cultivars, make paper from the extracted pulp and characterized the paper made from different banana samples.

2.0 Methodology

2.1 Sample collection

Three different banana cultivars: Banana (*Musa balbisiana*), Plantain (*Musa paradisiaca*) and Lady Finger Banana (*Musa acuminata*) pseudostem farm wastes were obtained from local farms in Ede area, along ido-Osun road of Osun State. The samples were washed with cleaned tap water and cleaned kitchen knife was use to split the each cultivar pseudostem into layers. The layers were thereafter sun dried for seven days and cut into smaller pieces in preparation for cooking as showed in Figure 1.

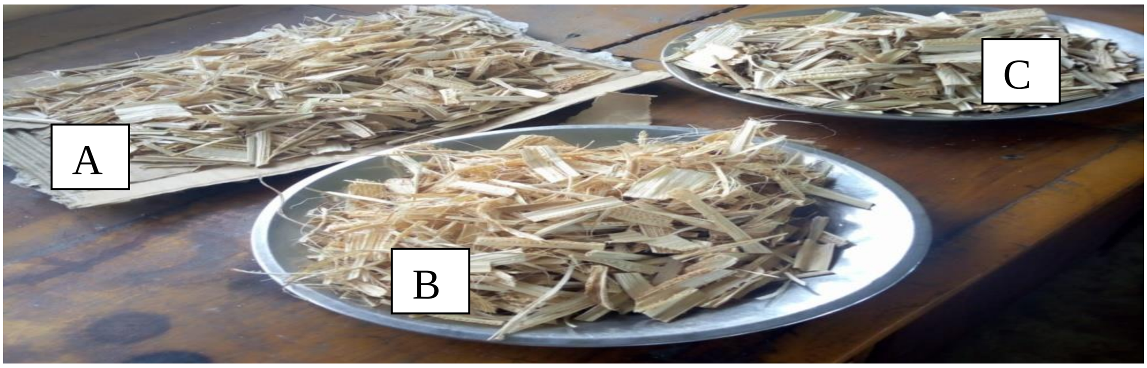

Figure 1: Dried Banana varieties pseudostem chips, A = Banana (*Musa balbisiana*), B = Plantain (*Musa paradisiaca*), C = Lady Finger Banana (*Musa acuminata*)

2.2 Pulp Extraction

The pulp was extracted through:

i. Cooking/Digesting: The dried fibre of each banana cultivar (50 g) was weighed into glass beakers and cooking liquor (500 ml) (12 % NaOH) was added (1:5) ratio and coked for 1 hour. The cooking liquor volume in the digester was maintained by adding hot water. The digested fibre (pulp) was rinsed with tap water till the mixture is neutral. The yield of pulp was gravimetrically determined after oven-dried [11].

ii. Pulping: The cooked fibers was soaked and thoroughly rinsed with water to remove the residual sodium hydroxide. The alkali-free fibre (when the drained water did not turn red litmus paper to blue) was then transferred into a blender and cool clean water was added. The blending was done until almost consistency solution was obtained. The blended solution was filtered using a muslin cloth. The pulp obtained was dried to a constant weight.

iii. Pulp bleaching: The pulp was bleached by soaking it in 2.5 % of chlorine water for 2 hours. Pulp bleaching is important to the production of quality paper. The bleach pulp was thereafter was rinsed free of chlorine.

Figure 2: (a) Wet pulps (b) Dried pulp

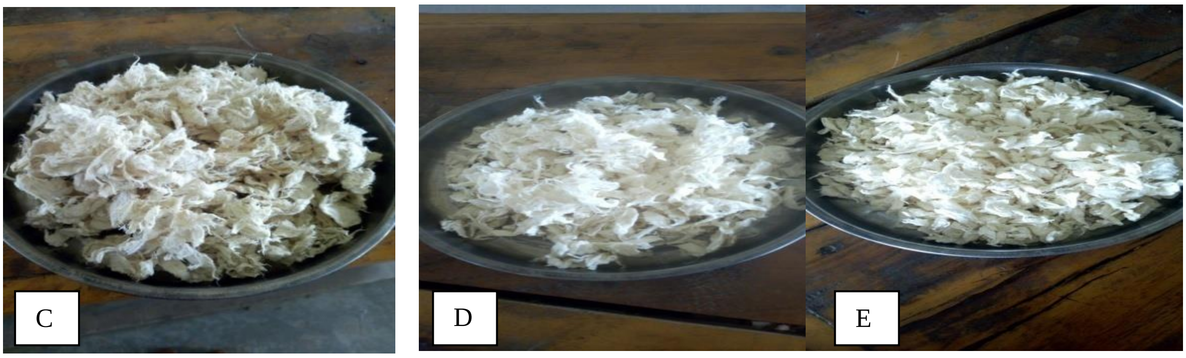

Figure 3: Bleached Pulp, C = Banana (*Musa balbisiana*), D = Plantain (*Musa paradisiaca*), E = Lady Finger Banana (*Musa acuminata*)

2.3 Paper sheet making

The bleached pulp (15 g) was weighed and blended (500 ml of water and 1% of Carboxymethyl cellulose (CMC) to separate fibers into consistency solution. The blend was poured into mold and deckle in a bowl filled with 2/3 water. Mold and deckle was removed from the bowl and it was allowed to drain completely before the deckle was removed [12].

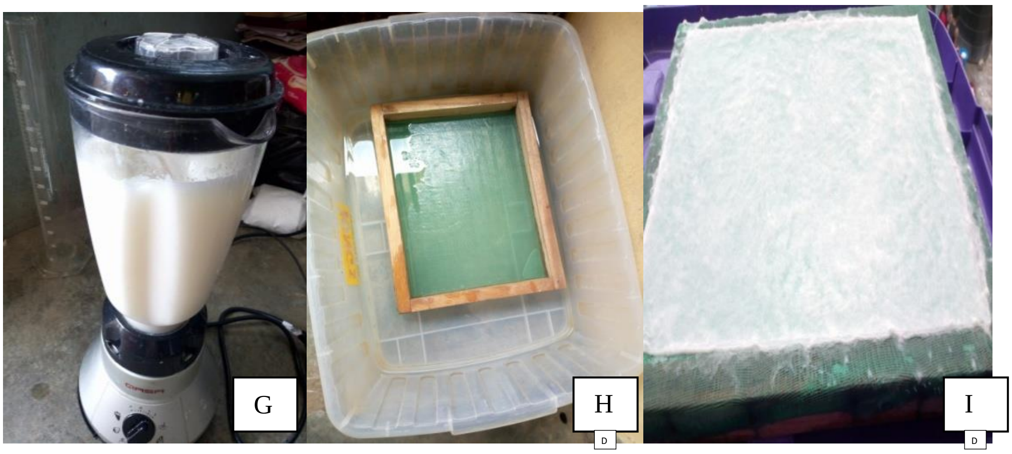

Figure 4: Sheet making process; G = Pulp blending, H = pulp pouring, I = Sheet draining

2.4 Paper and pulp characterization

i. Percentage pulp yield: The weight of different wet pulp was measured with the aid of analytical balance. The empty crucible was weighed as W_1. The pulp was transferred into the crucible and it was weighed as W_2, the sample was dried in oven at 60 ^{0}C for 1hour, cooled to room temperature in the desiccators and weighed. The crucible was returned into the oven for 30 minutes, cooling and weighing and this action was repeated until constant weight W_3 was obtained. The pulp yield was calculated using this formula:

Pulp yield = *W2-W3Banana chips used×100* $\frac{W2-W3}{\text{Banana chips used}} \times 100$

ii. Pulp FT-IR Characterization: Extracted and cleaned pulp from each banana cultivars was grinded into powdery form with mortar and pestle. Sieved pulp powder (0.5 g) was mixed with potassium bromide crystals (1% of sample concentration)and pressed into an IR disc. The formed disc was inserted into FTIR machine for analysis.

iii. Paper strength: The paper was hold with two retort stands and incremental weights were put on the retort-held paper and allowed to stand for five minutes before the weight increase. The weight held by the paper before tear is taken as the strength of the paper. The experiment was performed in triplicates for each paper type.

iv Folding Endurance:

Different papers was folded backward and forward about the same line in a complete oscillation, the number of double folds that is required to make a paper break was use to determine the paper folding endurance under a standard weight.

F = Log_{10}d $F = \text{Log } 10d$

v. Smoothness: Different sheet of paper was run through a fingers, the smoothness of each paper was noted.

3.0 Results

Different banana cultivars was processed into fibre, pulp was extracted, bleached and used to produce paper shown in the Figure 5. The paper sheets produced from the extracted pulp from the banana variety were subjected to mechanical tests. Out of the three paper types produced, Lady Finger paper has the highest paper strength and folding endurance with 20 g/mm^2 and 1.68 respectively as shown in Figure (5) which implied that Lady Finger banana paper has highest durability and strength than the other paper types.

Figure 5: Different paper produced: A = Banana (*Musa balbisiana*), B = Plantain (*Musa paradisiaca*), C = Lady Finger Banana (*Musa acuminata*)

The functional groups present in the pulp samples were determined in order to estimate their chemical compositions. The FT-IR spectra of the three pulp types; Banana (*Musa balbisiana*), Plantain (*Musa paradisiaca*), Lady Finger Banana (*Musa acuminata*)banana, plantain and Lady are shown in Figure (6).

The chemical composition is shown in Table 1. Lady Finger paper showed different functional groups which are identified as hydroxyl (3352 -3437), Amide (1630-1631), Carboxylate (1317-1371) $cm^{-1}$and Transition metal of carbonyl group (2009-2044) cm^{-1}. The hydroxyl group has the highest absorbance of all the functional groups present in the three pulp types (57.5, 34.5 & 37) followed by carboxylate (37.5, 16.5 & 16) cm^{-1}, Amide (21, 17 & 16) cm^{-1} and Transition metal carbonyl (5, 5 & 6) cm^{-1}.

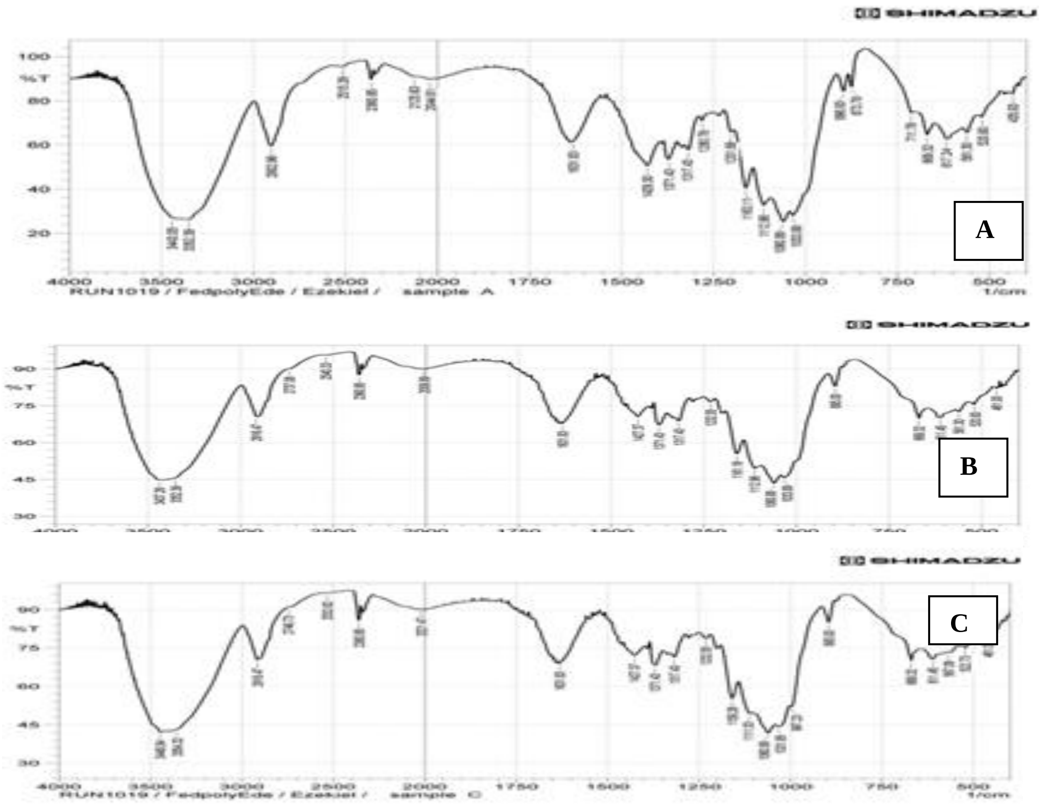

Figure 6:FT-IR Spectra of Banana Species Pseudostem Pulp: A = Plantain pulp, B = Banana pulp, C = Lady Finger pulp.

Table 1: FT-IR Functional group frequency bands of Banana pulps

% Transmittance	Functional group	Sample Peak band	Peak Type
3352-3437	Hydroxyl	A = 57.5	Strong
		B = 34.5	
		C =37	
1317 -1371	Carboxylate	A = 37.5	Weak
		B = 16.5	
		C = 16	
1630-1631	Amide	A = 21	Strong
		B = 17	
		C =16	
2009-2044	Transition metal carbonyl	A = 5	Weak
		B =5	
		C =6	

Conclusion

The banana pseudostem, a waste material has been converted into valuable product such as pulp and paper using a sustainable technology with little impact on the environment. The raw material for this valuable product is readily available and the production involved the use of simple dilute sodium hydroxide solution and apparatus. Paper manufacturing from banana pseudostem using this simple and affordable technology can will increase the wealth of banana farmers and reduce deforestation.

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