European Scientific Journal October 2015 edition vol.11, No.30 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431

SUITABILITY OF NIGERIAN CORN HUSK AND PLANTAIN STALK FOR PULP AND PAPER PRODUCTION

Aremu, M. O.
Aperolola, S. O.
Dabonyan, O. O.
Biochemical Engineering and Biotechnology Laboratory, Department of Chemical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Abstract

Wood is a prominent raw material in the production of pulp and paper, but due to the impact of forest depletion on the environment worldwide, research is being focused on non-wood sources as alternative sources of fibre and as a solution to destruction of the environment. The aim of this study therefore, is to investigate the suitability or otherwise of corn husk and plantain stalk which are abundant agro-waste materials in Nigerian environment in pulp and paper production. The pulping of corn husk and plantain stalk was achieved through Chemical Pulping process (Soda pulping) and the pulps obtained were analyzed for their chemical compositions. Also, the scanning electron microscopy (SEM) was used to analyze the surface morphological structure of the pulps produced. The resulting pulps were then used for papermaking and the Mechanical strength of papers obtained was determined. The results of chemical composition analysis for the pulp obtained from corn husk were (3.57%, 41.23%, 10%, 12.04% and 23.00 %) while that of plantain stalk were (11.19%, 57.86%, 10%, 4.60% and 35.96%) for Ash content, Cellulose content, Moisture content, Lignin content and Pulp yield respectively. The result of Mechanical strength analysis of the paper produced are (66.04 g/m^2, 0.30 mm,5.33 Nm/g,12.83Nm^2/g,0.13 N/mm^2,2.7 mm) from corn husk while that of plantain stalk are (30.99 g/m^2,0.08 mm,1.25 Nm/g,5.20Nm^2/g,2.95 N/mm^2,2.20 mm) for Grammage, Thickness, Tensile index, Tear index, Modulus of Elasticity and Elongation at break respectively. The SEM images analysis showed that there is a more condensed and packed arrangement of fibre in corn husk than plantain stalk. The overall results showed that Corn

husk and Plantain stalk have a promising potential as alternative source of fibre in paper making industry.

Keywords: Corn husk, Plantain stalk, Soda pulping, Chemical composition, Pulp yield, Fibre

Introduction

The word paper is derived from the name of the reedy plant papyrus, which grows abundantly along the Nile River in Egypt. Pulp is a ligno-cellulosic fibrous material prepared by chemically or mechanically separating cellulose fibres from wood, fiber crops or waste paper. The world's forests are being depleted for the production of paper products. Each year over 4 billion or 35% of the world's trees are felled and used in the production of paper products (Tor, 2013). The world consumption of paper has grown four hundred percent in the last forty years. Nearly four million trees or thirty five percent of the total trees fell around the world are used by paper industries on every continent (Canada, 2014). Paper, an important writing material in education is mainly from trees. More people are realizing that the Earth is getting depleted from its natural resources. As this issue becomes a crucial one, alternative fibres from non-wood sources will provide a good solution to hunting the destruction of the environment. There is an abundance of non-wood fibers potentially available for the paper industry. Non-wood fibers have been used in many countries like China, India, Spain, Italy, Turkey, Denmark and Romania (Hurter, 1998).Several agricultural food crop residues including rice husk, corn straw, okra stalks, corn stalk, plantain stalk, pineapple leaf and corn husks which do not have immediate beneficial applications in many communities have been proposed to be potential sources of pulp (Rymsza, 2007). Since all these plant materials contain cellulose in form of fibres, they stand to be potential sources for pulp with lesser environmental degradation threat than wood which is traditionally the most widely used ligno-cellulosic material in the production of pulp, furniture and boards of diverse types, as well as being a source of energy (Ekhuemelo and Tor, 2013). Non-wood plants offer several advantages including short growth cycles, moderate irrigation and fertilization requirements and low lignin content to alleviate energy and chemicals used during pulping (Taiwo, 2014).The present study therefore aims at investigating the paper-making potential from corn husk and plantain stalk through the determination of their fibre morphology, chemical composition as well as the strength of paper sheets produced from the corn husk and plantain stalk.

Methodology

Materials

Fresh samples of Corn husk and Plantain stalk were collected from various local corn processing stations and markets around Oshodi, Lagos, Nigeria.

Methods

The raw materials were air-dried in the laboratory and thereafter chipped into small sizes using cutting tools, such as knife and scissors. Parts of the dried sample were grinded using the Jar Mill Machine and size selection was done using a sieve of mesh size 0.4 mm. The samples were stored for further analyses. Chemical composition (Moisture, Lignin, Ash and Cellulose contents) of corn husk and plantain stalk was determined according to Technical Association of the Pulp and Paper Industry (TAPPI) Standard Test Methods (Wise, *et al*., 1946; Dutt *et al*., 2009). Prior to this determination, the corn husk and the plantain stalk meal were subjected to ethanolic extraction for about 6 hrs using the Soxhlet Apparatus. This was done to remove the extractives content of the samples which may interfere with the chemical composition determination. Pulping of corn husk and the plantain stalk was achieved using chemical pulping method (Soda Pulping). 200 g of the raw materials (Oven-dry weight) was loaded into a 1000 ml conical flask which was then placed in a pressure pot containing sufficient amount of water and 600 ml of 7% sodium hydroxide solution was poured into the conical flask. Pulping lasted for about 3 hours at 110^{o}C. A weighed amount of dried pulp was loaded into a beaker and measured amount of Hydrogen peroxide ($H_2O_{2)}$ was added. The mixtures were then heated on a hot plate for about 20mins after which it was observed that the colour of the pulp had changed from brown to off-white. The pulp obtained was thoroughly washed under running water to remove the residual chemicals still present. Pulp samples were thereafter oven-dried. The Pulp samples were then de-fiberized in a laboratory steel blender for 5 mins and the screening was done by sieving through a screen. Paper sheets were produced from the bleached pulp using a handmade paper mould and deckle. The paper mould with the fibres was then air dried for about 3 hours in an oven**.** After drying, the paper samples were then pressed with an electric hot iron to improve the smoothness of the paper.

Paper Characterization

Paper characterization was done using a Universal Testometric Machine to determine the grammage, tensile strength, tear index, thickness, modulus of elasticity and elongation at break.

Paper Surface Morphology

The produced paper sheets were observed under Scanning Electron Microscope (SEM) to study its fibre morphological properties. Images were taken under several magnifications to observe the content, arrangement and compactness.

Results and Discussion

Results

The result obtained for Pulp yield, Moisture, Ash, Lignin and Cellulose content is shown in Table 1.0 below for each of the tested agro waste. The result of Mechanical strength analysis carried out on the handmade paper from corn husk and plantain stalk are presented in Table 2.0.

Table 1.0/: Chemical Composition of Corn Husk and Plantain Stalk.

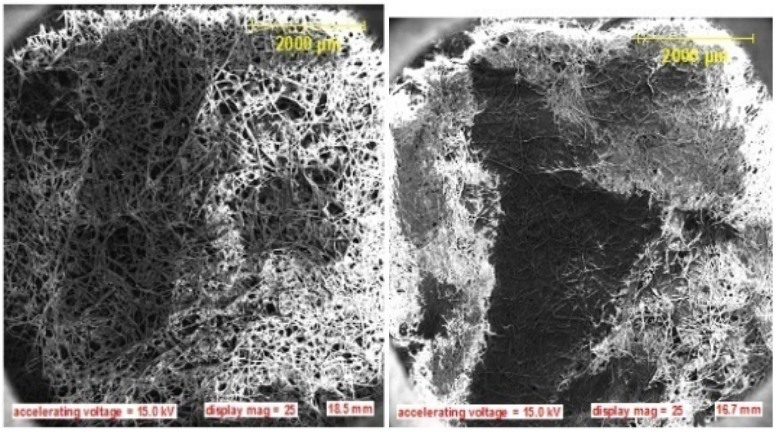
Agro-Waste	Pulp Yield (%)	Cellulose content (%)	Ash content (%)	Lignin content (%)	Moisture content (%)
Corn Husk	23.00	41.23	3.57	12.04	10
Plantain Stalk	35.96	57.86	11.19	4.60	5

Table 2.0: Mechanical Strength properties of paper sheets produced from the pulp of Corn Husk and Plantain Stalk.

Properties	Corn husk	Plantain stalk
Grammage(g/m^2)	66.04	30.99
Thickness (mm)	0.30	0.08
Tensile Index(Nm/g)	5.33	1.25
Tear Index (Nm^2/g)	12.83	5.20
Modulus of Elasticity (N/mm^2)	0.13	2.95
Elongation at break (mm)	2.70	2.20

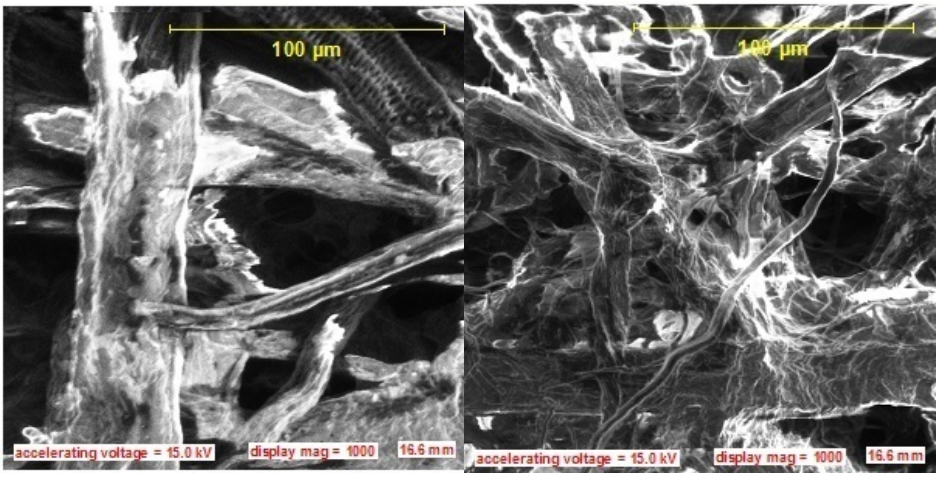
Surface Morphology Analysis

Scanning Electron Microscopy (SEM) analyses of the Front view of the papers produced from Corn husk and Plantain stalk are shown below:



A B

Plate 1 – SEM cross-section images of (A) Corn husk (B) Plantain stalk (Magnification 25x)



A B

Plate 2 – SEM images of (A) Corn husk and (B) Plantain stalk (Magnification 1000x)

Discussion of Result

The results of chemical compositions analysis of the tested Agro-wastes are listed in Table 1.0. Results indicate that these raw materials have a high potential for use as alternative fibres for pulp and paper making.

Corn husk fibre was found to have lower ash content (3.57%) than Plantain stalk (11.19%). The amount of ash content is a function of the absence or presence of other materials (various chemicals, metallic and mineral matters). Lower ash content indicates that good quality paper will be produced from the pulp. Plantain stalk has the higher value of pulp yield (35.96%) than Corn husk (23.5%) which can be as a result of the cellulose content of its fibre. This is because Plantain stalk was found to have higher cellulose content (57.86%) than Corn husk (41.23%). Cellulose is the component that makes the fiber content of non-wood materials to be stronger which can also determine the quality of pulp and paper that will be produced. Plantain stalk has the lowest value of lignin content (4.60%) than Corn husk (12.04%). Lower lignin content makes the fibre strength greater and difficult to break. Therefore, the paper produced will be of greater quality.

Based on the results of mechanical strength test on the conventional handsheet papers produced from the pulps obtained from corn husk and plantain stalk which include tests for Tensile strength, Tear index, Grammage, Thickness, Elongation at break and Modulus of Elasticity listed in Table 2.0. The results show that corn husk and plantain stalk could be considered as promising raw materials for papermaking applications. However, it must be noted that residual lignin, impurities, pulp consistency, degree of pulp beating, relative humidity of the environment are few of the factors that could influence the properties of paper sheets produce from any

pulp. The dimensions and strength of the individual fibres, their arrangement, and the extent to which they are bonded to each other are all important factors contributing to the test results.

Surface Morphology Analysis

This analysis reveals the structure and shape of the fibre bundles inside the two agro-materials tested. From SEM image with magnification of 25x, it was observed that Plantain stalk has the smoothness surface than Corn husk. From magnification 1000x, it was noted that Corn husk has the highest fibre matrix bundle than Plantain stalk. The strength of the fibre can be understood based on the arrangement and packing of the fibre matrix. The structure of the plantain stalk is also a closely packed arrangement. The thicker fibre could yield a stronger fibre bundle and hence indicate a higher strength for paper produced. Inevitably, the less dense arrangement and loose packing could make the paper produced become low in strength and quality. The compactness and arrangement of fibres contribute to the quality structure of the paper produced beside the other factors such as cellulose content in the pulp and paper produced. The observed chemical composition and morphology of these two agro-wastes indicate their suitability for use as fibre sources for the paper industry.

Conclusion

From this study, the chemical composition analysis show that Plantain stalk has a quite high cellulose content and low lignin content than corn husk which could give a high quality of pulp for paper making. Besides that, scanning electron microscopy (SEM) analysis shows that there is a condensed and packed arrangement of fibre in corn husk and plantain stalk. The overall result showed that corn husk and plantain stalk has a promising potential as alternative fibre in paper making industry. This practice will substantially assist the nation in eliminating the current importation dependence of the paper industry to a reasonable extent.

Acknowledgement

The Authors are grateful to the management of FIIRO (Federal Institute of Industrial Research Oshodi, Lagos, Nigeria) for allowing the usage of their laboratory equipments for analysis of this work.

References:

Canada, E. (2014). Pulp and Paper. Retrieved from Government of Canada

Dutt D., Upadhyay J. S., Bahadur S., Tyagi, C. H. (2009). Studies on *Hibiscus cannabinus* and *Hibiscus sabdariffa a*s an alternative pulp blend for

softwood: An optimization of kraft delignification process. *Industrial crops and products. 29:16–26.*
Ekhuemelo D.O., Tor, K. (2013). Assessment of fibre characteristics and suitability of maize husk and stalk for pulp and paper production. *Journal of Research in Forestry, Wildlife and Environment. 4(2): 20 – 25.*
Hurter R. W., Riccio F. A. (1998). Why CEOS don't want to hear about non woods- or should they? In: Tappi Proceedings, A Non wood fibres symposium, Atlanta GA, USA, Pg 1 – 11.
Rysma A. T. (2007.) Agricultural residues in pulp and paper; A discussion paper. Retrieved from www.visionpaper.com
Taiwo K. F., Fagbemi O. O., Otitoju O., Mgbachiuzor E., Igwe C. C. (2014). Pulp and paper making potential of corn husk. *International Journal of AgriScience 4(4): 209-213.*
Wise L. E., Murphy M., Addieco A. D. (1946). Chlorite holocellulose; its fractionation and bearing on summative wood analysis and studies on the hemicelluloses. *Paper Trade Journal 122 (2): 35–43.*