ASSESSMENT OF FIBRE CHARACTERISTICS AND SUITABILITY OF MAIZE HUSK AND STALK FOR PULP AND PAPER PRODUCTION

***Ekhuemelo D.O. and Tor K.**

Department of Forest Production and Products,

University of Agriculture Makurdi, Benue State.

***E-mail:** doekhuemelo@yahoo.com

ABSTRACT

Maize husk and stalk were assessed for their fibre characteristics and suitability for pulp and paper production. Fifteen (15) fibres were randomly selected and measured from each representative sample. It was observed that fibre length of maize husk was 1.37mm and that of maize stalk was 1.52mm. The fibre diameter (D) was 30.19 µm for each of the samples. The values of cell wall thickness and lumen width (d) for each sample were 8.82 µm and 13.67 µm respectively. Runkel ratio for maize husk and maize stalks was 1.23 each. This implies that they are feasible for pulp and paper production. The felting rate (slenderness ratio) was 45.93 for maize husk and 50.34 for maize stalk. The elasticity coefficient was 45.30% for maize husk and maize stalk and rigidity coefficients for maize husk and maize stalk was 29.21%. T-test showed that fibre length of maize husk and maize stalk were not significantly different.

Key Words: Maize, husk, stalk, pulp, and fibre length.

INTRODUCTION

Paper is one of the most fundamental things that is widely used by many people across the globe. 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. The world paper consumption was 300 million tons in 1996/1997 and is expected to rise above 400 million tons by the year 2010 (Hurter, 1998).

Paper, an important material in education is mainly from trees. 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 (Sam, 2011). More people are realizing that the Earth is getting depleted from its natural resources.

When paper made from trees goes into landfills, it produces methane which is a green-house gas and is very harmful to the environment (Sam, 2011). Wood has traditionally been the most widely used lignocellulosic matter in the production of pulp, furniture and boards of diverse types, as well as being a source of energy. The increasing demand for these raw materials, together with economic and environmental factors, makes it necessary to research alternative sources of lignocellulosic matter (Majid *et. al*, 2011). In recent times in many developing contries, there has been an upsurge in the establishment of domestic paper mills all in a bid to become self-sufficient in paper production (Fatehi *et al.* 2009)

In view of the shortage of conventional raw materials for pulping and the increasing demand for paper products worldwide; non-wood plants and agricultural residues have attracted renewed interest, especially in Mediterranean countries like Spain, Italy and Greece with insufficient forest resources (Hurter, 1988).

The objective of the study is to examine the physical properties of maize husk and stalk fibre and determine their suitability in pulp and paper production as alternative to the use of conventional wood in paper production.

MATERIAL AND METHODS

Study Area

The study was conducted at the Federal University of Agriculture, Makurdi, Benue State. Benue State is generally regarded as the "Food Basket" of Nigeria because the ecology of the State supports extensive arable cropping and livestock production as well as fruit, palm, grains, legumes, root and tuber production. Benue State falls within the coordinates 7^o 47' and 10^o 00' East, 6^o 25' and 8^o 8' North (UAM website, 2009).

The pulping process was done at the Department of Forest Production and Products' laboratory. The determination of fibre characteristics was carried out at Forest

Research Institute of Nigeria (FRIN), Ibadan, Oyo state.

MATERIALS

The materials used in this study included the following: maize husk, maize stalk, rain water, lye (potassium hydroxide), perforated clay pot, stand, grinding machine and miller, bucket, wood ash, fire wood and cutlass.

Potassium Hydroxide Production

A clay pot perforated underneath was suspended by a tripod stand. A layer of gravel was used to cover the holes at the bottom of the pot, and then a layer of straw was added on top of the gravel. The pot was filled with 10kg of wood ash and 15 liters of water poured into it. The preparation was left overnight and a plastic bucket was set under the stand to collect the potassium hydroxide.

Determination of Fibre Characteristics

Samples of maize stalk and husk were prepared into slivers of 40mm × 3mm x 3mm and put in test tubes for maceration in equal volume of glacial acetic acid (ethanoic acid) and hydrogen peroxide (1:1). The solution was put in the oven for 4 hours at temperature of about 100^0C for maceration. Random samples of macerated fibres were mounted on slides and examined under a light microscope. Fibres were viewed and measured using a stage micrometer under × 80 magnification. Fifteen (15) fibres were selected from each representative sample and the fibre length (L), fibre diameter (D), Lumen width (d) and cell wall thickness were measured.

The following morphological indices (derived values) were also determined as follows according (Kırcı, 2006).

i. **Felting rate** (Slenderness)**:** Fibre length ÷ Fibre diameter
ii. **Elasticity coefficient (%):** Lumen diameter ÷ Fibre diameter×100
iii. **Rigidity coefficient (%):** Cell wall thickness ÷ Fibre diameter ×100
iv. **Runkel ratio:** Cell wall thickness ×2 ÷ Lumen Diameter.

Statistical Analysis

Statistical Package for Social Science (SPSS) was used to calculate T-test used for comparison of means of the fibre length of maize husk and stalk.

RESULTS

Table 1 showed the physical characteristics of maize stalk and husk fibres. It was observed that fibre length of maize husk was 1.37mm and that of maize stalk was 1.52mm. The fibre diameter (D) was 30.19 µm for each of the samples. The values of cell wall thickness and lumen width (d) were 8.82 µm and 13.67 µm respectively.

Table1: Physical Properties of Maize Husk and Stalk fibres

Samples	Sample Number	Fibre Length (mm)	Fibre Diameter (µm)	Cell wall Thickness (µm)	Lumen Width (µm)
Maize Husk	15	1.37	30.19	8.82	13.67
Maize Stalk	15	1.52	30.19	8.82	13.67

Source: FUAM Forestry Laboratory, 2013.

Table 2 shows the fibre preparation and pulp making records of the experiment. The weight of the dried pulp produced from each sample was 0.7 Kg. The volume of water used for washing and soaking each of the samples was 15 litres. Maize husk sample took longer time to boil (71mins) for about than maize stalk (67mins).

Table 2: Fibre Preparation and Pulp Making Record

Samples	Weight of Sample (Kg)	Quantity of Water used in Litre	Quantity of Lye (KOH) used for Boiling Litre	Duration of Boiling (Mins)
Maize Husk	0.7	15	4	71
Maize Stalk	0.7	15	4	67

Source: UAM Forestry Laboratory, 2013.

Table 3: Derived Fibre Dimensional Values (indices) of Maize Husk and Maze stalk

Material	Runkel Ratio $\frac{2w}{L}$	Felting Rate	Elasticity Coefficient (%)	Rigidity Coefficient (%)
Maize Stalk	1.23	50.34	45.30	29.21
Maize Husk	1.23	45.93	45.30	29.21

The result in Table 3 showed that the Runkel ratios for maize husk and maize stalk were 1.23 each. Also in table 3, the felting rate (slenderness ratio) was 45.9 for maize husk and 50.34 for maize stalk. The values of rigidity coefficient for maize husk and maize stalk in Table 3 was 29.21 % each. Table 4 showed T-test for fibre length of maize husk and maize stalk.

Table 4: T – test for Fibre Length of Maize Husk and Maize stalk.

Paired Samples (mm)	Sample Mean ± SE	Paired Mean Difference ± SE	df	Correlation Value	T-value	Probability (2-tailed)
Fibre Length of Maize Husk	1.39±0.069	-0.130 ± 0.082	14	0.276	-1.623	0.13
Fibre Length of Maize Stalk	1.52 ± 0.068					

± Standard Deviation

*** Significant at P ≤ 0.01 ** Significant at p ≤ 0.05 * Significant at p ≤ 0.10

DISCUSSION

The result of this work showed that the fibre length of maize husk and stalk fall within the fibre length of most hardwood and non-wood materials (Encyclopaedia Britannica, 2012). Fibre length influences the physical and mechanical properties of the plant material is often associated with its toughness, workability and durability (Parameswaran and Liese 1976, Espiloy, 1987). Consequently, the toughness, workability and durability of pulp made from both samples in this work are expected to be closely related. The T-test of showed that there is no significant difference between the fibre length of maize husk and maize stalk.

The variation in the time taken for each samples to boil was due the irregular atmospheric condition at the time of boiling. The intermittent harmattan wind observed during boiling could have affected the boiling time.

According to Eroglu, (1980), when Runkel ratio or Runkel's proportion is greater 1, it is assessed as fibre having thick wall and cellulose obtained from this type of fibres is least suitable for paper production. When Runkel ratio is equal to 1, cell wall has medium thickness and cellulose obtained from this type of fibre is suitable for paper production. When the rate is less than 1, cell wall is thin and cellulose obtained from these fibres is most suitable for paper making. Therefore, the Runkel ratios for maize husk and a maize stalk of 1.23 implies that they are not suitable for paper production.

Generally, the acceptable value for felting rate of papermaking is 33 and above (Xu, *et al.,* 2006). Therefore, the felting ratio of maize husk and maize stalks in this study fall within the felting ratio value required for paper making. Elasticity Coefficient (flexibility ratio) are classified into four groups of fibers (Bektas, *et al.,* 1999: (1) High elastic fibers having elasticity coefficient greater than 75. (2) Elastic fibers having elasticity ratio between 50-75. (3) Rigid fibers having elasticity ratio between, 30-50. (4) Highly rigid fibers having elasticity ratio less than 30. According to this classification, the flexibility coefficient of maize husk and maize stalk were 45.30% respectively thus making them to belong to the rigid fiber group. Because rigid fibres do not have efficient elasticity, they are not suitable for paper production and they are used more on fibre plate, rigid cardboard production (Akgul and Tozluoglu, 2009).

High rate of rigidity coefficient negatively affect tensile, tear, burst, and double fold resistance of paper negatively. According to the study by Hus, *et al.,* (1975), rigidity coefficient of juvenile beech wood was 25.85; black pine juvenile wood fibre was 13.30, 27.66 for eucalyptus and 19.97 for softwood, *Pinus syvestries* (Akkayan, 1983). In this study, the rigidity coefficient of maize husk and maize stalk is 29.21. This implies that paper made from these samples would have less tensile, tear, burst, and double fold resistance compared with previous work by Akkayan, (1983).

CONCLUSION

The increasing demands for paper and environmental concerns have increased the need for non-wood pulp as a low-cost raw material for papermaking. This has also led to the developing of alternative pulping technologies that are environmentally friendly. The result of this study showed that although there are no significant difference between the physical properties of maize husk and stalk, other fibre characteristics revealed that they are fairly suitable as alternative to pulp and paper production.

REFERENCES

Akgul, M., and Tozluoglu, A. (2009). Some Chemical and Morphological Properties of Juvenile Woods from Beech (*Fagus orientalis* L.) and Pine (*Pinus nigra* A.) Plantation. *Trends in Apply Science Reseach, 4(2): 116-125. Academic Journal Inc.*

Akkayan, S.C., (1983). Researches on cellulose mixture obtained from *Pinus seyvestrie, Pinus brutia* and *Orienta Beech (F. Orientalis).*

Bektas I, Tutus A, Eroglu H (1999). A Study of The Suitability of Calabrian Pine (*Pinus brutia* Ten.) For Pulp and Paper Manufacture. *Turk. J. Agric. For. 23(3): 589-597*.

Encyclopaedia Britannica, (2012). Corn (*Zea mays*). Encyclopaedia Britannica Library, Encyclopædia Britannica Ultimate Reference Suite. Chicago.

Eroglu, H. (1980). Investigating possibilities of obtaining wood pulp from wheat straw by O_2-naoch method. Ph.D Thesis, Karadeniz Technical University.

Espiloy, Z. B.(1987). Physico-mechanical properties and anatomical structure relationships of some Philippines bamboos.

Recent Research on Bamboos. Proceedings of the International Bamboo Workshop. October 6-14, 185. Hangzhou, China.

Fatehi, P.S., Ates and Ni, Y. (2009). Fungal pre-treatment of wheat straw and its effect on the soda-AQ pulps. Nord. Pulp Pap. *Res. J. 24: 219 – 224.*

Hurter, A.M. (1988). Utilization of annual plants and agricultural residues for the production of pulp and paper. Proceedings of TAPPI piulping conference. New Orleans, LA, USA, Book1. TAPPI Press ,Atlanta, GA, p.139–160.

Hus, S., Tank, T. and Gosksal, (1975). Considering Eucalyptus (E. Camadulensis Dhnh) wood which grow in Turkey (in Tarsus-Karabacak). Morphology and opportunity for evaluating semi chemical cellulose in paper industry. Tubitak publication, USA.

Kırcı, H., (2006). Pulping Industry. KTU Faculty of Forest Press, No: 86,Trabzon

Majid Kiaei, Ahmad Samariha and Jafar Ebrahimpour Kasmani 2011). Characterization of biometry and the chemical and morphological properties of fibers from bagasse, corn,sunflower, rice and rapeseed residues in Iran. *African Journal of Agricultural Research Vol. 6(16), pp. 3762-3767.* *www.academicjournals.org/AJAR*

Parameswaran and Liese (1976). On the fin structure of bamboo fibres. *Wood Science and Technology 10: 231 – 246.*

Sam Martin (2011). Paper chase. *http://www.ecology.com/2011/09/10/paper-chase/* (Assessed, 2013).

UAM website, (2009). *http://uniagricmakurdi.mycportal.com/web/?about* (Assessed, 2013).

Xu, F., Zhong,X.C., Sun, R.C. and Lu, Q. (2006). Anatomical, structure and lignin distribution in cell wall of Caragana korshinskii. *Industrial Crops and Products, 24: 186-193.*