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Strength Properties of Paper from Pulp Blend of Kenaf Bark and Corn Husk: A Preliminary Study

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Authors' contributions

This study is a product of the conscientious efforts and contributions of all the Authors. Author ODF designed the study, carried out the pulping experiment, bleaching studies, handsheet preparation, strength properties testing and manuscript preparation with active involvement of author TKF under the supervision of authors EM and CCI. Data analysis was done by authors TKF and OO. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

This study investigates the strength properties of paper samples obtained from pulp blend of corn husk and kenaf bark. Soda pulping of kenaf bark and corn husk was carried out using 18% and 7% alkali respectively. Handmade paper sheets were produced from bleached pulp samples combined in ratios 50% - 50%, 75% - 25% and 25% - 75%. Using a universal testometric machine, strength properties of the papers such as modulus of elasticity, tensile index and tear index were assessed. Results showed that, paper sample from 100% kenaf bark has the highest tear index (20.72 $mN.m^2/g$) and tensile index (7.79 Nm/g), while paper sample from mixture of Kenaf bark and Corn husk (75% - 25%) possess highest modulus of elasticity (42.05 N/mm^2). Lowest tensile index (2.77 Nm/g) and modulus of elasticity (12.42 N/mm^2) values were observed for paper sample from 100% corn husk. Depending on targeted end use, papers of differing strength properties can be obtained from the combination of kenaf bark and corn husk.

Keywords: Agro-waste; corn husk; kenaf bark; paper; pulp; fibre.

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1. INTRODUCTION

The ever-growing world demand for paper and paperboard is expected to reach an estimated 490 million tonnes by 2020 [1]. This coupled with intense competition for resources between corporations and countries around the world means that alternative fibre sources such as non-wood plants and agro-wastes are needed. Non-wood fibres for papermaking can be extracted from non-woody cellulosic plant materials, most of which are annual plants which develop full fibre potential in one growing season. Many fast growing annual and perennial plants such as straws, bagasse, bamboo, hemp, kenaf, jute, sisal, abaca, cotton linters, reeds have so far been identified, cultivated and studied for their suitability for pulp and paper manufacture [2]. These non-wood fibers have tremendous variations in chemical and physical properties. Of particular importance for pulping are fibre length, lignin content and cellulose content [3].

With sufficient cellulose content and relatively good fibre properties, Kenaf (*Hibiscus cannabinus*) and corn husk (*Zea mays*) have been extensively studied and reported to be veritable sources of suitable fibres for papermaking [4,5,6,7,8,9,10]. Corn husk, like several other raw materials suitable for paper making, is exclusively short fibered with an average fiber length <2mm. It is well known that several properties of the paper produced from short fibered pulp are of inferior quality [11]. On the other hand, pulps from kenaf have desirable properties for papermaking and generally possess strength characteristics compatible to commercial coniferous wood pulps [12,13]. Particularly, pulps prepared from the bark fraction with long fibres compares favourably with softwood pulps in their general papermaking whereas those from the woody fractions are more like hardwood pulps but drain more slowly and have lower tearing strength [14].

Paper and paper board testing is important to the pulp and paper industry because of the demands placed upon it for a wide range of applications. To meet this increasing demand and competition, paper makers have continually developed and improve their products vis-à-vis strength properties. However, to achieve this, pulp blending plays an important role. Although, understanding the mechanical properties of paper in fundamental terms is a difficult task, it remains an area of intense study in many laboratories around the world [15]. This study presents a preliminary investigation into the strength properties of papers from pulp blend of kenaf bark and corn husk. It assesses the variation in strength properties of papers from different pulp blend ratio.

2. MATERIALS AND METHODS

2.1 Materials

Fresh samples of corn husk were collected from local corn processing station within the vicinity of the Institute while samples of kenaf were collected from the Institute of Agricultural Research and Training (IAR&T), Ibadan, South West Nigeria.

2.2 Pulping Process

Isolation of fibres from air-dried and manually chopped kenaf bark and corn husk was achieved through the soda pulping process in a 5L conventional autoclave. After pulping, the cooked materials were thoroughly washed with water to remove residual cooking liquor and defiberized in a laboratory disintegrator. Defiberized materials were passed through a standard size 1 mm x 1 mm netted sieve in order to remove materials not well cooked. The screened pulp was washed, pressed, drained and allowed to dry to a moisture content of

10% at room temperature. Pulp samples were thereafter bleached in a mixture of hydrogen peroxide and acetic acid (2:1). Kappa numbers of bleached pulp samples were determined according to TAPPI T236 om-99 standard procedure. Table 1 highlights the pulping parameters and pulp characteristic.

Table 1. Pulping parameters and pulp characteristic

	Kenaf bark	Corn husk
Soda concentration (%)	18	7
Liquor: sample ratio	5 : 1	6 : 1
Temperature (ºC)	121	121
Pressure (atm)	4.08	4.08
Gas down period (min)	20	20
Time of pulping (min)	105	105
Kappa number	30.0	11.9

2.3 Preparation and Testing of Laboratory Paper Sheets

Pulps of corn husk and kenaf bark (3% consistency) were blended together in ratios, 50% - 50%, 75% -25% and 25% - 75% respectively in the presence of 0.1% soluble starch and 0.1% kaolin. Slurry of pulp, starch and kaolin was prepared and handmade paper sheets were obtained by spreading the slurry on a laboratory sheet former. The paper samples were couched and then allowed to dry for about 24 hours. Measurement of strength properties of handmade paper samples such as modulus of elasticity, tensile stiffness, elongation at break, tensile strength, and tear strength (BS 3424 test method) was done by testing of paper strips using the universal testometric machine (M500 – 25 KN. DBBMTCC – 250kg, Rochdale, England) according to TAPPI T 220 and T404 standard procedures. These values were used to obtain the tear index and tensile index of the various paper samples as highlighted in TAPPI T 414 procedural standard.

3. RESULTS AND DISCUSSION

3.1 Strength Properties of Paper

Mechanical and strength properties are important in papers for printing, packaging papers, boards and other uses. Blending of long fibered pulp with short fibred pulp is one of the important aspects in this regard [16] because this is expected to have attendant effect on the quality of paper produced from both materials [17]. Papers made with long fibers generally have higher tensile strength properties than paper made of short fibers. Because short fibers are obviously easier to pull out than long fibers, papers made of long fibers also show much better tearing resistance than those made with short fibers [18]. As shown in the result presented in Table 2, there exists a clear distinction in the strength properties of paper from kenaf bark and corn husk. The tensile index, and tear index of paper from 100% kenaf bark were 7.79 Nm/g and 20.72 $mN.m^2/g$ respectively. These values were much higher than that of paper from 100% corn husk with tensile index (2.77 Nm/g) and tear index (10.73 $mN.m^2/g$). The extent of interfiber bonding is considered the most important factor contributing to tensile properties [19]. At low levels of bonding, tensile strength is dependent on interfiber bond strength and fiber length, while at high levels of bonding there is a greater dependence on fiber strength.

Modulus of elasticity (MOE) is an important paper property which measures the resistance to deformation or stiffness and structural rigidity of paper and board sheets. Pulp mixture of Kenaf bark and corn husk (75% - 25%) produces paper with the highest MOE (42.05 N/mm^2). This is much higher than the MOE of paper from 100 % kenaf bark (41.76 N/mm^2) and 100 % corn husk (12.41 N/mm^2). On the other hand pulp mixture in ratio 25% - 75% has a lesser MOE of 34.33 N/mm^2. Tear strength of a paper, which is the average force required for a cut in a sheet of paper to propagate that is, to continue to tear was found to be highest in paper sample from 100% kenaf bark (2.07 N/mm). While, paper sample from 100% corn husk was found to possess the lowest tearing value (1.22 N/mm).

The mechanical and strength properties of paper reflect the intrinsic chemistry, morphology, and structure of the individual fibers as well as the network structure of the paper. However, it must be noted that residual lignin (kappa number), impurities, pulp consistency, degree of pulp beating, additives, 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 fibers, their arrangement, and the extent to which they are bonded to each other as well as paper basis weight are all important factors contributing to test results.

Table 2. Properties of paper samples from pulp mixture of kenaf bark and corn husk

Pulp blend ratio (Kenaf bark : corn husk)	Grammage (g/m^2)	MOE (N/mm^2)	Elongation at break (mm)	Tensile index (Nm/g)	Tear index ($mN.m^2/g$)
100 % - 0	82.06	41.76	2.46	7.79	20.72
75 % - 25 %	127.14	42.05	3.35	4.53	7.87
50 % - 50 %	121.92	22.62	5.38	5.49	8.20
25% – 75 %	130	34.33	2.75	3.23	10.00
0 – 100 %	93.21	12.41	3.49	2.77	10.73

4. CONCLUSION

Strong papers and paperboard are important both for traditional use as well as in new fields of application, such as fibre-based packaging, furniture and light-weight building material. This study investigated the strength properties of handmade papers obtained from the pulp blending of long-fibre kenaf bark and short-fibre corn husk in different ratios. Tear index, modulus of elasticity, elongation at break and tensile index of paper from pulp of corn husk vary significantly when combined with pulp of kenaf bark. Blending of pulps from agricultural wastes such as corn husk and pulps from other non-wood materials such as kenaf contributes to the improvement of the paper strength properties and has the potential of producing paper of differing qualities and can find use in wide variety of applications.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. John O'Brien. Paper demand continues to grow. Paper Age*.* 2006;122:1.
2. Cunningham RL, Clark TF, Kowlek WF, Wolff IA, Jones Q. Tappi 53 (9),1967 delignification process. Industrial crops and products. 1970;29:16–26.
3. Atul K, Brij PS, Rakesh KJ, Ashwini KS. Blending studies of hosiery waste pulp with alkaline sulphite cooked pulp of natural fibres & the use of Lignosulphonate. International Journal of Innovative Research in Science, Engineering and Technology. 2013;2:10.
4. Ekhuemelo DO, Tor K. Assessment of fibre characteristics and suitability of maize husk and stalk for pulp and paper production. Journal of Research in Forestry, Wildlife and Environment. 2013;5(1).
5. Dharm Dutt, Upadhyay JS, Bahadur Singh, Tyagi CH. Studies on *Hibiscus cannabinus* and *Hibiscus sabdariffa* as an alternative pulp blend for softwood: An optimization of kraft delignification process. Industrial crops and products. 2009;29:16–26.
6. Nieschlage HJ, Nelson GH, Perdue RE. A research for new fiber crops. TAPPI. 1960;43(3):193-201.
7. Oluwadare AO. Evaluation of the fibre and chemical properties of some selected Nigerian wood and non-wood species for pulp production. J. Trop. For. Res. 1998;14:110-119.
8. Bagby MO, Clark TF, Cunningham RL. Uniform quality pulps from wet-processed stored green kenaf. In: Tappi non-wood plant fibers conference, Atlanta. 1973;61–67.
9. Clark TF, Nelson GH, Nieschlag HJ, Wolf IA. A search for new fiber crops; V pulping studies on kenaf. Tappi. 1962;45(10):780–786.
10. Fagbemigun Taiwo K, Fagbemi OD, Otitoju O, Mgbachiuzor E, Igwe CC. Pulp and paper-making potential of corn husk. International Journal of Agri Science. 2014;4(4).
11. Dutt D, Upadhyay JS, Agrawal G, Upadhyay MK .IPPTA. 1999;11(2).
12. Clark TF, Cummingham RL, Lindelfelser LA, Wolff IA, Cummins DG. A search for new fiber crops XVI kenaf storage. Tappi Non-wood plant fibers conference, New Orleans, LA, published as CA Report No. 34. Tappi non-wood Fiber Pulping Progress Report. 1970;107–132.
13. Clark TF, Cunningham RL, Wolf IA. A search for new fiber crops; Part XII bond paper containing continuously pulped kenaf. Tappi. 1970b;54(1):64–65.
14. Ververis C, Georghiou K, Christodoulakis N, Santas P, Santas R. Fiber dimensions, lignin and cellulose content of various plant materials and their suitability for paper production. Industrial Crops and Products. 2004;19:245-254.
15. Caulfield DF, Gunderson DE. Paper testing and strength characteristics In: TAPPI proceedings of the 1988 paper preservation symposium: 1988 October 19-21; Wahsington, DC. Atlanta, GA: TAPPI Press. 1988;31-40.
16. Nandkumar P. Pulp blending and its effects on the strength properties of *Ipomoea carnea* jacq. Journal of environmental research and development. 2009;3:4.
17. Ann Axelsson. Fibre based models for predicting tensile strength of paper. Master's Thesis submitted to Luleå University of Technology for MSc Degree in Engineering Wood Engineering Department of Skellefteå Campus, Division of Wood Science and Technology; 2009. ISSN: 1402-1617 - ISRN: LTU-EX--09/036—SE.

18. Van den Akker JA, Lathrop AL, Voelker MH, Dearth LR. Importance of fibre strength to sheet strength. Tappi. 1958;41(98):416.
19. Casey JP. Pulp and paper. Interscience Publishers, New York; 1966.

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