

Strength properties of paper from pulp blend of kenaf bark and corn husk: A preliminary study.

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 1:1, 3:1 and 1:3. Using a universal testometric machine, strength properties of the papers such as modulus of elasticity, tensile stiffness, tensile strength, elongation at break, tear strength, tensile index and tear index were assessed. Results showed that, paper sample from 100% kenaf bark has the highest tearing strength (2.07 kN/m), while paper sample from mixture of Kenaf bark and Corn husk (3:1) possess the highest tensile strength (0.67 kN/m) and highest modulus of elasticity (42.05 N/mm²). Lowest tensile strength and modulus of elasticity values were observed for paper sample from kenaf bark and Corn husk (1:1) and 100% corn husk respectively. Depending on targeted end use, papers of differing strength properties can be obtained from the combination of kenaf bark and corn husk in varying ratios.

Keywords: agro-waste, corn husk, kenaf bark, paper, pulp, fibre.

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].

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

38

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

47

48 2. MATERIALS AND METHODS

49 2.1 Materials

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

53 2.2 Pulping Process

54 Isolation of fibres from air-dried and manually chopped kenaf bark and corn husk was achieved through
55 the soda pulping process in a 5L conventional autoclave. After pulping, the cooked materials were
56 thoroughly washed with water to remove residual cooking liquor and defiberized in a laboratory

Comment [C1]: The aim of the study is not well stated. It is well known fact that examined two pulps can be blended, but it is not known the optimal blending ratio.

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-299 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 <u>ratio</u>	5:1	6:1
Temperature (°C)	121 ^{oC}	121
Pressure (Q)	60 psi	60 psi
Gas Down period (min)	20 ~~minutes~~	20
Time of pulping (min)	1 ~~hr~~ 45 ~~mins~~ 105	105
Kappa number	30.0	11.9

Comment [C2]: Please note the screen yield.

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Comment [C3]: Convert pressure to SI units

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2.3 Preparation and testing of laboratory paper sheets
Pulps of corn husk and kenaf bark (3 % consistency) were blended together in ratios, 1:1, 3:1 and 1:3 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, tear index, tensile index and tear strength 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.

Comment [C4]: The common tearing testing device for paper is Elmendorf type device. This is dynamic tearing device, if you use static tearing device that must be noted. Example <http://dergipark.ulakbim.gov.tr/jffiu/article/download/1023012618/1023011847>

3 Results and Discussion

3.1 Strength Properties of Paper

77 Mechanical and strength properties are important in papers for printing, packaging papers, boards and
78 other uses. Blending of long fibered pulp with short fibered pulp is one of the important aspects in this
79 regard [16] because this is expected to have attendant effect on the quality of paper produced

80
81
82 from both materials [17]. As shown in the result presented in table-Table 2, there exists a clear distinction
83 in the strength properties of paper from kenaf bark and corn husk. The tensile strength, tear strength and
84 tensile stiffness of paper from 100 % kenaf bark were 0.64 kN/m, 2.07 kN/m, and 34.24 kN/m
85 respectively. These values were much higher than that of paper from 100 % corn husk with tensile
86 strength (0.25 kN/m), tear strength (1.22 kN/m) and tensile stiffness (10.18 kN/m). The grammage of
87 paper obtained (Table 3) from 100 % corn husk (93.21 g/m²) was however higher than the grammage of
88 paper from 100 % kenaf bark (82.06 g/m²). This may be attributed to the fact that strength properties of
89 paper are mainly influenced by the type of fibre and alignment of the fibres in the microstructure of the
90 paper. Papers made with long fibers generally have higher tensile strength properties than paper made of
91 short fibers. Tensile strength was found to be highest (0.67 kN/m) in paper from pulp blend (3:1) and
92 lowest (0.06 kN/m) in paper from pulp blend (1:1). The extent of interfiber bonding is considered the
93 most important factor contributing to tensile strength properties [18]. At low levels of bonding, tensile
94 strength is dependent on interfiber bond strength and fiber length, while at high levels of bonding there is
95 a greater dependence on fiber strength.

96
97 Modulus of elasticity (MOE) is an important paper property which measures the resistance to deformation
98 or stiffness and structural rigidity of paper and board sheets. Pulp mixture of Kenaf bark and corn husk
99 (3:1) produces paper with the highest MOE (42.05 N/mm²). This is much higher than the MOE of paper
100 from 100 % kenaf bark (41.76 N/mm²) and 100 % corn husk (12.41 N/mm²). On the other hand pulp
101 mixture in ratio 1:3 has a lesser MOE of 34.33 N/mm². Tear strength of a paper, which is the average
102 force required for a cut in a sheet of paper to propagate i.e to continue to tear was found to be highest in
103 paper sample from 100% kenaf bark (2.07 N/mm). While, paper sample from 100% corn husk was found
104 to possess the lowest tearing value (1.22 N/mm). Because short fibers are obviously easier to pull out than
105 long fibers, papers made of long fibers show much better tearing resistance than those made with short
106 fibers [19].

107
108 The mechanical and strength properties of paper reflect the intrinsic chemistry, morphology, and structure
109 of the individual fibers as well as the network structure of the paper. However, it must be noted that
110 residual lignin (kappa number), impurities, pulp consistency, degree of pulp beating, additives, relative

Comment [C5]: Missing row

Comment [C6]: Give the index values for tensile and tear strengths.

Comment [C7]: The high variation of handsheet basis weights indicate poor evaluation of stock concentration.

Comment [C8]: Discuss the index values, due to the variations of grammages strength values cannot be compared.

Comment [C9]: There is something unusual when investigate the other strength properties. Standard deviation data must be given.

Comment [C10]: Index data must be evaluated. According to the results the blending give the worst results that must be explained!

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: Strength Properties of paper samples from pulp mixture of kenaf bark and corn husk

Sample code	Kenaf bark	Corn husk	MOE (N/mm ²)	Tensile stiffness (kN/m)	Elongation at break (mm)	Tensile strength (kN/m)	Tear strength (kN/m)	Tensile Index (mN/g)	Tear Index (mN.m ² /g)
KC1	100	0	41.76	34.24	2.46	0.64	2.07	7.79	25.23
KC2	0	100	12.41	10.18	3.49	0.25	1.22	2.77	13.09
KC3	1	1	22.62	15.84	5.38	0.06	1.71	5.49	14.03
KC4	1	3	34.33	28.15	2.75	0.42	1.59	3.23	12.23
KC5	3	1	42.05	34.48	3.35	0.67	1.34	4.53	10.54

- Comment [C12]: Delete row
- Comment [C11]: Sample code is not important data. For better expression of results arrange the sample according to the blending ratio. For example from 100% kenaf to 0 % kenaf. 100-0, 75-25, 50-50, 25-75, 0-100.
- Comment [C13]: Delete row

Table 3: Grammage of paper samples from pulp mixture of kenaf bark and corn husk

Sample code	Grammage (g/m ²)
KC1	82.06
KC2	93.21
KC3	121.92
KC4	130
KC5	127.14

- Comment [C14]: For better explanation for results the graph must be given. X axis – blending ratio from 100% to 0%, Y axis change ratio (in %) of strength properties (index).
- Comment [C15]: Give the data in table 1.

4. Conclusion

Strong papers 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-fibered kenaf bark and short-fibered corn husk in different ratios. Tear strength, modulus of elasticity, tensile strength and tensile stiffness of paper from pulp of corn husk was significantly increased 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 writing papers and packaging materials of good qualities.

- Comment [C16]: Conclusion must be rewritten according to the stated aim of the study.

129

130 **Acknowledgement**

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133 of Science and Technology, Nigeria.

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