

Original Research Article

Effect of pulp blending on the strength properties of paper from kenaf bark and corn husk

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. Bleached pulp samples were combined in ratios 1:1, 3:1 and 1:3. With the addition of 0.1 % soluble starch and 0.1 % kaolin, handmade paper sheets were produced and the strength properties of the papers were assessed. Results showed that, paper sample from 100% kenaf bark has the highest tearing strength, while sample from mixture of Kenaf/Corn husk (3:1) possess the highest tensile strength and highest modulus of elasticity. Low tensile strength and modulus of elasticity values were observed for paper sample from kenaf bark/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 (O'Brien, 2006). 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 (Cunningham *et al.*, 1970). 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 (Atul *et al.*, 2013).

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 (Ekhuemelo and Tor, 2013; 2011 Dutt *et al.*, 2009; Nieschlag *et al.*, 1961; Oluwadare, 1998; Bagby *et al.*, 1973; Clark *et al.*, 1962). 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 (Dutt *et al.*, 1999). On the other hand, pulps from kenaf have desirable properties for papermaking and generally possess strength characteristics compatible to commercial coniferous wood pulps (Clark *et al.*, 1970a,b). 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 (Ververis *et al.* 2004).

Paper makers have continually developed and improve their products. However, one way to meet the increasing competition on the world paper and board market is to increase paper strength properties. In order to achieve this, blending plays an important role. Hence this study presents the strength properties of papers from pulp blend of kenaf bark and corn husk.

2. MATERIALS AND METHODS

2.1 Materials

Fresh samples of corn husk were collected from corn sellers 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 5-litre conventional autoclave. Table 1 highlights the pulping parameters. 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

sample from kenaf bark was bleached in a mixture of acetic acid and Hydrogen peroxide (2: 1). While, pulp of corn husk was bleached with hydrogen peroxide only

Table 1: Pulping parameters

	Kenaf bark	Corn husk
Soda Concentration (%)	18	7
Liquor : sample	5:1	6:1
Temperature	121 °C	
Pressure	60 psi	
Gas Down period	20 minutes	

2.3 Preparation and testing of laboratory paper sheets

Bleached pulp of corn husk and kenaf bark 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. Handmade paper sheets were obtained from the mixture and also from individual pulp samples. The paper samples were then tested for tensile strength properties such as modulus of elasticity, elongation at break, breaking length and tensile stiffness using the universal testometric machine according to TAPPI T 220 “Physical Testing of Pulp Handsheets”

3 Results and Discussion

3.1 Strength Properties of Paper

Blending of long fibered pulp with short fibred pulp is one of the important aspects in paper making (Nandkumar, 2009) and this is expected to have attendant effect on the quality of paper produced from both materials. 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 strength, tear strength and tensile stiffness of paper from 100 % kenaf bark were 0.64 N/mm, 2.07 N/mm, and 34.24 m respectively. These values were much higher than that of paper from 100 % corn husk with tensile strength (0.25 N/mm), tear strength (1.22 N/mm) and tensile stiffness (10.18 m). This confirms the notion that long-fibered material like kenaf bark produces paper of better strength quality compared to short-fibered material like corn husk.

Modulus of elasticity (MOE) is the resistance to deformation or stiffness and it is an important paper property. Pulp mixture of Kenaf bark and corn husk (3:1) produces paper with the highest MOE (42.05

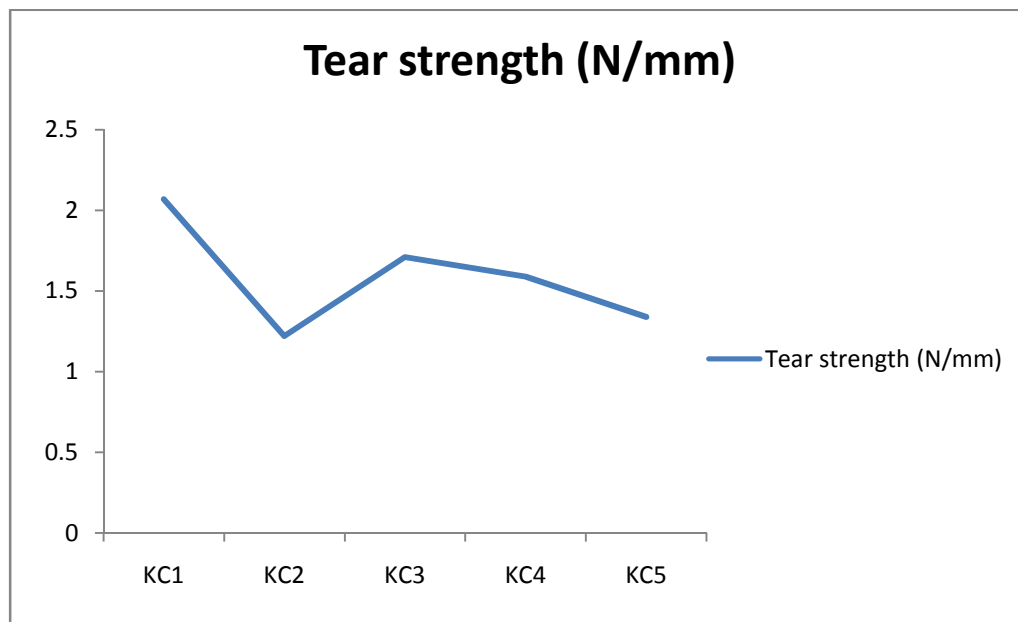
N/mm). This is much higher than the MOE of paper from 100 % kenaf bark (41.76 N/mm) and 100 % corn husk (12.41 N/mm). On the other hand pulp mixture in ratio 1:3 has a lesser MOE of 34.33 N/mm. Tensile strength was also found to be highest (0.67 N/mm) in paper from pulp blend (3:1) and lowest (0.06 N/mm) in paper from pulp blend (1:1). Also, paper sample with 100% kenaf bark has the highest tearing value (2.07 N/mm). While, paper sample from 100% corn husk was found to possess the lowest tearing value (1.22 N/mm). This result agrees with Seth (1990) and Seth and Page (1988) which reported that tensile strength increases with increasing density and increasing fibre length and decreased with decreasing fibre strength. Tearing resistance of a sheet with a low degree of bonding is also determined by the fibre length.

With the addition of 25 % kenaf bark, tensile stiffness of paper from corn husk increased significantly from 10.18 – 28.15 m. Same effect was observed for the stress at peak (0.31 – 0.51 N/mm²). Also, pulp blend in ratio 1:1 produced paper with better strength quality compared to paper from 100 % corn husk, except for the tensile strength which reduced somewhat.

97 Table 2: **Strength Properties of paper samples from corn husk and kenaf bark**

Sample code	Kenaf bark	Corn husk	MOE (N/mm)	Tensile stiffness (m)	Elongation at break (mm)	Stress at peak (N/mm ²)	Tensile strength (N/mm)	Tear strength (N/mm)
KC1	100	0	41.76	34.24	2.46	0.78	0.64	2.07
KC2	0	100	12.41	10.18	3.49	0.31	0.25	1.22
KC3	1	1	22.62	15.84	5.38	0.08	0.06	1.71
KC4	1	3	34.33	28.15	2.75	0.51	0.42	1.59
KC5	3	1	42.05	34.48	3.35	0.81	0.67	1.34

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100 **Fig 1: Variation of tear strength with different pulp mixture**

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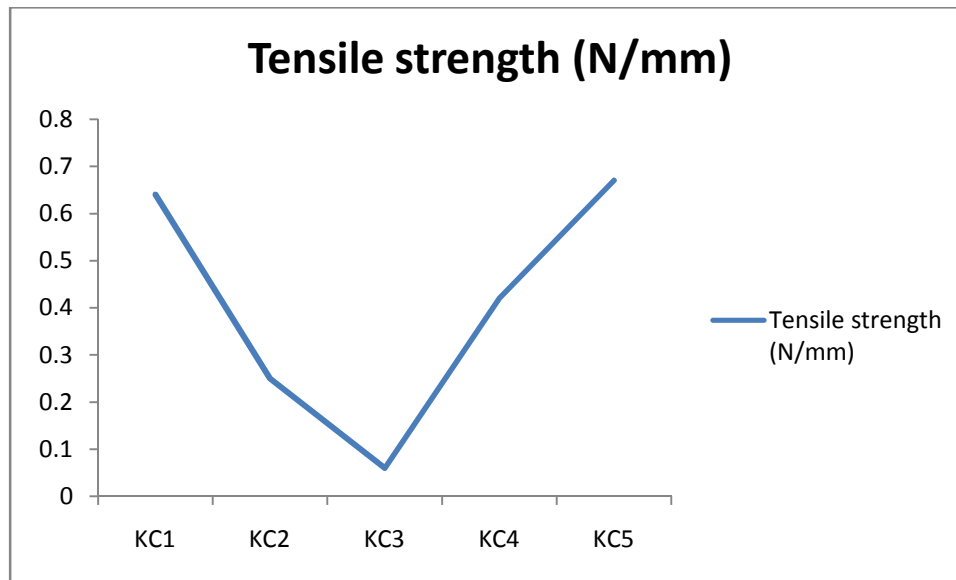


Fig 2: Variation of tensile strength with different pulp mixture

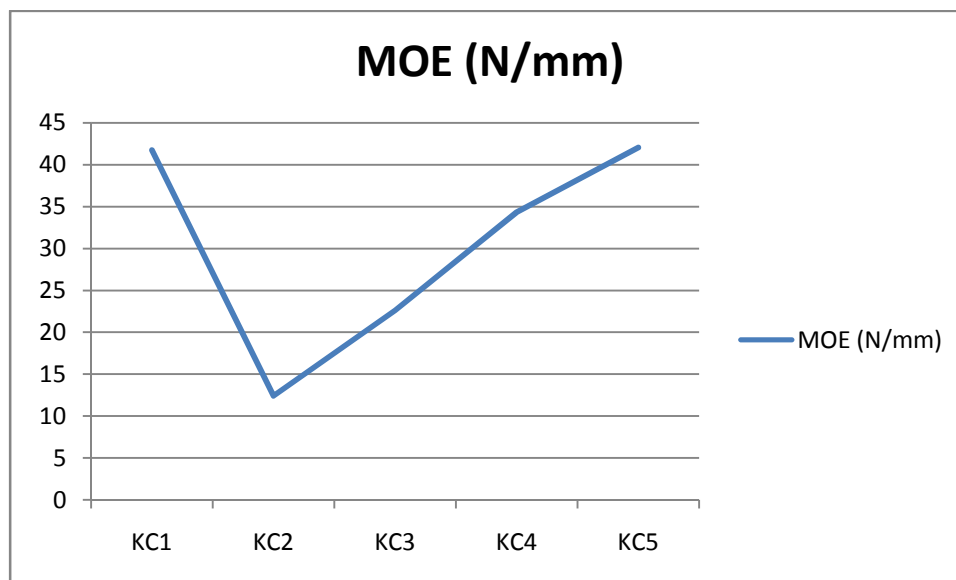


Fig 3: Variation of Modulus of Elasticity (MOE) with different pulp mixture

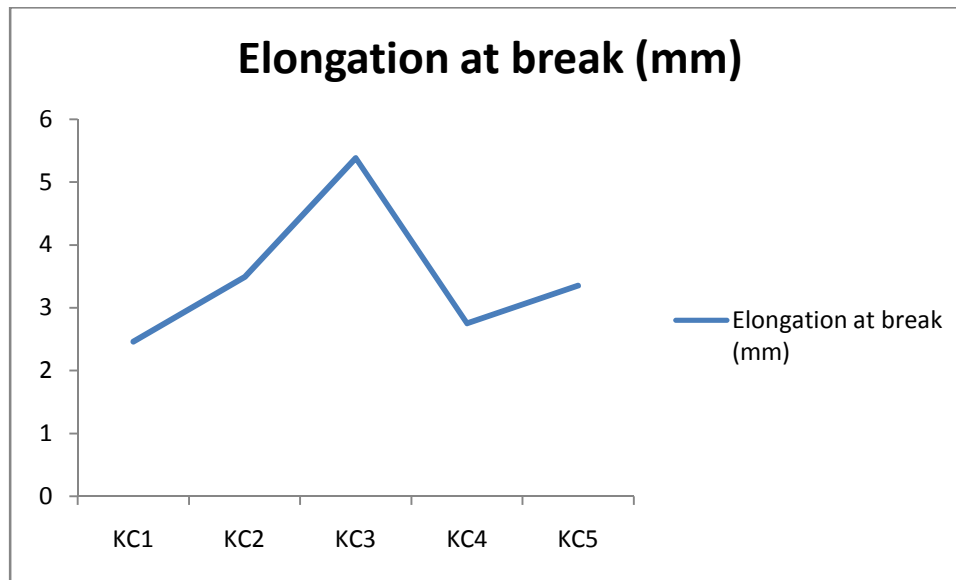


Fig 4: Variation of Elongation at break with different pulp mixture

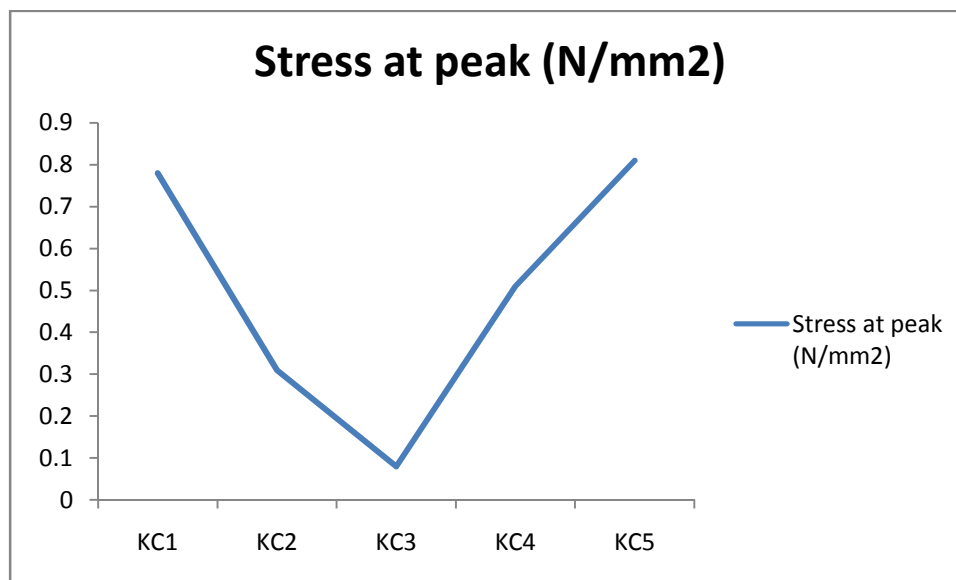


Fig 5: Variation of stress at peak with different pulp mixture

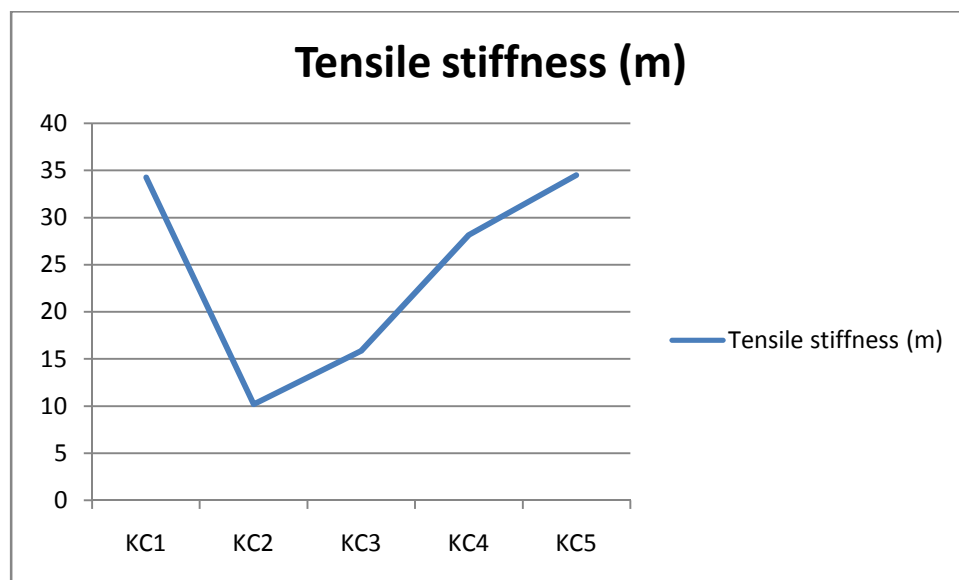


Fig 6: Variation of tensile stiffness with different pulp mixture

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.

Acknowledgement

The authors appreciate and acknowledge financial and technical supports from the management and staff of the Federal Institute of Industrial Research Oshodi (FIIRO) under the auspices of the Federal Ministry of Science and Technology, Nigeria.

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