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Effect of Cooking Mixtures of Kenaf and Bagasse and Blending Their Pulps on Paper Properties

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Abstract

*T*he aim of this study was to find the effect cooking kenaf and bagasse mixtures and blending their pulps, in addition to beating time on paper properties. Optimum cooking conditions were also examined. Mixtures (50:50 and 70:30) of kenafbast toKenaf core were cooked with 16% active alkali charge to produce the same yield (42%) which was close to that produced for kenaf core (43%).As for paper properties.the burst index for the mixture of kenafbast and kenaf core by ratio (50:50) active alkali (16%) increased from 1.3 to1.9 kpa*m/g with increased beating time, while tensile index increased from61.6 to 68.5 Nm/g).With bast/core mixture of (70:30) however, tensile index increased from 75.9 to 90.0 Nm/g and burst index increased from 4.0 to 4.7 kpa*m/g with beating time. The bulk density ranged between 6.28 and 6.8 g/cm³ in case of the first ratio and between 9.71 and 9.77 with the second ratio while the brightness remained at 20%. Longer fiber with lower cell wall thickness showed significant advantages in physicalproperties of papers produced. When kenafbast and kenaf core pulps were blended with 70:30 ratio the tensile index of the paper produced increased from 62.7 to 95.5 Nm/g, while burst index increased from 2.5 to 4.0 pka*m/g. With the second ratio (50:50) the tensile index increased from 40.9 to 73.1 and then decreased to 71.1 Nm/g with beating time, while burst index increased from 1.1 to 3.3. The bulk density ranged between 6.34 and 12,6 g/cm³ in the first ratio and between 10.93 and 11.25 g/cm³ in the second ratio and the paper brightness remained at 22%. When bagasse pulp was mixed kenafbast pulp (50:50) the tensile index increased from 53.5 to 87.4 Nm/g with increased beating time, while burst index increased from 1.8 to 3.6 and then dropped to 3.5. When bagasse to kenafbastratio changed to 70:30 the tensile index increased from.41.8 to 66.3 Nm/g and the burst index increased from 1.1 to 3.0 kpa*m/g.When bagasse pulp was mixed with kenaf core pulp 50:50, the tensile index of the paper increased from 28 to 55Nm/g, while the burst index increased from 0,50 to 2.2 kpa*m/g with beating time. The bulk density ranged between 6.29 and 10.10 g/cmm^3 and the brightness was 37%., Finally with kenafbast, kenaf core and bagasse pulp blends 60:20:20 the tensile index of the paper decreased from 79,5 to 58.8 and then increased 94.1 Nm/g, with increased beating time, while burst index decreased from 4,5 to 2.0 and then increased to 3.9 kpa*m/g. the bulk density ranged between 6.5 and 9.9 g/cm^3 and the brightness was 25%.

Keywords: Soda pulping,, fiber characteristics, papermaking

Introduction

Due to the shortage in forest based raw materials for paper, the possibility of alternative cellulosic fibrous raw materials have been explored. Among these Kenaf and bagasse draw the attention as promising nonwood fibrous materials. Throughout the 18th century the papermaking process remained essentially unchanged, with linen and cotton rags furnishing the basic fiber source. However, the increasing demand for paper during the first half of the 19th century could no longer be satisfied by the waste from the textile industry. Thus, it was evident that a process for utilizing a more abundant material was needed. Consequently, major efforts were undertaken to find alternative supplies for making pulp. As a result, both mechanical and chemical methods were developed for the efficient production of paper from wood. Mechanical wood pulping was initiated in 1840 by the German Friedrich Gottlob Keller. The wood-pulp grinding machine was first commercialized in Germany in 1852 (Biermann, 1996). Furthermore, the potential availability and economics of using agricultural residues is interesting despite of their limitations

Although most of the nonwood materials would require specialized handling and pulping systems, some can be dealt with without major equipment changes in the existing mill. Replacement with straw fibers in the paper furnish may require reduced refining of the wood fibers to control drainage while maintaining the paper properties (Tschirner,*et. al,* 2003).

Chemical pulp from jute, flax, hemp, sisal and bagasse are suitable for special paper grades (e.g. filtration papers, lightweight printing papers). In tropical and subtropical countries, pulp wood is grown mainly in plantations (Sexita, *et. al*, 2006)

Bagasse was evaluated for the production of pulp and papers. It has fairly long fiber length and low lignin content suitable for paper making. Samples paper were produced and tested for mechanical strength properties. They exhibited standard qualities for tearing resistance above for all grades of papers except test liner, hence its papers can be used for writing, printing, corrugating medium and insulating board applications (Ibrahim, *et. al,* 2011). Kenaf is indigenous to Africa and the species *Hibiscuscannabinus* most likely originated from Sudan, although it is commonly cultivated for both food and fiber in West Africa. Fiber in both the retted and raw forms is used in the manufacture of cordage and newsprint. Leaves and small branches, when ground, have high digestibility and can be used as a source of roughage and protein for cattle andsheep .

In papermaking, blending or mixtures of fibers is one of the ways to enhance mechanical properties of paper. The properties of paper manufactured from mixtures of oil palm empty fruit bunch (EFB) and kenaf fibers were investigated. Using kenaf whole stem fibers improved the mechanical properties of the blended papers and complied with the standard requirement for writing and printing grade paper (Rafidah, *et. al*, 2017).

Soda pulping and traditional bleaching has been used for bagasse pulping, and this technology is in its mature stage. The soda process still has limited use for easily pulped materials like straws and some hardwoods, but is not a major process. Anthraquinone may be used as a pulping additive to decrease carbohydrate degradation. A recent development is the use of oxygen in soda pulping. While oxygen bleaching is not very specific to delignification compared to other bleaching methods, it is fairly specific to delignification relative to other pulping methods.

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Materials and Methods

Pulping and Blending

The soda pulping method was used to cook kenafcore, kenafbast and bagasse as well as a mixture of kenaf bast and kenaf core in a laboratory, cylindrical digester. This digester included an electrical heater, a motor actuator, and instruments required for measurement and control temperature and pressure. The raw material was 500g oven dried of bagasse, and kenaf (core, bast). Pulping conditions of the soda processe for each of the two raw material are shown in table (1).In one cae mixtures of kenafbast and kenaf core were cooked together with 16% active alkali in two bast:core ratios namely 50:50 and 70:30 respectively and the pulp and paper produced from them were evaluated.At the end of cooking the pulp was washed by water and mechanical standard terpopulper. Fibers were then disintegrated using a disintegrator according to (TAPPI 205) standard. The cooked pulp was then screened with a screen plate. .The yield of pulp and reject were determined by measurement in the laboratory. The screened yield was determined from duplicate analysis. The kappa number was determined according to (TAPPI 1236-om-99).

Many trials were also made by blending pulps made from the two raw materials in different ratios. The first blend was between kenafbast / kenaf core pulps using 50:50 ratio and 70:30 ratio. Different pulps were beaten to different beating time before handsheets were made and tested. A second blend was between bagasse/kenafbast pulps using the same ratios: 50:50 and 70:30. From which handsheets were made and evaluated. The third blend was between bagasse and kenaf core using one ratio only 50:50. Again handsheets were formed and tested. The same was made with the last blend which was between kenafbast: kenaf core: bagasse using 60:20:20 ratio respectively.

Table.1 Pulping conditions for bagasse and kenaf

Control condition	Bagasse	Kenaf
Oven dry weight (g)	500	500
Active alkali as Na_2O %	12-13	16-17
Liquor/fiber ratio	5:1	6:1
Max temp. ^oC	160	170
Time to max temp, min	40-45	1h
Time at max temp ,min	1h	1h

Beating and handsheets formation

Before handsheet formation the different pulps were beaten to different beating times in accordance to (TAPPI-200-SP-01).

Bagasse had three beating times 0, 4 and 5 min..Kenafbast, also had three beating times 0, 1 and 2min. While kenaf core had tow beating times 0 and 5min. Canadian standard freeness resulting from the different beating times were measured according to (TAAPI- 227-om-1199). Finally the handsheets were formed according to (TAPPI 220-sp-01) and conditioned according to (TAAPI-402-sp-97) before testing.

Evaluation of paper properties

Evaluation of the quality of paper produced from this investigation was based on five paper properties, namely: bulk density, tensile index which was carried out according to (TAAPI-404 –cm-92), burst index in accordance with (TAPPI -403-om-97), in addition to brightness (TAAPI-425-om81).

Results and Discussion

Table 2 shows the effect of cooking mixtures ofKenafbast and kenaf core fibersusing two different ratios (50:50 and 70:30) and cooked in 16% active alkali on physical properties of paper. The pulp from 50:50 ratios gave an acceptable brightness of 25%with bulk density increasing from 6.28 to 6.98g/cm^3 with increasing beating time in the first mixture (50:50) and slight increase from 9.71 to 9.77 g/cm^3 in the second ratio.

Table 2. Effect of beating time on bulk density and brightness of paper made from cooking mixturesof kenaf core and kenafbast.

gmixtureskenafbast and core 50:50				mixtures kenafbast and core 70:30			
BT (min)	Freeness (0SR)	Bulk density g/cm^3	Brightness %	BT (min)	Freeness (0SR)	Bulk density g/cm^3	Brightness %
zero	36	6.28	25	Zero	39	9.71	20
2	41	6.98	25	2	50	9.77	20

BT=beating time

Table 3 shows that burst index for the firstmixture was found to increase from1.3 to 1.9kpa*m^2/g with increased beating time, while tensile index increased from 61.6 and 68.5Nm/g with increased beating time. Higher values were obtained for all of the studied properties when a higher ratio of kenafbast fibers were used (70:30), where tensile indexincreased from 75.9 to 90.9Nm/g; whileburst index increased from 4 to 4.7kpa*m^2/g. It could also be noticed from the table that mixing kenafbast and core)required minimum beating time to make an appreciable increase in tensile index.The results revealed improvement in all of the strength properties with increased beating time and increased portion of kenafbast. The brightness was found to be 27 and 28.

Table 3. Effect of pulping mixtures of kenafbast and kenaf core and beating time on tensile index and burst index

mixtures kenafbast and core 50:50				mixtures kenafbast and core 70:30			
BT (min)	Freeness (0SR)	Tensile index Nm/g	Burst index kpa*m2/g	BT (min)	Freeness (0SR)	Tensile index Nm/g	Burst index kpa*m2/g
zero	36	61.6	1.3	Zero	39	75.9	4
2	41	68.5	1.9	2	50	90.9	4.7

BT=beating time

Table 4 shows effect of blendingkenafbast and kenaf core pulps and beating time on physical properties. The brightness of kenafbast and kenaf core blend (50:50, 70:30) ratios was 25 and 22%, respectively. The bulk density for the first ratio (50:50) increased from 6.34 to 12.06 g/cm3with increasing beating time, while the change was not significant in case of the second ratio, but it was slightly higher than that with the first ratio.

Table 4.Effect of mixingkenaf core and kenafbast pulps and beating time on bulk density and brightness of paper:

Blend kenafbast and kenaf core50:50				Blend kenafbast and kenaf core70:30			
BT (min)	Freeness (0SR)	Bulk density g/cm3	Brightness %	BT (min)	Freeness (0SR)	Bulk density g/cm3	Brightness %
zero	38	6.34	25	Zero	38	11.25	22
1	45	10.17	25	1	45	10.93	22
2.3	50	12.6	25	2.3	50	11.1	22

BT=beating time

Table 5 shows the effect of blendingkenaf core and kenafbast pulps and beating time on tensile index and burst index of paper:Best values were obtained when the blending ratio of kenafbast to kenaf core was 70:30, where tensile index increased from 62,7 to 95,5 Nm/g with increasing beating time whereas burst index increased from 2.5 to 4.0 kpa*m/g.In case of 50:50 ratio the tensile index increased from 40.9 to 73.1 Nm/gm before decreasing again to 71.1, while burst index increased from 1.1 to 3.3 kpa*m/g. Tensile and burst strength are known to increase with fiber length and refining which leads to better distribution of fibers and better fiber contacts.

Table 5 Effect of mixing kenaf core and kenafbast pulps and beating time on tensile index and burst index of paper

Bagasse and kenaf bast50:50				Bagasse and kenaf bast70:30			
BT (min)	Freeness (^{0}SR)	Tensile index Nm/g	Burst index kpa*m^2/g	BT (min)	Freeness (^{0}SR)	Tensile index Nm/g	Burst index kpa*m^2/g
zero	31	53.5	1.8	zero	31	41.8	1.1
1	40	67.4	3.6	2	41	47.6	2.3
2	50	87.4	3.5	3	52	66.3	3

BT=beating time

Table 6 shows the effect of mixing bagasse and kenaf bast pulps and beating time on strength properties of paper. With 50:50 ratio the tensile index increased from 53.5 to 87.4

Table 6 Kenaf bast/ bagasse pulp blends on paper properties

blend kenafbast and kenaf core70:30				Blend kenafbast and kenaf core 50:50			
BT (min)	Freeness (0SR)	Tensile index Nm/g	Burst index kpa*m/g	BT (min)	Freeness (0SR)	Tensile index Nm/g	Burst index kpa*m/g
zero	38	62.7	2.5	Zero	38	40.9	1.1
1	45	90.5	3.4	1	45	73.1	2.6
2.3	50	95.5	4	2.3	50	71.1	3.3

Table 7 shows the effect of mixing bagasse and kenaf core pulps (50:50) and beating time on paper properties. Tensile indexincreased from 28 to 55 Nm/g with increased beating time, while burst index increased from 0.50 to 2.2kpa*m/g. Bulk density ranged between 6.29 and 10.10 g/cm³ and brightness was 37%. The short fiber of the two materials was the cause of the low strength properties.

Table 7 effect of mixing kenaf core /bagasse pulp and beating time on on paper properties

Bagasse and kenaf core 50:50					
BT (min)	Freeness (^{0}SR)	Tensile index Nm/g	Burst index kpa*m/g	Bulk density g/ cm^3	Brightness %
zero	28	28	0.5	10.10	37
5	41	41	1.7	6.29	37
7	55	55	2.2	9.18	37

BT=beating time

Table 8 show the Effect of mixing kenaf bast /bagasse pulps and beating time on bulk density and brightness on paper:The bulk density (9.38 – 10.24 g/cm³) and brightness (27%) did not change much with beating time in case of the 50:50 ratio, while bulk density increased from 9.25 to 11.23 g/cm³ with beating time and brightness was 28%.

Table 8. Effectof kenafbast /bagasse blend and beating time on bulk density index and brightness on paper:

Bagasse and kenaf bast50:50				Bagasse and kenaf bast70:30			
BT (min)	Freeness (^{0}SR)	Bulk density cm^3/g	Brightness %	BT (min)	Freeness (^{0}SR)	Bulk density g/cm^3	Brightness %
zero	31	10.24	27	zero	31	9.25	28
1	40	10.04	27	2	41	9.51	28
2	50	9.38	27	3	52	11.23	28

BT=beating time

Table 9 shows the effectof mixingkenafbast,kenafcore andbagasse pulps (60:20:20)and beating time on paper properties. The tensile index decreased from 79.5 to 58.8 and then increased to 94.1 Nm/g with beating time.

The burst index showed the same trend by decreasing from 4.5 to 2.0 and then increased again to3,9 kpa*m/g, Bulk density, on the other hand, showed the opposite trendby increasing from 6.54 to 9.91 and then decreasing slightly to9.57 g/cm³ with beating time; while brightness remained at 25 % . The first drop in tensile and burst indexes may be due the breaking and shortening of kenafbast fibers, while the final increase may be due to the increased fiber flexibility and better contacts between fibers due to the beating.

Table 9. Effect of kenafbast ,kenafcore andbagasse blend and beating time on tensile index and burst index on paper:

Bagasse and kenaf core and core 60:20:20					
BT (min)	Freeness (^{0}SR)	Tensile index Nm/g	Burst index kpa*m/g	Bulk density g/cm^3	Brightness %
zero	36	79.5	4.5	6.54	25
1	43	58.8	2	9.91	25
2	55	94.1	3.9	9.57	25

Conclusions and recommendations

Conclusions

The following conclusion of the present study:

1. Tensile index and burst index of paper made froma mixture of kenafbast and kenaf core cooked together increased with the increase of kenafbast component and with increased beating time.

2. Tensile index and burst index of paper made from blended bagasse and kenafbastpulps decreased with increased bagasse component and increased with increased beating time.

3- Tensile index and burst index of paper made from kenafbast and kenaf core blended pulps increased with increased kenafbast component and with increased beating time.

4- Tensile index and burst index for paper made from blended bagasse and kenaf core pulps increased with increased beating time with lower values than all of the above combinations.

5- The highest basic density was associated with paper made from kenaf pulps, while the highest brightness was associated with paper made from bagasse pulps.

Recommendation

The future scopes will cover investigating the effect of cooking mixtures of non wood fiberous raw materials on paper properties and group raw materials adapted to similar pulping conditions together. They will also cover exploring optimum cheaper pulping conditions for any material or group. This in addition to investigating the effect of blending pulps of different raw materials on paper properties.

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