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Extraction of kenaf fiber and its physico-chemical properties for various end uses

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Abstract
Natural fiber seems to be the most imminent alternative for chemically treated synthetic fibers. One of the bast fiber Kenaf which is being selected for the study is a feasible source of cellulose which is economically viable and ecologically friendly which could be utilized for extraction of fiber. This study is an attempt to explore the possibilities of Kenaf fibers by studying its extraction parameter and also its physico-chemical properties of the fibers. The mechanical properties of the fiber were also evaluated by Infrared studies (IR) and Scanning electron microscopy (SEM) test of the retted, degummed and bleached fibers.

Keywords: Kenaf, retting, degumming, bleaching, infrared (IR), scanning electron microscopy (SEM)

Introduction
Textiles specially for the clothing is known, ever since the mankind learnt how to protect themselves by using animal skin, tree leaves etc. the civilization taught us to make clothing by using conventional and non- conventional fibers . This drives textile manufactures to seek new approaches to producing environmental friendly products, such as recyclable and biodegradable textile materials.

Currently, one of the major challenges in the textile industry is a related environmental problem. Textile industries are facing great pressure to reduce pollutant emissions. This drives textile manufactures to seek new approaches to producing environmentally friendly products, such as recyclable and biodegradable textile materials. More and more attention has been drawn to agricultural products, wastes, and derivatives because of their renewability. One of the crops being investigated is kenaf, an old crop with many uses. Kenaf has now become a potential natural fiber source for both apparel and industrial applications (Zhang 2003) [1] Kenaf (*Hibiscus cannabinus* L.; Malvaceae) is one of the three largest fibre crop of economic importance (Keshk *et al.*, 2006) [2].

Most natural fibres are composed of cellulose, hemicelluloses and lignin in different relative amounts. (Ahmad, T.V.; Ramaswamy, G.N.; Kimmel, L. and Boylson, E. (2002) [3] Kenaf is a short day annual herbaceous plant belongs to the Malvaceae, a family notable for both its economic and horticulture importance. A kenaf bast fiber is composed of a bundle of single fibers bound by lignin and pectins usually the fibre bundles are very coarse and brittle. This investigation mainly focuses towards the development of kenaf yarn and evaluation of the quality of the yarn which can be use in various textiles fields.

Materials & Methods
Materials
Selection of materials
Kenaf fiber was selected for the present study and was collected from Krishi Vigyan Kendra (KVK), Gossaigoan, Telipara. Assam, India.

Extraction of kenaf fiber
The extraction of the fiber from the Kenaf plant was carried out by water retting process. The stem of the kenaf plants was submerged in a water bath and covered with water hyacinths for 26days. Finally, the fibres were washed properly and dried under shade and kept ready for further use (Tahir *et al.*, 2011) [4].

Degumming and bleaching of fiber

Degumming of Kenaf fiber was carried out as suggested by (Gahlot, *et al*. (2012) [5]. The extracted kenaf fiber contained significant amount of gummy matter. Hence it is essential to remove gum content from the fiber.

After degumming the fibers were subjected to bleaching following the method suggested by (Ghosh *et al*, 1994) [6] During the bleaching process natural colours of fibers was removed and fibers attend good whiteness.

Determination of physical and chemical characteristics of the plant

The average length and width of the kenaf plant were taken with the help of measuring tape, average weight of the cut plant were weighted in weighing balance. The moisture content, ash content, lignin, Cellulose content & Alpha-Cellulose content of the fibre were determined by using TAPPI standard method (Technical Association of Pulp and Paper Industry, USA).

Results and Discussion

Physical characteristics of the selected plant fiber

The plant that collected from the field was evaluated for their morphological and anatomical studies in the laboratory. The results were presented in Table 1.

Table 1: Physical characteristics of the kenaf plant fibers

Parameters	Measurement
Height of the plant (cm/m)	2.5-3.5
Diameter(cm)	
a) Bottom	3.00
b) Middle	2.40
c) Top	1.82
Moisture content (%)	
a) Whole plant	76.00
b) Bark	78.60
Weight of the whole plant (g)	570.00

From Table 1. it was inferred that the under good condition Kenaf can grow at a height of 20 feet in 4-5 months (Wood 2003) [7]. It grows with a straight slender stems to the height as tall as 1.8-3.5 m whereas the mature plants reach a height of 2.5 to 3.5m (Rowell and stout 1998) [8] or more with basal diameter of the stems varying from 1.0-5.0cm. The width of the representative stem was taken by dividing the whole plant length into three parts *viz.* bottom, middle and top. The highest diameter found in the bottom portion was 3.00 cm followed by middle 2.40cm and top 1.82cm portion. The average weight of the whole plant was 570.00g and moisture content was recorded 76.00 for the whole plant and bark 78.60 per cent respectively.

Chemical constituents of kenaf fibres

The chemical analysis of the kenaf fibers was evaluated and results were listed in Table 2.

Table 2: Chemical analysis of kenaf fibres

Constituents	Retted Kenaf	Degummed Kenaf	Bleached Kenaf
Moisture (%)	8.80	8.65	8.56
Ash (%)	0.76	0.65	0.60
Lignin (%)	15.0	12.0	11.5
Alpha cellulose (%)	65.10	63.80	62.40
Cellulose (%)	60.00	57.60	56.70
In cold water (%)	5.87	6.67	6.87
In hot water (%)	8.68	9.95	9.96
In dilute alkali (%)	10.65	10.78	10.88

The experimental data presented in Table 2 evidently showed that the ash and lignin content (0.76% and 15.0%) were found maximum in retted fibers followed by degummed fibers where ash content was (0.65%) and lignin was (12.0%). But minimum ash (0.60%) and lignin (11.5%) contents were observed in bleached fibers. Similar observation was stated by Mishra (1987) Mohanty *et al* (2001) [10] stated that chemical composition of different kinds of fibers were different where lignin ranges from (15 to 19%).

The maximum moisture (8.80%) was observed in degummed fibers and minimum were recorded in bleached fiber (8.56%). The highest alpha- cellulose (65.10%) and cellulose content (60.00%) were recorded in retted fibers .Similar observation was observed by Rowell and Han (2000) [11] stated that cellulose percentage ranges from (44 to 57%) and moisture content percent (10 to 20%).

Physical Properties of Kenaf fibers

The characteristics on geometrical properties of kenaf fibers were analyzed and data such as length, diameter and wall thickness were presented in the Table.3

Table 3: Physical Properties of Kenaf fibers

Kenaf fiber	Properties		
	Retted fiber	Degummed fiber	Bleached fiber
Length (mm)	5.86	3.25	3.25
Diameter (µm)	10.11	9.40	8.20
Wall thickness (µm)	6.92	4.86	4.94
Tensile Strength (g/tex)	89	75	72
Elongation (%)	3	5.10	6.00
Density (g/cc)	1.52	1.44	1.32

Table 3 depicted that among the kenaf fibers the average staple length of retted fiber was 5.68 mm which is the highest and it is followed by degummed 3.25 mm and bleached 3.25mm. Similar work related to fiber length was reported by (Calamari 1997) [12] stated that kenaf fibers are only 1 to 7 mm long and about 10 to 30 microns wide, thus too short for textile processing.

It was observed from the table that the maximum diameter 10.11 µm was observed in retted fiber and minimum diameter of 8.2µm was recorded in bleached fiber. The retted kenaf fiber recorded highest cell wall thickness 6.92 µm followed by degummed 4.86µm and bleached fiber 4.94µm. Similar observation was stated by (Paridah *et al*; 2008)[13] as the fibers from the bast are long and have thick cell wall compared to the core fiber.

The difference in length and diameter of the fibres might be is due to the method of extraction employed. (Gohl and Vilensky, 1987) [14] Length of fibre is an important factor in obtaining good quality yarn, because of spinability, thereby producing quality yarn with high productivity.

In case of mechanical properties of fiber, it was inferred that the maximum tensile strength (89g/tex) was recorded in retted fiber and the minimum was found in bleached fiber (72g/tex). On the other hand bleached fiber showed highest elongation (6.0%) followed by degummed (5.1%) and retted (3.0%).The results have also showed more or less similar with work of (Han, J.S., Kim, W., and Rowell, R.M. 1995) [15] stated that tensile strength was 70 g/tex to 120 g/tex for fiber as water retting has great impact on the strength and elongation of retted fiber was 2.40 to 6.0%.

From the data generated, it was noticed that retted fiber posed highest density (1.52 g/cc) while the lowest was found in

bleached Kenaf fiber (1.32g/cc). It may be due to the bleaching process which has some positive effects on density of fiber.

Infra-red (IR) studies of Kenaf fiber

Infra- red (IR) studies were performed on raw and treated kenaf fibers as shown in Fig 1 to find out the removal of lignin, hemicelluloses and waxy substances. The increase in the cellulose, as confirmed by the IR analysis, is shown in Fig 1(a). The strong O-H stretching absorption value and C-H stretching absorption value are 3469cm^{-1}. The characteristic peaks of cellulose and lignin are around 1734-1264cm^{-1} (C-O stretching vibration of cellulose) and fig 1(b) shows 1422cm^{-1} (aromatic skeleton vibration of lignin), respectively (Chen *et al*., 2009) [16] The strong peak around 1515-906cm^{-1} indicates that the lignin was removed by chemical and physical treatments as shown in fig1(c). This result is consistent with the treated fibers structure that the lignin content decreased in bleached kenaf fiber.

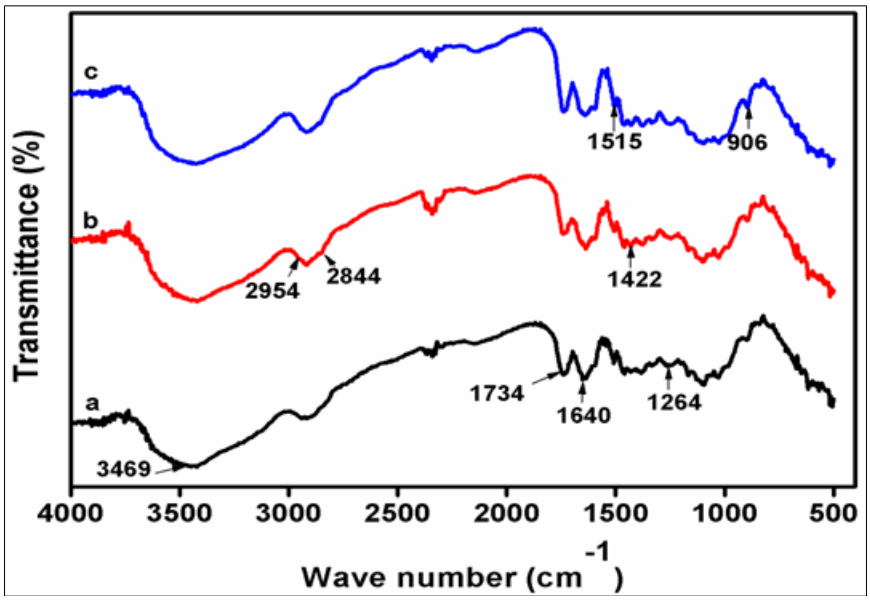
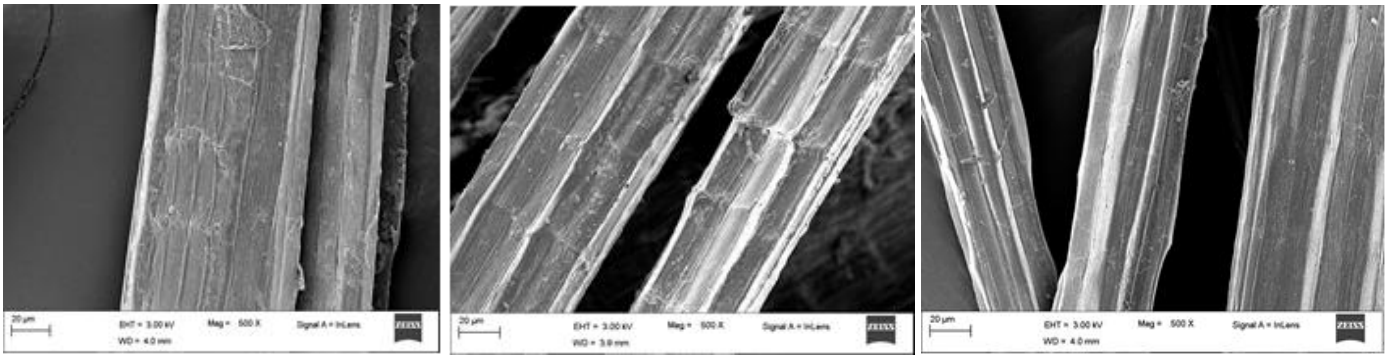


Fig 1: IR Spectra of (a) Kenaf fiber (Retted) (b) Kenaf (degummed) and (c) Kenaf (bleached)

Scanning electron microscopy (SEM)

The surface appearance of raw, degummed, and bleached fibers was studied using SEM images as shown in Fig 2(a, b, c). The gum content of the raw fibers is clearly visible in the SEM image (Fig 2 (a)). The surface is found to have cracks. This indicates the presence of gummy matter on fiber surface. The alkaline degumming almost removed the gummy matter (Fig 2(b)) and bleaching process removed whole of the gum from the fiber surface (Fig 2 (c)). Degumming and bleaching resulted in individualization of fiber entity and smoothening of surface by removing the gum from the fibers.



(a) Retted Kenaf fiber (b) Degummed Kenaf fiber (c) Bleached Kenaf fiber

Fig 2: Scanning Electron microscopy (SEM)

Conclusion

Currently, one of the major challenges in the textile industry is a related environmental problem. Textile industries are facing great pressure to reduce pollutant emissions. This drives textile manufactures to seek new approaches in producing environmentally friendly products, such as recyclable and biodegradable textile materials. More and more attention has been drawn to agricultural products, wastes, and derivatives because of their renewability. The chemical and physical analysis of the kenaf fibres were determined and found suitable as textile grade fibre for various applications. The moisture content of the fibres were found suitable which will further enhance the comfort properties of the fabric. The cellulose content of the fibre was found satisfactory. The increase in cellulose percent will give higher strength to the fibre. The physical properties such as length and diameter were found suitable for spinning of yarn. The strength of the retted fiber was found maximum as compared to bleached fibre as the bleached fibres has

undergone different chemical treatments. The Infra-red studies reveals the presence of different chemical groups in the fibre. The results of SEM depict the complete removal of gummy and other substances from the surface of the fibre.

From the present investigation it may be concluded that it opens wide scope of diversifications by blending Kenaf with other natural fibres like ramie, jute, eri etc into the manufacture of home textiles and furnishings.

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