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Full Length Research Paper

Process Ability Enhancement of False Banana Fibre for Rural Development

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In this work, the structure and characterization of false banana fibers (FBF) modified by physico-chemical treatment were studied. One of the components of the research was to develop a process for softening false banana fiber or yarn for the production of diversified FBF products like sack, mat or carpets with a supple feel and improved texture on an industrial scale. Some important physico-chemical properties of these fibers changed due to chemical and biochemical treatments adapted in the research. The physico-chemical changes due to the treatments include changes in percentage weight loss, moisture content/regain, tensile strength, fineness, bending and torsional rigidity of the fibers, which were studied in relation to process performance in FBF yarn manufacturing. Results showed that treated FBF had good flexibility, supple feel, and excellent moisture regain and were finer than untreated FBF. Also treated FBF were a low cost alternative to imported jutes and sisal in Ethiopian sack manufacturing industry.

Keywords: FBF, physico-chemical, process performance, low cost

INTRODUCTION

The interest in using natural fibers has increased significantly in the last few years, especially because of their use as an agent of reinforcement and more recently as heavy metals bio-adsorbent. Their abundance in nature combined with the ease of their processing has an attractive feature, which makes them an important substitute for synthetic fibers. These ligno-cellulosic fibers possess many characteristics which make their use advantageous: low cost, low density, biological degradability, renewability, good mechanical properties and non-toxicity (Jie and Lina, 2005). Now a day, Natural fibers (NF) are preferable for their appropriate stiffness, mechanical properties and high disposability. False banana fiber (FBF), a ligno-cellulosic fiber, obtained from the pseudo-stem of false banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties (Matthews, 1954). Natural fiber (NF) from false banana is among widely used natural fibers in southern parts of Ethiopia. Natural fibers are treated with different materials in different modes to increase their strength, durability and sustainability while retaining their inherent degradable character to protect environment from pollution. The stem of the false banana plant furnishes a very important fiber for cordage and sacking fabrics. Generally, false banana plant can be classified into two groups, depending on the edibility of the starch found in it: edible and wild false banana plant having a species name *M. textilis*, *M. ensete*, *M. fehi* (Reddy and Yang, 2011). In this paper, more attention is given on studying the physico-chemical properties and chemical composition of false banana fiber. As far as the false banana fiber process ability enhancement is concerned, some parameters of jute and banana fibers are also studied here. Chemical treatments to remove unwanted chemical substances present in the fiber structure and modification of the physico-chemical property of the fiber with process ability enhancement has been studied. A typical fibre material extracted by the above process was shown in Figure1.

Ethiopia has an agricultural lead economy, producing a variety of cereals, fruits, vegetables and cash crops. In spite of this, a shortage of raw materials is a notable hindrance limiting the industrial growth of the country. Besides the main agricultural products, different parts of the plants and fruits of many crops may be viable sources of raw material for industrial utilization, but only a part of this material is exploited

Figure 1. False banana fibres (Reddy and Yang, 2011)

Table1. Composition of false banana fibers

S.No	Constituents	Reported values	
		Range	Average
1	Cellulose	67.4- 67.89	67.63
2	Lignin	4.8-6.13	5.41
3	Ash	1.0-1.40	1.20
4	Moisture	10-15	12.5
5	Cold water soluble compounds	1.9-2.61	2.37
6	1%NaOH soluble compounds	28.5-29.90	29.40

profitably because of lack of knowledge and technology for its economic use and much is returned to nature, unused (Carolina et al., 1991). The waste by-products of agricultural products are numerous and quantitatively lucrative in a country like Ethiopia with its vast agricultural resources. Depleting natural resources, regulations on using synthetic materials, growing environmental awareness and economic considerations are the major driving forces to utilize annually renewable resources such as biomass for various industrial applications.

Biomasses such as agricultural crops and residues, forest resources and residues, animal and municipal wastes are the largest source for cellulose in the world. Approximately $2x10^{11}$ tons of lingo-cellulosic are produced every year, compared with $1.5x10^{8}$ tons of synthetic polymers. The main problems which elucidate the need and efficient utilization of agro-wastes and problems arising from usage of synthetic fibers can be outlined are studied.

MATERIAL AND METHODS

Material

Banana tree was arranged from the Kombolcha town (Ethiopia).

Composition of false banana fiber

The carbohydrate portion of the vast majority of FBF is composed of cellulose and hemicellulose polymers with minor amounts of other sugar polymers such as starch and pectins. The combination of cellulose and hemicelluloses are called holocellulose and usually accounts for 65-70 percent of the plant dry weight. When compared to other lignocellulosic plants, banana pseudo-stem has higher cellulose content probably due to the higher amount of fruit they support (Sinha, 1974; Lewin M, Eli, 1985;). The composition of false banana fiber is mention on Table 1.

Physical and Chemical Properties of FBF

Fine structure and appearance

Commercial banana and jute fibers are in the form of strands containing many individual fibers held together by natural gums. Both have good natural luster. Their color depends upon the condition under which they have been processed; good quality banana is off-white, where

Table 2. Physical properties of banana fiber

S.No	Physical properties	Banana fiber*	White jute	Tossa Jute
1	Single fibre tenacity(gf/tex)	46-64	35-45	35-50
2	Single fibre extension at break (%)	2.9-4.3	1.0-2.5	1.0-1.0-2.5
3	Fibre bundle tenacity(gf/tex)	24-30	13-29	15-31
4	True density(g/cm3)	1.31-1.33	1.44	1.45
5	Apparent density(g/cm3)	.62-.86	1.23	1.23
6	Flexural rigidity	33-40	4-6	4-6
7	Length of raw fibre(cm)	34-85	-	-
8	Moisture regain at 65%r.h	14.0-15.2	12.0	12.0
9	Fiber porosity (%)	35-53	14	14

* The banana species used was Musa sapientum from reference (Gupta et al., 1972).

as some poor quality fiber is nearly yellowish (Kulkarni, 1983; Batra and Subhash, 2010).

Tenacity modulus and elasticity

When we see the load elongation or stress strain property, banana fiber has less tenacity and elasticity property than other fibers like jute (Matthews, 1954).

Length

The strand length varies greatly depending on the precise source and treatment of the fiber during fiber extraction. If the fiber is removed from the full length of the sheaths, as in hand or machine stripping, fiber strands from the middle sheaths may run as long as 15ft or more; average length ranges from 3 to 15 ft (Barreto et al., 2010). The physical properties of banana are mention in Table 2 and comparing with other sources.

Water absorbency

FBF has higher capacity of water-release and water absorbability. Compared to other fibers like jute and cotton, false banana fibers have higher water absorbency and water release properties owing to a higher content of non-cellulosic material and lower crystallinity in the fiber structure.

Effect of acids and alkalis

According to different research works, acid hydrolysis results in the breaking of long chain molecules into shorter chains. In these cases, the bonds connecting the subunits are unstable to strong acid treatments, and the result is a loss of tensile strength. Like acids, as reported by different literatures, strong bases at high temperatures do not appreciably harm cellulosic fibers including false banana. However for bases, because of radical physical changes that improve the strength and appearance of false banana fiber, a special treatment with alkalis like sodium hydroxide is at times given to this fiber (Gupta et al., 1972).

Methodology and procedures

The false banana fibers were collected from all representative villages in southern, northern, western and eastern part of Ethiopia. Both fibers and stems were used as source of fiber material. The fibers from different locations were cut into small strips with scissors for carrying out chemical analysis. The Strips were small enough to be used for chemical analysis during FTIR tests. Some physical characteristics were recorded and the fibers were transported in sealed plastic bags, which were washed with detergents, rinsed with water and dried completely prior to use. Softening, alkalization and peroxide treatment was done by different chemicals like NaOH, H_2O_2 (30%), $NaClO_2$, and HCl for lignin and hemicellulose analysis.

Chemical and biochemical fiber modification

(a) Treatment with peroxide: Scouring and bleaching of false banana fibers was done using caustic soda and hydrogen peroxide. The major peroxide recipes were H_2O_2 (4% owf), NaOH (2%owf), Na_2CO3 (1.5% owf), Na_2SiO_4 (1.5%), $MgSO_4$ (1.5% owf), and a few droplets of wetting agent, at a temperature of 60^oC-90^oC for 1hour.

(b) Treatment with alkali: Alkalization at a temperature of 80-100^{O}C for 30 minutes- 1Hr with 2.5%, 5%, 10% and 15% NaOH with a few droplets of wetting agent was done.

(c) Treatment with softeners: False banana fibers are basically stiff, harsh and in consequence they do not possess good spinning properties. Raw false banana fibers if carded and spun in their natural state, without any oil in water emulsion, there would be heavy short fiber generation during spinning preparatory process, and the resultant yarn will be hairy as well as of very poor quality. To process false banana fibers successfully with minimum waste, it require to be softened (i.e. it must be made pliable) with nearly 35 – 40 % water as well as to be oiled to a limited extent which reduces the fiber – metal friction and the evaporation of water increases fiber to fiber friction (Klemm et al., 2005). The false banana fibers were treated with a number of softeners like castor oil, silicon softener, aloe vera, soap, cottonseed oil etc, for imparting a soft and supple feel to them in simple processes. The experiments were done in the lab scale by applying 4000 ml of water on 200 g of false banana fiber; 1-2% silicon softener, 4-6% (owf) castor oil; 4-6% (owf) castor oil , 6-12% (owf) aloe vera and 2%(owf) soap; 4-6% (owf) castor oil , 6-12% (owf) aloe vera , 2% (owf) soap and 4-6%(owf) cottonseed oil were applied.

(d) **Treatment with silicone softener:** Different grades and types of silicone and modified silicones are available. However, in this research, amino-silicone was used for modifying the false banana fiber. Peroxided and alkalized false banana fibres were treated with 0.5% -6% (owf) amino silicone emulsions followed by a pad-dry-cure technique.

(e) **Treatment with castor oil, cottonseed oil and aloevera:** The softener was prepared by the combination of castor oil (4-6%), aloevera(4-6%), cotton seed oil(4-6%), water and the emulsifier (2.5%). The purpose of emulsifier is to help the mixing of the castor oil and water since they cannot mix with each other because of the immiscible property of castor oil. The purpose of the aloe gel is to give the oil property plus enzymatic effect but the oils property gets lost if we do not preserve aloevera gel. To solve this problem we use castor and cottonseed oil during softener preparation.

Experimental methods adapted for analyzing results

(a) Fiber fineness: The fineness of representative false banana fibers was determined by using a microscope (single fiber fineness tester) and torsion balance. In case of torsion balance, the mass and length of the fiber was measured and calculated by the following relationship: Tex (1 Tex = 1g/ 1000m). Vibroscope works on the theory of vibrating strings to measure the fineness of individual fibers. Individual fiber samples were prepared. The fibers were hanged by the upper clamp and tensioned by a weight having a mass of 7000mg since the fibers are strong and coarse. After the fibers are tensioned, the wheel should be rotated by hand until a clear image of the fiber is seeing. Data from the display were recorded in terms of decitex after a clear image of the fiber was seen.

(b) Tensile strength: Tensile strength of false banana fibers was determined by using single thread strength tester. The separation (gauge length) between the upper and lower jaws was set to 250mm. The upper jaw was opened by unscrewing the wing nuts. The wing nuts were tightened and the jaw closed. The lower jaw is opened and the lower half of the specimen is inserted. It is ensured that there is no slackness. The jaw is closed and specimen secured. The application of load on specimen causes a tension to be developed in its axial direction. Data from the display was recorded in the form of elongation (%) and force (N) after the fiber got broken.

(c) Moisture content/regain: Moisture content of the fibers was determined using ETADRY (moisture testing oven) machine. The fibers were first weighed for their mass. The weighed samples were placed in the opened canister. The drying chamber lids were closed and the sample weighed. The oven is switched on and run for approximately 20 minutes at 105±5 degree centigrade. The oven is then switched off and without opening the oven doors, samples are re-weighed. Further weighing at interval of 5 minutes was done until there was no progressive weight change of the sample greater than 0.05%. The last weight record was taken as the dry weight of the sample. Moisture content and moisture regain of the fibers were evaluated using the formulae:

$$\text{Moisture Content} = \frac{(\text{Original weight} - \text{Dry weight}) \times 100}{\text{Original weight}} \quad \textbf{(1)}$$

$$\text{Moisture Content} = \frac{(\text{Original weight} - \text{Dry weight}) \times 100}{\text{Dry weight}} \quad \textbf{(2)}$$

(d) Weight loss: This is a reduction of the total body mass of FBF due to a mean loss of fluid, bark, hemicelluloses, lignin etc, by treating the fibers with chemicals like NaOH, H_2O_2, Na_2CO_3, $MgSO_4$ etc.

Weight loss % = [(IW – AW) /IW] x 100

(3)

Where, IW is initial weight and AW is actual weight.

(e) Fourier transform infrared analysis: To study the chemical property of the untreated and treated false banana fibers from various varieties, FTIR spectra was taken at the wavelength of 4000-400 cm^{-1}. The fine powdered sample of untreated and treated fibers with pellet was taken to record the FTIR spectrum, using Jasco FT/IR- 460 plus FTIR Spectrometer.

(f) Flexural / bending / torsional rigidity: The method of Searle's double pendulum was taken as a

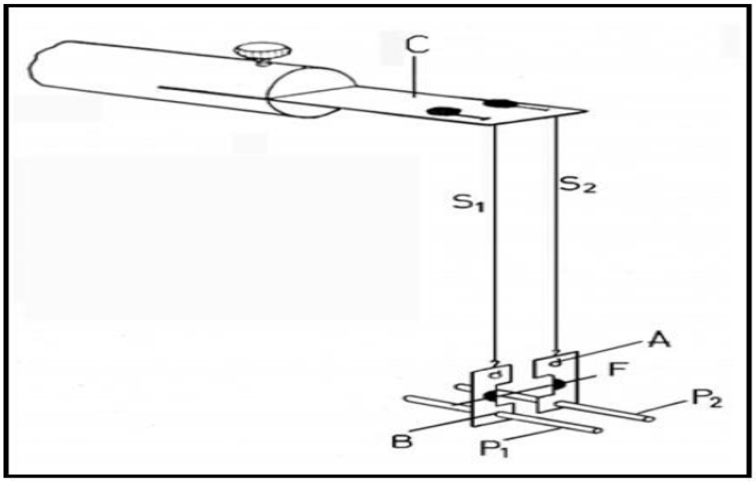

Figure 2. Schematic of the instrument for measuring bending rigidity

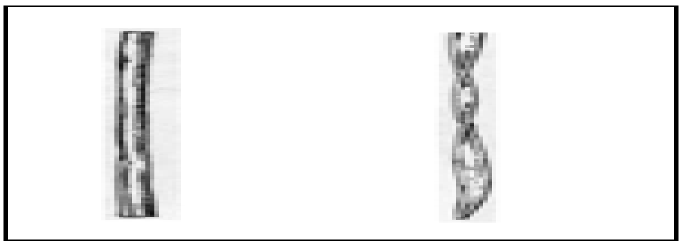

Figure 3. Longitudinal macroscopic view of FBF

basis for measurements of the bending rigidity of FBF fibers, which is shown in Figure 2. The measuring instrument used for the fibers rigidity.

The schematic shows a pair of pendulums P_1 and P_2. The rod in a hole B is attached to a metal plate of special shape and thickness 0.005 or 0.010 inch. In the instrument described in the pendulums, the mass about 0.065 g and moment of inertia $7.75{*}10^{-10}$ kg×m^2 is kept. The pendulums are hung on the block plate C by the filaments S_1 and S_2 of 20 cm length. At the bottom ends, the filaments have little hooks by which the pendulums are hung in holes A. In plate C the filaments are drawn through small holes 5 mm apart and the ends are fixed with wax to the surface of the plate. The fiber specimen (F) of 5 mm length was glued to the surface of the plates as shown in figure 2 so the spacing of the filaments S_1 and S_2 along the whole length is the same (5 mm). The registered period of vibration depends on fiber bending rigidity (C_g), which is calculated by the following formula:

$$Cg = \frac{2\pi 2JpL}{Tg2} \tag{4}$$

Where J_p is a moment of inertia of one pendulum, in kg (m)^2; L is the length of fiber specimen, m, T_g is the mean period of vibration of the fiber-pendulum system, s. while the registered period of torsional vibration T_t depends on the moment of inertia J of the weight and on the torsional rigidity C_t of the pull rod that the weight was hung on. Substituting the pull rod with the fiber specimen, the torsional rigidity of the fiber can be obtained using the formula:

$$Ct = \frac{4\pi 2Jp}{Tt2} \tag{5}$$

RESULTS AND DISCUSSION

Structural change

Alkalization treatment improves the fiber surface adhesive characteristics by removing natural and artificial impurities, there-by producing a rough surface topography. After chemical treatment the size of crystallites, longitudinal shape and their orientation modified FBF from cylindrical to convoluted shape, which is shown in Figure 3. This property is desirable to enhance the spinnability of the fibers because the fiber can easily pass through different rollers without slippage. The weight losses during peroxide treatment were mention in Table 3.

Table 3. Weight loss during peroxide treatment

	Weight before bleaching	Weight after bleaching	Weight Loss (%)	Chemicals and recipe
Average weight of FBF	288.82	253.4597	12.243	H_2O_2=4%owf; NaOH = 2%owf Na_2CO_3=1.5%owf;MgSO4 =1.5%owf MLR = 1:20;Few droplets of wetting agent; Temperature =100 ^{O}C; Time =1Hr
	402.56	350.06	13.0415	H_2O_2=4%owf;NaOH = 2% owf MLR =1:20;Few droplets of wetting agent; Temperature =100 ^{O}C; Time = 1Hr

Table 4. Weight loss during alkalization

S.No	NaOH Concentration	Total weight before alkalization	Total weight after alkalization	Weight loss (%)	Chemicals and recipe
1	2.5% Treatment	338.1665	324.2286	4.1216	MLR = 1:20 Time = 30 min Temperature= 95^{o}C
2	5% Treatment	338.1665	306.4255	9.3862	
3	10% Treatment	126.08	111.9938	11.1724	
4	15% Treatment	126.08	106.1338	15.8203	

Table 5. Weight loss during alkalization

S.No	% of NaOH concentration	Total weight before bleaching and mercerization	Total weight after bleaching & mercerization	Weight loss (%)
1	2.5% NaOH Treatments	126.08	112.7027	4.1216
2	5% NaOH Treatments	126.08	110.1736	9.3862

Weight loss

When FBF was treated with different chemicals like alkali and peroxide, during the removable of bark and other impurities, considerable weight loss was observed. The main objective of chemical treatment was to decrease the crystal structure of cellulose by a penetration and swelling of the crystalline regions of the fiber so that it can absorb moisture well (Han, 1998).

$$\textit{Fiber – OH + NaOH} \longrightarrow \textit{Fiber } O^{-}Na^{+} + H_2O, \textit{ NaOH}$$

Treatment leads to the irreversible alkalization effect which increases the amount of amorphous cellulose at the expense of crystalline cellulose. Crystalline reduction is achieved by removal of lignin, hemicellulose and other residues from the surface of the fibers. As the result shows form the given tables the weight of the fiber was decreased by 9.3862% after the alkali treatment. The weight losses during alkalization are mention in Table 4 and 5.

Fiber fineness

The fineness of representative false banana fibers and jute fibers were determined by using a vibroscope and torsion balance. The result shown that the average fineness of false banana fiber is 6.45 -7 Tex. The fineness of banana fibers is an average of 6.77 Tex. Therefore, the fineness of false banana fiber and banana fiber is relatively close to each other. But as compared to jute fiber, false banana fiber is coarser. The fineness should be improved by treating the fiber with caustic soda, so as to manufacture fine yarn. The fineness of the fiber is related to the hardness and rigidity of the fibers.

Table 6. Fineness of FBF

S.No	Sample name	Fineness FBF (tex)
1	Raw false banana fiber	31.2
2	Alkalized FBF by 2.5%NOH	8.2
3	Alkalized FBF by 5%NOH	5.46
4	Alkalized FBF by 10%NOH	4.8
5	Alkalized FBF by 15%NOH	3.7
6	FBF bleached with H_2O_2 & NaOH	5.5
7	FBF bleached with H_2O_2,Na_2CO_3 and NaOH	5.8

Table 7. Tensile properties of FBF

S.No	Samples	Tensile strength (MPa)	Extension (mm)	Elongation at break(%)
1	Raw FBF	176	2.1	1.8
2	FBF treated with alkalization and peroxide followed by softener	519.2 (by silicon)	2.7	2.4
		525 (batching oil)	2.9	2.8
3	Treated (alkalization and peroxide) with vegetable oil.	743	3.3	3.6

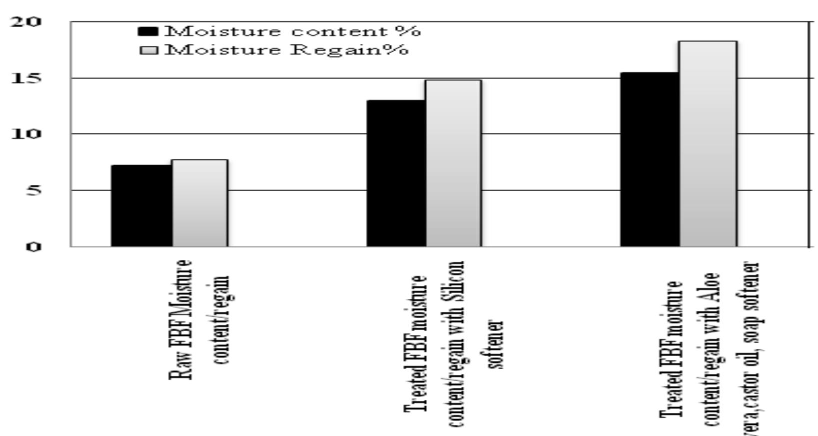

Figure 4. Comparison of moisture content and regain of raw and treated FBF.

The fineness of false banana treated with different chemicals is given in Table 6. As the result shows, treating FBF with caustic soda by changing concentration of NaOH gives different fineness values. So fineness of the fibers was good if FBF was alkalized with concentrated NaOH (15%) but as we increase the concentration of caustic soda the strength of the fiber decreases. So the better fineness without affecting the fiber strength was obtained between 2.5% - 5% NaOH concentration.

Tensile strength

Tensile tests were carried out at strain rates of 0.1 mm/sec. The tensile properties of false banana fiber softened with silicon and vegetable oils along with that of peroxide and alkalization are presented in Table 7.

From the experimental results remarkable differences can be seen on the ultimate tensile strength of FBF treated with different softeners, which is shown in Figure 4. It can be noticed that for all specimens the ultimate tensile strength of false banana fiber treated with silicon softener was 519.2 MPa though it was still less than that of the vegetable oil treated one (castor and cotton seed oil), which had ultimate tensile strength of 743 MPa. It was seen that addition of silicone and vegetable oils on the fibers significantly affects the modulus of elasticity. About 12% increase in modulus of elasticity has been seen due to alkalization and softening (James et al., -1996).

Table 8. Moisture content/regain FBF after softening with oils.

S.No	Sample	Original weight	Weight after 20 min	Weight after5 min	Weight after 5min	Weight after 5 min	Oven dry weight	Moisture content %	Moisture regain %
1	Raw FBF	34.31	32.1136	31.9653	31.9553	31.8239	31.8239	7.1857	7.745
2	FBF softened with silicone	24.22	21.12	21.1	21.09	21.0801	21.08	12.9645	14.8956
3	FBF softening with Aloe Vera, castor oil, cottonseed oil, soap	24.22	21.12	23.3513	23.3301	23.32	23.32	15.4766	18.3105

Table 9. Percentage improvement in softness of FBF after treatment

S.No.	Sample	Flexural Rigidity(Ncm2)	Softening (%)
1	Raw false banana fibers	1.2438	-
2	Treated with silicon and NaOH	0.7768	37.54
3	FBF treated with castor Oil, cottonseed oil, soap	0.69	44.52
4	Bleached, Alkalized , and treated with Castor oil, cottonseed oil, soap	0.3226	74.06

Table 10. Bending and torsional rigidity before and after treatment

S.No	FBF Parameter	L,cm	T_g,S	T_t,S	Cg, Nm^2	Ct Nm^2
1	Before treatment	100	5.98	7.11	$4.72*10^{-9}$	$6.68*10^{-9}$
2	After treatment	96.67	7.23	9.55	$3.12*10^{-9}$	$3.7*10^{-9}$

Moisture Content

The main problem with FBF is its very low moisture holding capacity. For example, if a bone dry mass of the fiber is immersed in water, more water molecules can diffuse in, initially, to form hydrogen bond between the hydroxyl groups of the fiber and water molecule. But it does not retain the moisture from it. As we observed from % of weight loss given from the above Table 8, treating of the false banana fibers with different chemicals(to removes impurities like, hemicelluloses, lignin, fat and wax) results the fiber can absorb more water. To retain this moisture in the fiber for a long time, the fibers were softened with castor oil, cotton seed oil, and aloe vera. From the experimental results we know that the moisture content of FBF improved from 7.1857 to 15.4766 % by softening the fiber with vegetable oils (Arun, 2000).

Flexural rigidity, bending rigidity and torsional rigidity

The flexural rigidity is a characteristic for estimating the degree of softness of FBF. The experimental result shows the change in basic physical and mechanical properties of the fibers after peroxide, alkalization and softening treatments. The flexural rigidity and percentage improvement in softness obtained with false banana. Fibers treated with different softeners are shown in the table below. Fiber rigidities, the mean periods of pendulums vibration in bending (T_g) and in torsion (T_t) on whose basis the mean bending and torsional rigidities were calculated are shown in the table below. In the investigations of fiber rigidities in each case 30 singular periods were measured (Gordon, 2000). Mean bending and torsional rigidities of the FBF are mention below in Table 9.

From the given data in table 10 it is evident that the FBF are very rigid fibers. After chemical treatment the bending rigidity of fiber reduced approximately by 33.89%. Quite similar situation was seen for the results of the influence of chemical treatment on torsional rigidity. After chemical treatment the fibres became almost similar rigid in torsion as the Bangladesh tossa cuttings fiber (imported jute fiber in Ethiopia). Generally if false banana fibers were treated with the combination of aloe vera, castor oil, cotton seed oil and

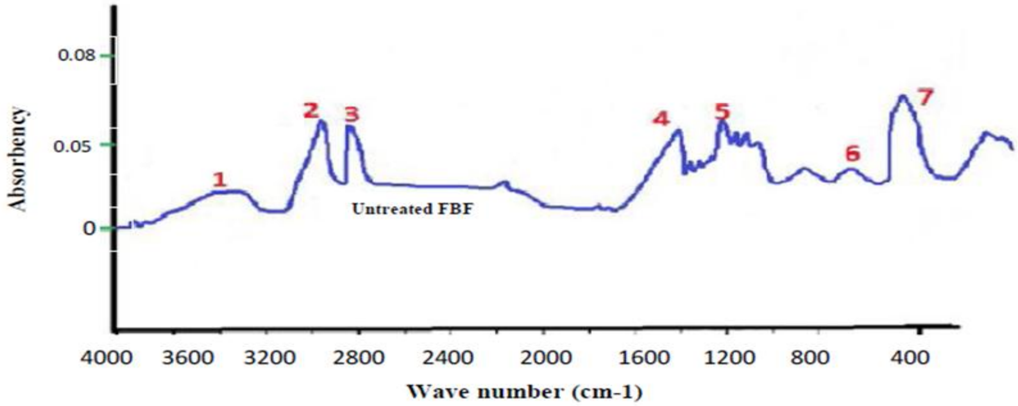

Figure 5. Infrared spectroscopy of false banana fibers

soap with alkalization and peroxide, we can improve the flexibility and process ability of FBF by 74.06%.

Fourier Transform Infrared Analysis (FTIR)

FTIR spectrophotometry is an appropriate technique to establish the variations introduced by the different treatments on the chemical structure of false banana fibers. FTIR spectra of untreated and treated false banana fibers are shown in the figures in subsequent segments.

FTIR for raw FBF

The Fourier transformed infrared study for raw FBF is shown in Figure 5. It was found that spectra of FBF raw samples exhibited a strong band at 896 cm^{-1} due to C-O-C symmetric stretching dialkyl ether linkages and C-O stretching vibration in cellulose, hemicellulose and minor lignin contribution.

In the Figure 5 points indicates bond between inside the fibres which mention in below:

1 - Hydroxyl group and bonded O-H stretching(C+L) C - (cellulose + hemicellulose)

2 - CHn aliphatic and aromatic (C+L)

3 - CHn aliphatic and aromatic (C+L)-O; 4 - CO(C+L);

5 - Large overlapping of C-C, C=C, CO, OH, C-O-C, CH aromatic, CHn band

6 - CO, C-O-C (C)

7 - C-C-C symmetric stretching and C-O stretching vibration(c+ minor L)

A large band 3452 – 3100 cm^{-1} is characteristic of the polymeric association of the hydroxyl groups and the bonded O–H stretching vibration present in carbohydrates (cellulose + hemicellulose) and lignin. A large region of absorption can be seen involving overlapping bands in the range of 1635-1100 cm^{-1} due to C–C, C=C, CO, CHn, C-O-C, CH aromatic linkages; band at 2927, 2850, 1635, 700-900 cm^{-1} is seen due to vibrations of CHn (aliphatic aromatic) present in carbohydrates and lignin. For all of them the strongest peak occurred around 896 cm^{-1} after the treatment:

Fiber-OH + NaOH $\longrightarrow$ Fiber-O^- Na^+ + H_2O

The most significant effect introduced by alkali treatment was associated with the attenuation of vibrations around 1745–1725 cm^{-1}, which corresponds to the reduction of carbonyl groups present into fatty acids of the fiber and C=O of non conjugated ketone present in hemicellulose. The slight intensity decrease of the band around 1510 cm^{-1} showed that some lignin is removed, but these compound still remains on fibers after alkalization. Vibrations in the region between 3000 and 2850 cm^{-1} associated with the C-H stretching of lignin, hemicelluloses and cellulose, decrease upon alkalization. A comparatively FTIR studied of FBF with different concentration of NaOH is shown in Figure 6 below

CONCLUSION

From the experimental results, the treated false banana fiber softened with vegetable oil and aloe vera gel shows excellent moisture content, good flexibility, and good fineness as compared to the untreated ones. When FBF was alkalized and bleached, the crystalline part of cellulose becomes amorphous, hydrophobic components like lignin, pectin, wax and gummy substances are removed and also the fibers become individualized and disintegrated by removing the bark. This treatment made the fibers to retain more water. On the contrary, results in loss of weight due to the dissolving of hemicelluloses and lignin is an indirect benefit which reduces the cost related to the weight of sack during import –export and local market selling. The presence of hemicelluloses, lignin and wax contributes

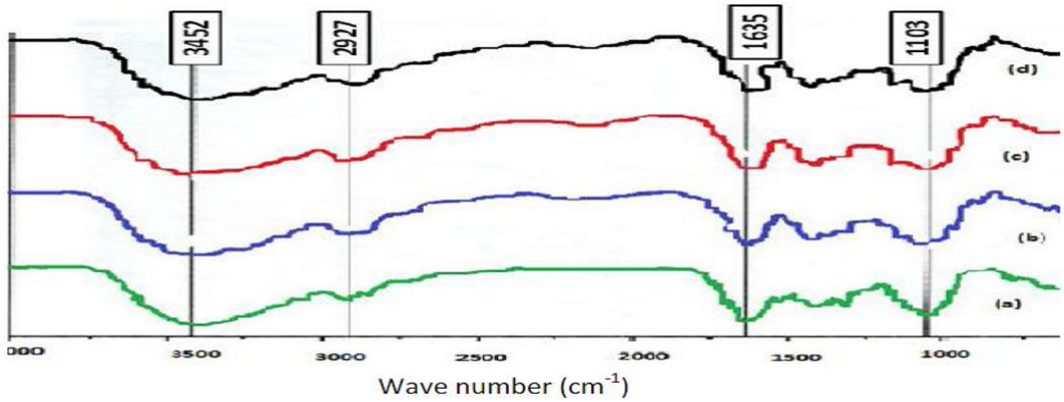

Figure 6. FTIR of FBF (a) raw fibers (b) treated with 2.5% (c) treated with 5% and (d) treated with 10% of NaOH

to a homogeneous morphology of the natural composite of false banana fibers while treating with caustic soda (2.5%-5%), the soluble components (hemicellulose, lignin and wax) were partially removed. some cavities also appeared due to modifications on the surface. That is, cylindrical shape of the fiber was changed in to a convoluted shape; this effect can contribute to improve its spinnability. Generally, it was seen that caustic soda, aloe vera and vegetable oils performs best in imparting softness, supple feel and flexibility to FBF fibers with low cost of treatment. Therefore FBF can be used economically for sack manufacturing with a higher cover factor and for producing diversified products.

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