SABAI GRASS FIBER: AN INNOVATIVE AND SUSTAINABLE TEXTILE FIBER

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ABSTRACT-The review is based on the study of properties of Sabai grass fiber (Eulaliopsis Binata) for making low-cost fiber reinforced composites with an approach to creating an environment-friendly greener world. It has already been developed Natural Fiber Reinforced Composites (NFRC) from bamboo, coir, hemp, rice straw, wood fiber. Man-made/Synthetic fibers are now replaced by natural bio fibers for their numerous novel properties like strength to weight ratio, low density, low cost, biodegradable, reusable etc. Saibai grass fiber is an innovation of this type, which will be inline to build a healthier and sustainable environment. It has excellent properties which will be used as filler material in making composites. Hence, it's the right time to make some alternation and move back to nature for efficient fiber replacing the synthetic one.

Keywords: **Saibai Grass Fiber; Eulaliopsis Binata; Low Cost Composites; NFRC; Sustainability; Environment friendly;**

1. INTRODUCTION

Eulaliopsis Binata (EB) commonly known as Sabai, Babui or bhabar, is a perennial plant comes under the grass family Poaceae. It is mainly grown in south-east China province and also found in some other Asian countries such as India, Pakistan, Nepal, Bhutan, Myanmar, Thailand, Malaysia and Philippines. It covers a major forest area of certain states like Bihar, Orissa, Punjab, West Bengal and Central part of India. Sabai Grass is only the second important raw material after bamboo for manufacturing of paper in India. It has been used in making paper since 1870.[1,18] Apart from being used in paper making it has been used in rope making that are useful for making household furniture and also to tie cattle. In Odisha, it is mainly considered as the lifeline of tribal people in Mayurbhanja district. It is harvested annually during the month of November and December, having a total turnover of around 3to 4 crores annually.[4] It shows even more comparative properties than the existing natural fiber. Its cellulose content is approximately 45%, which is higher than sisal and palm and lignin content is approximately 18%. It shows excellent fiber length of around 20mm, good flexibility. It also shows excellent strength and toughness. It also plays a crucial key role in soil-water conservation, which maintains the ecology as well**.**

2. WHY NATURAL FIBERS?[2]

a) It has changed the economic scenario of many developing countries by feeding and giving a job for a better lifestyle. In addition to that, it is somehow lowers the hunger and poverty rate and hence, make some contribution towards the country's GDP also. Therefore, it is called a "***Responsible choice***".

b) Natural fibers have a great impact on our day to day life as cotton give cool effect on a hot day whereas wool makes warmer in winter. Coconut possesses resistance to fungus, hemp, and bamboo from bacteria. Besides these, linen is used for hospital bed sheets due to its inherent hygienic property. Due to the above-mentioned properties, natural fibers are hence called a "***Healthy choice***".

c) Greener world means the use of renewable energy, low carbon emission, recyclable raw material for big polymer manufactures. These qualities make the natural fibers an "***Eco-friendly and sustainable choice***".

d) These fibers have high mechanical strength, low weight and cheap in cost as compared to other fibers. It has been used as reinforcement material in cement and polymer composites, making it as a "***Hi-tech choice***" for the current technological world.

e) Fashion means creativity and natural fibers create a delicate effect on garments. Now a day fashion market demand for eco-fashion and natural fibers take a vital role in fulfilling this. At last, we can call it the ultra-modern "***Fashionable*** choice" also.

3. PROPERTIES OF SABAI GRASS FIBERS

The natural textile fibers of plant extract are of major five types i.e. bast fibers, leaf fibers, seed fibers, fruit fibers, grass fibers and wood fibers. The first three types of fiber are together called as vegetable fibers.[3] Sabai grass fiber is of grass fiber type. The physical properties of plant fibers are generally depended on both the internal structure and constituents of that plant. These fibers composed of lingo-cellulosic structures having cellulose, hemicelluloses and lignin as major components and several minor components such as pectin, wax, protein, tannins, ash, coloring material, nitrogenous substances, and inorganic salts. The constituent materials are different depending upon the ultimate climate, digestion processes, growing conditions, plant age, soil and source of the fiber. Its properties just alike plant fiber; hence it got a place in the plant fiber classification table.

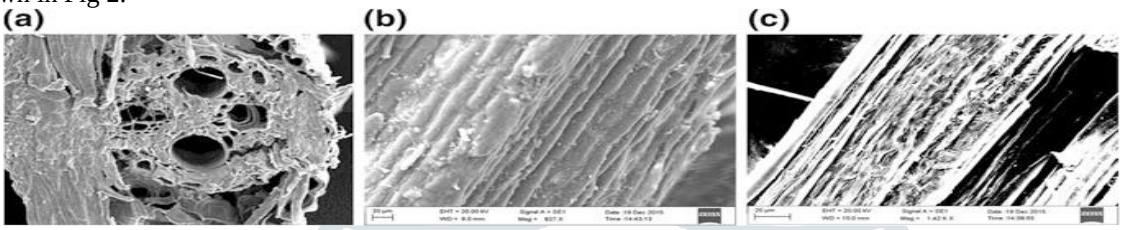
3.1. PHYSICAL PROPERTIES OF SABAI GRASS FIBER

Sabai grass fiber has some unique physical properties when compared to other textile fiber. The raw Sabai grass and its fiber just look like as shown in the fig. 1 and fig. 2 respectively.

[Fig.1 Raw Sabai Grass][5]

[Fig.2 Extracted Sabai Grass Fiber]

Its anatomical structure is quite open and loose with a very low percentage of lignin make the fiber bleachable easily. Its SEM analysis gives clear idea about the internal structure and important characteristics that found in individual fiber and shown in Fig 2.[6]



[Fig.3 Scanning electron microscope images (a) Cross sectional image of Sabai grass fibre (b)Sabai grass scoured Bleached SEM1(c)Sabai grass SEM1[7,8]]

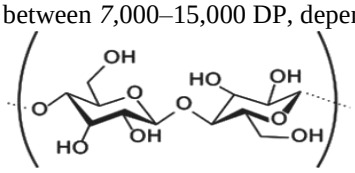
The average length of sabai grass fiber is 2.4 mm whereas bamboo is 17 mm. Hence, it possesses better mechanical properties than that of bamboo in every aspect. The uniqueness of its morphological characteristics along with low lignin content makes it preferable for pulp and paper manufacturing industry. The manufacturing of quality paper is due to the good water drainage system, which is shown by the cross-sectional images of fiber.[9] It implies to be very less refining to create fibrillation, hydration and inter-fiber bonding for its making. The other morphological/ Physical properties are shown in Table 1.[6,7,8]

Sl No.	Parameters	Range of value	Mean value
1.	Colour	Brownish yellow	
2.	Fiber Length(in mm)	0.35 -4.4	1.57
3.	Fiber width(in µm)	7-45	13.5
4.	Lumen Diameter(in µm)	---------	1.11
5.	Cell wall thickness(in µm)	---------	6.3
6.	Fiber curl index(in mm)	0.50 - 10.0	0.162
7.	Fiber kink index(in mm)	0.50 - 5.0	2.01
8.	Runkel Ratio		11.4
9.	Ultimate Tensile Stress(in MPa)	---------	76

Table 1.Physical properties of Saibai grass fiber

3.2. CHEMICAL PROPERTIES OF SABAI GRASS FIBER WITH COMPARISON WITH OTHER PLANT FIBER:

The Sabai grass fiber is chemically composed of cellulose, hemicelluloses, lignin, and ash. The fiber is very much similar to cotton in terms of cellulose content. Cellulose is the main structural component, providing strength and stability to the plant cell walls and the fiber. The typical structure of cellulose is shown in fig.4. The fiber properties, fiber production, and its uses are influenced by the amount of cellulose content. Fibers having higher cellulose content are preferable for textile. As the cellulose content is above 50%, it is also used in textile purpose. The degree of polymerization (DP) of cellulose plays a key role in determining properties of fiber and the value varies between *7*,000–15,000 DP, depending upon the type of fiber.[10,11,12,13]



[Fig.4 Structure of cellulose]

Hemi-cellulose is a copolymer and generally located in between the interface of cellulose and lignin. The structure of hemicellulose varies depending on the type of plant. Its DP is within the range of 500–3,000. It has little strength due to the amorphous region present in it. It is highly hydrophilic in nature and almost soluble in alkaline solution. In addition to that, we can also easily hydrolyze it in acid. The following table 2 shows the chemical constituent of plant based fibers.

Sl No.	Type of Fiber	Annual Availability 10^3 tonnes	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Ash (%)
1.	Corn stover	727	38-40	28	7–21	3.6–7.0
2.	Pineapple leaf fiber	-	70-82	18	5–12	0.7–0.9
3.	Coir	100	36-43	0.15–0.25	41–45	2.7–10.2
4.	Bagasse	100	32–48	19–24	23–32	1.5–5
5.	Banana	-	60–65	6–8	5–10	4.7
6.	Wheat straw	568	33–38	26–32	17–19	6–8
7.	Rice straw	579	28–36	23–28	12–14	14–20
8.	Sorghum stalks	252	27	25	11	–
9.	Barley straw	195	31-45	27–38	14–19	2–7

[Table 2 chemical constituent of plant based fiber]

4. SABAI GRASS AS SUSTAINABLE TEXTILE FIBER

The following special characteristics of Sabai grass fiber make it a sustainable and useful textile fiber.

4.1. ACID HYDROLYSIS

The hydrolysis is done at textile chemical processing lab in Cet, Bhubaneswar. The materials are Sabai grass, H_2SO_4 solution, HCl solution, HNO_3, Liquor ratio1;15, Temperature 45^0,$55^0$and 65^0.

[Fig. 5: Typical view after acid hydrolysis]

4.2. ALKALI-H_2O_2 ONE BATH DEGUMMIMG PROCESS

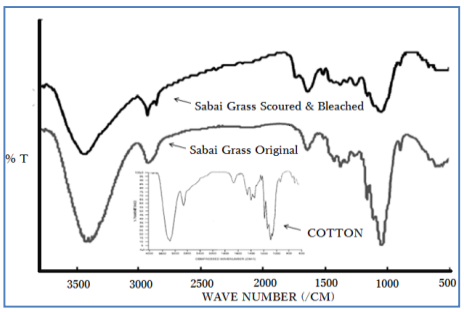
The ***alkali-H_2O_2 One Bath Degumming Process*** is considered as the conventional method for extracting EB fibers. The Hydrolyzed Sabai grass will be processed in degumming with the use of some chemical constituents like *Magnesium Sulfate* ($MgSO_4.7H_2O$) Solution (5g/L), *Hydrogen peroxide* (H_20_2) Solution (4g/L), *Amino Trimethylene Phosphonic Acid* (ATMP), *Magnesium Chloride* ($MgCl_2$) as the stabilizer. It is evident that the material to Liquor ratio (M/L) will be in the ratio of 1:15 at a maintained temperature of 99^0C for 150 minutes in automatic shaker machine. After completion of the degumming process, it is necessary to give hot wash followed by a cold wash for the removal of sticky chemical that used earlier and dried it before using it in other use.[14,15]

4.3. FTIR ANALYSIS

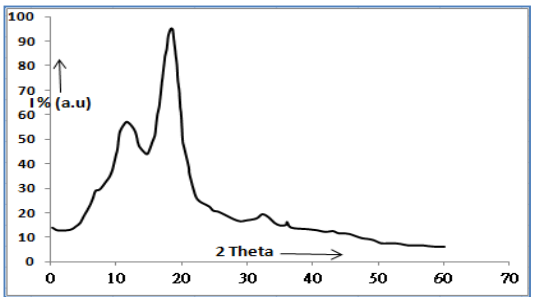
0.01gm of finely crossed powder of fibre mixed with 0.2gm of FTIR grade KBr and mixed well in dry condition. Tablet was made by pellet making apparatus supplied along with Perkin Elmer FTIR and spectra were measured for untreated and extracted Saibai grass fibers. The comparison with cotton is shown in Fig.6 along with FTIR spectra of treated and untreated sabai grass at the lower side. It has been seen that most cellulose structure in Eulaliopsis binata is not disrupted by the acid hydrolysis and the fingerprint transmittance peaks of cellulose are preserved in all cases (peaks of 3402 cm−1 for OH group, 1431, 1166, 1059 cm−1 fingerprint area attributes to the cellulose structure).

4.4. XRD ANALYSIS:

The pectin and hemicelluloses have been eliminated to some extent, extracted fibers giving the absence of vibration peak at ≅1735 cm−1 region. The absorption band of lignin is found at 1510 cm−1 region in Sabai grass raw fiber. But, it is absent in case of extracted fiber as the non-cellulose material like pectin, lignin, hemicelluloses, wax etc. was being removed, leaving cellulose I structure with more crystalline region and orientation as compared to original raw Sabai. The fig.7 shows the typical view of XRD analysis of hydrolyzed Saibai grass fiber.



[Fig.6 FTIR of Eulaliopsis Binata: Original & Scoured and Bleached (Lower case: cotton)[16]]



[Fig.7 XRD of Hydrolysed Saibai]

4.5. ANTIMICROBIAL EFFECT

The Saibai grass fiber is treated with two different microbes such as E.coli (fig.9)and yeast(fig.8).
We cannot find any any kind of effect but we can try different microbes for this affect.

[Fig.8 Yeast Microbes]

[9.E.Coli Microbes]

5. RESULTS AND DISCUSSIONS

The Sabai grasses have unique morphological structure, which was shown in SEM images.[fig.2] It is also evident that the XRD and DSC analysis gives some interesting data that reasonably compares with the cotton fiber. Hence, we can try to dye it with the same kind of dye used for cotton. The fiber can be used for making low-cost composites as it has a high percentage of cellulose. The fiber degradation and weight loss after the alkali treatment is negligible. Moreover, the extracted fiber shows comparable breaking strength as well as moisture retention very much similar to cotton and flax. As it is abundantly available at very low cost and is relatively grow easily, making a good alternative to make some sustainable eco-friendly composites. As per a report, the *Khadi and Village Industry Commission* under *gramodyog rojgar yojana* estimates that from an investment of around 1 lakh there would be a return of around 118%,94%,82% and 70% in consecutive years. We can also be used this for manufacturing of supercapacitors (*Electric Double-Layer Capacitors* (EDLCs)).[17] EDLCs are rechargeable electrochemical energy storage devices having higher values than other capacitor types available in the market. The antimicrobial effect in the case of E.Coli and yeast is negligible, but it is an area of research for other microbes.

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