

Palm leaf sheath fiber extraction, bleaching, softening and characterization of effect of softening on longitudinal view, tensile strength and elongation of the fiber

Abstract

Sheath of Palm tree indigenous to Ethiopia was used to extract fiber by chemical degumming using 80 % sodium hydroxide; bleached, softened and characterized the physical properties of the extracted fibers before and after softening. The extracted fibers were subjected to bleaching using 30% H₂O₂ bleaching agent to remove the reddish yellow color of the extracted. By mass; 203.4g of decorticated dried palm tree sheath was subjected to chemical degumming. Degumming of the raw decorticated palm sheath with 20% sodium hydroxide solution and 5% wetting agent was carried out. The degumming process was incubated at the temperature 120°C for 2hours. To remove residual gummy substances which are already dissolved and left on the fibers; the fibers were washed by warm water and dried. It's found that 28.87% degummed fiber was extracted. After bleaching the degummed fibers; the fibers were washed to remove residual H₂O₂ from the fibers. The bleached fibers were treated by silicone emulsion to soften the fibers. Finally the fibers were dried and their Characteristics (before and after softening); Longitudinal view, Tensile strength at break and Elongation at break characterized. Also moisture regain (R %) and moisture content (W %) of the softened fibers were characterized and found as 12.65 and 11.23% respectively.

Keywords: fiber extraction, bleaching, softening, characterization

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Introduction

The different sources of Natural fibers are Animals, plants and Minerals. Plant fibers can be extracted from stems, leaves, roots, fruits and seeds etc. Many researchers have been investigated the use of natural fibers as reinforcements in polymer composites.¹⁻⁴ several Investigations were conducted on the mechanical properties of composite materials reinforced with natural fibers including palm, Kenaf, jute, hemp, flax, bamboo, etc.⁵⁻⁸ Studies undergone by researchers^{9,11} have shown the possibility of fiber extraction from oil palm tree stems, fruits, trunk and leaves. Different fiber extraction methods have been explored, including water retting and underground burying next to the stream followed by wetting with water for 20 days.¹⁰

By another review paper it is stated that enhancing hydrophobic nature by suitable chemical treatments is necessary in order to develop composites with improved mechanical properties and different types of natural fibers are subjected to a variety of physical and chemical treatments. The types of treatments studied in these papers include Physical treatments such as beating and heating, and chemical treatments like alkalization, silane, acetylation and benzylation. The effects of these treatments on mechanical properties of the composites are analyzed. Fractures are analyzed by using the scanning electron microscopy (SEM). Analysis by FTIR and DMA showed that physico-chemical changes of surfaces of treated natural fibers. In general, treatments to the fibers can significantly improve adhesion and reduce water absorption, thereby improving mechanical properties of the composites. The purpose of this review paper is to summarize

the research work done on various pretreatments in the preparation of natural fiber reinforced composites and to highlight the potential use of natural fiber reinforced polymer composites in industry and its potential to replace the synthetic fiber composite and conventional materials in the future.¹² But this review paper did not investigate the effect of the pretreatment and softening on longitudinal, tensile and elongation property of the fibers.

In this study, the extraction of palm tree sheath fiber was carried out using chemical degumming method. The extracted fibers were bleached, softened and their longitudinal view, Tensile strength at break and Elongation at break characterized before and after softening. There are few reported morphological and mechanical characteristics of palm fiber bundles in few publications. But the effects of bleaching and softening on the fiber morphology, Tensile strength at break and Elongation at break are left behind without investigation. This research is commenced to disclose the effect of the bleaching and softening treatments on the longitudinal, Tensile strength and Elongation palm fiber.

Materials and methods

Materials

In order to extract palm fiber from palm sheath the following materials were used: Gloves are used to prevent stinging from the plant), cut palm tree stem sickle was used, vat for degumming and to immerse decorticated fiber, thermometer, Digital weighing balance pipette and chemicals (NaOH, H₂O₂ AND wetting agent).

Methods

Palm leaf sheath preparation: Palm leaf sheathes harvested from kombocha-Ethiopia. The sheath stripped off the leaves and thorns carefully with the help of the sickle, without causing any damage to the stems. The leaf sheath dried in a shaded area out of direct sunlight

for two days. Then soaked with water for two days to facilitate removal of sheath husk. Finally; washed the fibers with water and chemical degumming continued.

As shown in Figure 1 palm leaf sheathes swell when soaked so that decortications of the sheathes will be easier.



Figure 1 Procedures of palm leaf sheath preparation for extraction A) Harvested leaf sheath B) Soaked leaf sheath C) decorticated fiber.

Chemical degumming: The gum present in palm leaf sheath is composed of primarily xylan (Hemi cellulose or Pectin's) which are in soluble in water but easily soluble in alkaline solutions which means degumming is the process of removing pectin's and impurities like ash from palm. Palm sheath was initially boiled in alkaline solution (NaOH) to dissolve the gummy substance inside the sheath then washed with water to remove the dissolved gummy substance. The procedure employed to degum the leaf sheath was; first 20 % sodium hydroxide is prepared and taken in to a vat. 203.4gm of raw decorticated palm fiber immersed in to the alkaline solution. The fiber liquor ratio kept at 1:10 and with 0.5 % wetting agent. The mixture is incubated at 100°C for 2 hours 30 minutes. Finally washed the fibers with warm water to remove the dissolved gummy substance and then dried.

As it is clear from Figure 2, the color of raw fiber extracted from palm leaf sheath by chemical degumming is reddish yellow and the raw extracted fiber is sticky.



Figure 2 Raw palm leaf sheath Fiber extracted by chemical degumming. The raw fiber has reddish yellow color and its sticky.

After extraction by chemical degumming; the extracted fibers were dried in oven dry to almost dry constant weight (Mf) of the fiber and the amount of fiber extracted from palm leaf sheath was calculated as the ratio between the final weight of the fiber (Mf) and that of the palm tree leaf sheath before chemical degumming (Mi).

As it is stated in Table 1; 351.3gm of palm leaf sheath was extracted by chemical degumming and yield 102.4gm fiber. This weight is not the actual weight of fiber; its weight of fiber and the moisture. The fibers were dried in oven dryer and the fibers were weighed after every 15minutes. The Fiber did not show significant weight reduction for the last oven dry (M4). This implies the fiber is fully dried and the actual fiber weight is 101.47gm. From the above table; by taking 351.3gm as leaf sheath extracted by chemical degumming (Mi) and 101.47gm as final dried weight of yielded fibers the amount of fiber extracted from the palm leaf sheath was calculated as follows:

$$\begin{aligned} \text{Extracted Fiber}(\%) &= \frac{MF}{Mi} * 100 \\ &= \frac{101.47gm}{351.3gm} * 100 = 28.87\% \end{aligned}$$

Table 1 Weight of palm leaf sheath, extracted fiber and oven dried fibers in calculating fiber yield of palm leaf sheath. Oven dry weight after completing drying the extracted fiber in oven, i.e, no more weight change due to drying was used as dry weight

1	Prepared leaf sheath for extraction	351.3g
2	Oven dry weight of extracted fiber (M1)	102.4g
3	Oven dry weight of extracted fiber (M2)	101.7g
4	Oven dry weight of extracted fiber (M3)	101.5g
5	Oven dry weight of extracted fiber (M4)	101.47g

Bleaching process: Residual gums or layers attached to the degummed fibers were removed with the help of H₂O₂. Apart from removing residual gums and layers attached to the fibers; bleaching removes the naturally occurring coloring matter and disclosed the creamy white color of the fiber. To bleach the fiber 15% of hydrogen peroxide and 0.5% of wetting agent taken in vat, immersed 345gm fiber in it, liquor ratio was kept at 1:10, incubated at 100°C for 2 hours and 30 minutes. Finally washed and dried.

As it can be understood by comparing Figure 2 and Figure 3; the fiber in Figure 2 is white and fiber stickiness is less compared to fiber in Figure 2. The peroxide bleaching revealed the white color of the palm leaf sheath fiber and rid off the sticky substances from the fibers.



Figure 3 Peroxide Bleached palm leaf sheath fiber. The whiteness of the fiber is due to bleaching effect.

Softening treatment of palm leaf sheath fiber: Sample cluster of bleached fibers taken out and kept to characterize longitudinal, tensile and elongation of the bleached fiber. The other fibers treated with silicone emulsion softener followed by steaming and then dried.

Testing, tensile strength, elongation and longitudinal: Both softened and un softened fibers characterized under the same condition. The tensile test carried out on a batch of 50 fibers relating to

the determination of the strength and elongation at break under tensile stress. 25mm distance between clamps taken. At constant speed equal to 20mm/min and a force of 50N. The test was conducted at (ambient temperature of 28°C and R.H. of 65%).

As one can understand from Table 2 softening of extracted palm leaf sheath fiber increase tensile strength and elongation at break of the fibers. Especially elongation at break of the fibers after softening was almost twice that of before softening.

Table 2 Tensile and elongation property of palm leaf sheath fiber before and after softening characterized by the study

S.N	Fiber property	Bleached fiber	Bleached
		(un softened fiber)	softened fiber
1	Tensile strength	6.94N	8.31N
2	Elongation at break	9.38%	19.60%

The specimen's longitudinal view tested by Scanning Electron Microscope (SEM) to characterize the morphology of the untreated fibers and softener treated as presented below.

Figure 4 revealed softening the palm leaf sheath fibers improved fiber orientation and changed the random oriented of the fibers. In Figure 4A the fiber seems more amorphous. After softening Figure 4B the fibers were oriented and due to the orientation of the fibers the fiber cross-section became cylindrical.



Figure 4 Longitudinal view under scanning electron microscope. A) un softened B) softened fiber. In fig4b Due to softening the palm leaf sheath fiber got a cylindrical shape.

Moisture regain (R%) and Moisture content (W%) of the softened palm leaf sheath fibers were also characterized. To calculate the R% and W% of the fibers; first the fibers were conditioned at room temperature for 24hr. After 24 hrs the conditioned fiber weight was measured and found as 13.52gm. Following that the weighed fibers were dried in oven at a temperature of 100°C again and again until the fiber dry fully and no reduction in weight.

In Table 3 the oven dry weight of fibers every 15 minutes listed. From the list in the table; the weight reduction stopped at oven dry number 4. This weight was considered as dry weight of the fiber.

from Table 3; R% and W% calculated as follows:

$$R\% = \frac{\text{conditioned weight} - \text{dry weight}}{\text{dry weight}} * 100$$

$$R\% = \frac{13.52 - 12.001}{12.001} * 100 = 12.65\%$$

$$W\% = \frac{\text{conditioned weight} - \text{dry weight}}{\text{conditioned weight}} * 100$$

$$R\% = \frac{13.52 - 12.001}{13.52} * 100 = 11.23\%$$

Generally the moisture regain and moisture content of palm leaf sheath fiber is in the range of the other bast fibers like jute, hemp and flax.

Table 3 Dry weight of extracted palm leaf sheath fiber

No	Oven dry	Weight of dried fiber
1	Oven dry weight(1)	12.03g
2	Oven dry weight(2)	12.01g
3	Oven dry weight (3)	12.006
4	Oven dry weight (4)	12.001
5	Oven dry weight (5)	12.002

Discussion and conclusion

In present study extraction of Palm leaf sheath fiber by chemical degumming using NaOH was investigated. The alkaline solution helps to dissolve the naturally available gums from the leaf sheath the dissolved gum is washed off from the fibers by washing. Alkaline concentration, temperature, time, and presence of antioxidants are factors which affects chemical degumming. This particular extraction was carried out using NaOH and wetting agent at 100°C for 2 hours and 30 minutes. The Investigation found that Fiber extraction from palm sheath fiber by chemical degumming has 28.87% fiber yield.

The longitudinal study of the fiber under scanning electron microscope revealed that softening of the bleached fiber changed the longitudinal view of palm leaf sheath fiber from rectangular to cylindrical shape.

The mechanical properties: Tensile and elongation of palm leaf sheath fiber increase significantly if treated with softener. The softened leaf sheath fiber has tensile strength of 8.31N and elongation of 19.6%. The moisture regain (R%) and moisture content (W%) of the softened fiber is 12.65% and 11.23% respectively. The moisture regain and moisture content of the fiber is good but it needs to be enhanced more by further treatments (Figure 5).

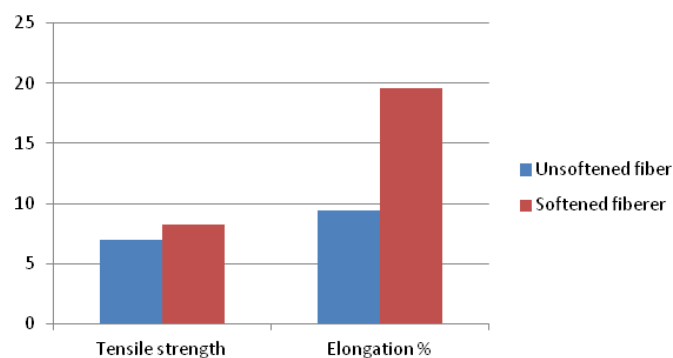


Figure 5 Tensile and elongation of palm leaf sheath fiber.

Generally; bleaching revealed the creamy white color of the fiber and softening changed the longitudinal view and enhanced moisture regain and moisture content of the fibers. This implied that

pretreatment textile influence mechanical, morphological and also chemical characteristics of palm leaf sheath fiber.

Data availability

The data used to support the findings of this study are included within the article.

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Conflicts of interest

The authors declare that they have no competing interests.

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