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Original Research Article

Study on the Physico-Mechanical Properties of Okra Fibre at Different Harvesting Time

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Abstract

Natural fibers obtained from plants or animals. Okra fiber is one of the source of natural fibres, which comes from okra plant (*Abelmoschus esculentus*). Okra fiber is eco-friendly, biodegradable, available, and cost effective materials. The properties of okra fiber are changed with different harvesting time. This work studied to determine the physico-mechanical and thermal properties using Stelometer, Fibre fineness analysis system, Photovolt meter, Fourier Transform Infrared Spectroscopy (FTIR), and Thermogravimetric analysis (TGA) at different age of okra fibres. The results showed that strength (gm/tex) 30.78, fineness (µm) 40.50, whiteness or color (%) 48.40 of four-month okra fiber and the six-month okra fiber strength (gm/tex) 31.98, fineness (µm) 56.12, whiteness or color (%) 43.56. FTIR assessment of the okra fiber reveals the presence of functional group. Thermally stability of six-month sample is good compare to the four-month okra fiber. The okra bast fibre is an important unconventional source of fibres, which could be, characterized for their use in blending yarn, reinforcing materials and diversified products.

Keywords: Natural fibres, okra fibre, ladies finger, physical, mechanical, thermal properties. different age.

INTRODUCTION

Natural fibers obtained from plants or animals. Okra fibre is on of the source of natural fibres which comes from okra plant. Natural fibres are good for us and good for the environment. Increasing concerns of environment pollution, natural fiber are widely used instead of synthetic materials. Natural fibers has biodegradable, nontoxic, renewable, high specific strength, high moisture absorption, excellent thermal properties, and economical [1]. Okra fibre is natural bast fibre which is known botanically named as (*Abelmoschus esculentus*) belongs to the Malvaceae family [2]. After harvesting of vegetable i.e ladies finger, the huge amount of okra fibre are wasted every year lack of collection fibre [3]. The okra plants mainly cultivated for vegetable and pharmaceutical application [4]. The okra plants grow rapidly and its height up to 2-3 metre [5]. After harvesting of vegetable (ladies finger), fibre are extracted from okra plant by way of stagnant water retting [6]. The chemical constitute of okra fibre are 67.5 % α -cellulose, 15.4 % hemicellulose, 7.1 %lignin, 3.4 % pectic matter, 3.9 % fatty and waxy matter and 2.7 % aquous extract which are related to jute fiber [7]. Yellowing and photochemical decomposition is responsible which causes of lignin. Mechanical properties are good because of high molecular weight compounds intrinsic of okra fibres [8].

At present, many researchers have characterized of okra fibre for application of diversified products. De Rosa and coworkers have reported that thermal and mechanical properties of okra fibers which are potential as reinforcement of polymer matrix composite [9]. S. Yamuna Devi and Dr. S. Grace Annapoorani have investigated high cellulose content and better mechanical strength of okra fibre [1]. M.N Duman and coworkers have observed that agriculture waste fibres (okra fibre) are good mechanical properties and thermal conductivity [10]. S. I. Hossain and co-authors have founded that, chemically treated of fibres are increased tensile properties and no significant effect of thermal stability Natural Fiber [11]. A. Guleria and coworkers have aloso studied of okra fibres on their fourier-transform infrared spectroscopy (FTIR), thermo-gravimetric analysis (TGA), and scanning electron microscope (SEM) analysis [12].

In present study, discover a new concept to characterization on the physico-mechanical and thermal properties at different age of okra fibres. The properties of okra fibres are changed with at different age of okra

fibres. The objectives of this study, the physico-mechanical and thermal properties at different age were characterized on their breaking tensile strength, diameter, fineness, whiteness or color, and moisture contents. Fourier transform infrared spectroscopy analysis (FTIR), and thermogravimetric analysis (TGA) also used to characterize of okra fibres. These properties will be helpful to select the raw materials for diversified applications. Further research can be determined change in chemical composition at different age of okra fibres.

MATERIALS AND METHODS

Materials

The waste okra plants were collected from farmer's field at different age like as four month, six month, and one year six month after harvesting of vegetables. Okra fibres (Abelmoschus esculentus) were extracted by water retting.

Fig-1: Okra plant

Fig-2: Okra fiber

Methods

Stelometer

A Stelometer tester were used to determine the fibre bundle strength in gm/tex which are perform tests according to test method of ASTM D1445. A well combed fibres are placed on the pair of small clamp using zero gauge length and all protruding ends were sheared off evenly. The fiber clamp is inserted at the top of the pendulum and tension was applied to break the fibres. The broken bundle fibres were weighed by a precision balance. The breaking force and weight are used in the following equation to determine the strength.

$$T = f / m \times 11.81^*$$

Where

f = breaking force in Kp
m = mass of the tested fiber bundle in milligrams
T = tenacity in gm/tex
*11.81 stands for the length of the specimen in millimeters.

Computerized Fiber Fineness Analysis System

Fineness of four-month and six-month okra fiber are determined by Fiber fineness analysis system (YGOO2C, Panasonic WV-CP310/CH) with 40 times magnification.

Photovoltmeter

Whiteness percentage of okra fibres was determined by PHOTOVOLT (Model 577 Reflection meter, made in America). To determine lightness or whiteness of a color irrespective of hue, the green tristimulus filter is used as it most closely transmits light detectable by the human eye. Green filter transmittance (LaCroix range 450-620) and transmittance (peak) 550 nm.

Fourier Transform Infrared (FTIR) Spectroscopy

The infrared spectra of the synthesized four-month and six-month okra fiber were recorded on Fourier transform infrared spectroscopy (FT/IR – 4600LE JASCO) with attenuated total reflectance (ATR) mode with a diamond crystal. Scanning was conducted in the frequency range 4000–500 cm^{-1} with a 16 repetitions scan average for each sample and a resolution of 4 cm^{-1}.

Thermogravimetric Analysis (TGA)

Thermogravimetric analysis (TGA) was used to study the thermal stability of okra fibers. The thermal stability analysis was performed using Thermogravimetric analyzer (ELTRA THERMOSTEP). The specimen (minimum 400 mg) was heated from room temperature to 550∘C at a dynamic heating rate of 3°C/min using N_2 gas.

RESULTS AND DISCUSSION

Strength analysis

To determine the fiber strength is one of the most important part of the physical properties of okra fiber. The strength of okra fiber is its capability to stand against a stretching load. Fiber strength is measured by breaking the fibers held between clamp jaws, which is reported as grams per Tex. In this way to determine the strength of okra fiber. Mujeera fathima and coworkers have found tenacity 13.62 gm/tex to 43.28 gm/tex [13]. In this study found, Fig-3 shows the six month strength 31.98 gm/tex is higher as compared to four month strength 30.78 gm/tex.

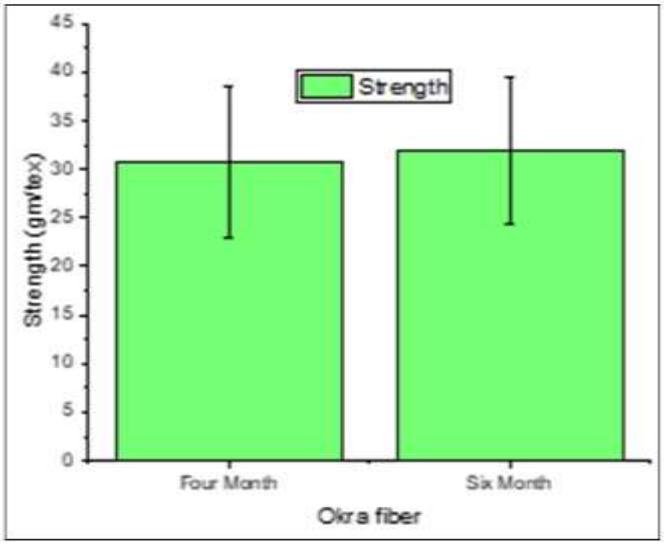

Fig-3: Strength of okra fiber

Fineness analysis

The fineness of the fiber is one of the most important parameters of okra fiber to impart its applicability. Increasing the fiber fineness to produce good quality yarn because of fiber fineness determines how many fibers are present in the cross-section of a yarn of given thickness. The Fig-4 shows that fineness of four month 40.50 (µm) is better than of six month 56.12 (µm) of okra fiber. In a previous study, the authors found that the diameter of okra fiber is 40-180 (µm) [14].

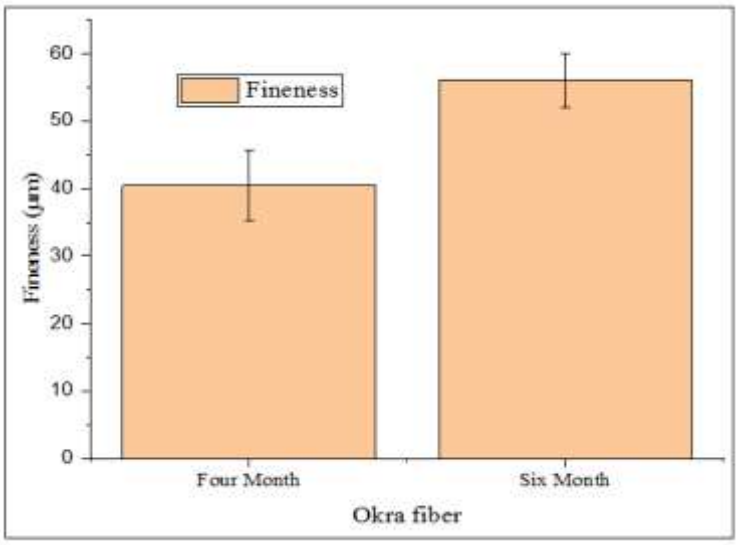

Fig-4: Fineness of okra fiber

Whiteness or Color (%) analysis

Whiteness or color percentage is the attribute of color perception by which an object is compared to approach the preferred white. Whiteness measures the ability of fiber to reflect all colors of light. Fig-5 shows that whiteness of four month 48.4% is higher as compared to six month 43.56% of okra fiber.

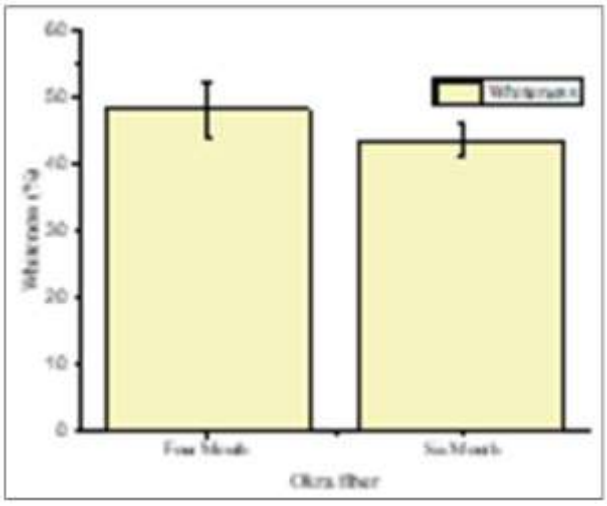

Fig-5: Whiteness or color (%) of okra fiber

FTIR Spectra analysis

ATR-FTIR spectra results of four-month and six-month of okra fiber are shown in Fig-6 from wavenumber 4000 to 500 cm^{-1}. The characteristic features from spectrum of the okra fiber having of its intrinsic properties α-cellulose, hemi-cellulose, lignin, pectin and waxy mater[15]. The spectrum of the okra fiber at 3600–3100 cm^{-1} corresponds to the intra and inter molecular hydrogen bonding of OH stretching in cellulose, hemicelluloses [16]. The broad absorption peak at 3000-2842 cm^{-1} responds to the C-H stretch in methyl and methylene group [17]. The band at ~1735 cm^{-1} which belongs to C=O stretching vibration of carboxylic acid in pectin or ester group in hemicelluloses [18].Vibration peak at 1641 cm^{-1} represents H-O-H bending water content of fiber [19]. The two peaks 1504 cm^{-1} and 1425 cm^{-1} are attributed to benzene ring stretching and CH_2 deformation which functional group is lignin [20]. The absorptions band near at 1367, 1320, 1240, 1155 and 1125-895 $cm^{-1}$are assigned to CH bending of cellulose and hemicelluloses, CH_2 wagging of cellulose and hemicelluloses, C-O stretching of acetyl groups, C-O-C stretching and C-O stretching in cellulose [21]. The peak at 1504 cm^{-1} indicates to the aromatic ring in lignin shown in the four month sample, is not present in the six month sample causes of decreasing lignin.

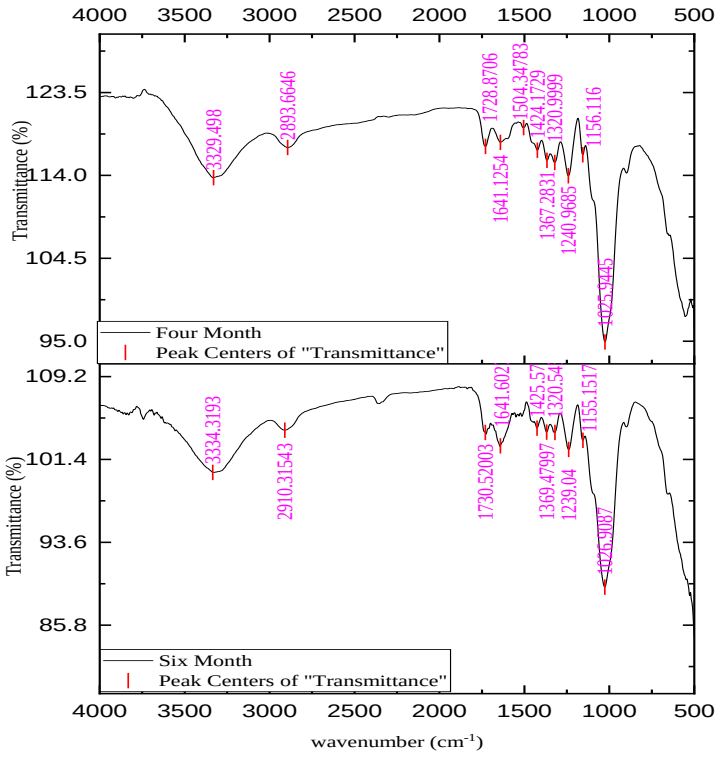

Fig-6: FTIR spectra of four month and six month of okra fiber

Thermogravimetric Analysis (TGA) analysis

Thermogravimetric analysis were observed on the four-month and six-month sample to determine the effect of different age on the thermal stability of the okra fiber. TGA curves shown that four stages of decomposition occurred of four-month and six-month okra fiber are shown in Fig-7. First decomposition started at 100^0C, which resulted weight loss due to the vaporization of water in the fiber. Second and third decomposition started at 220^0C to 450^0C, which observed that weight loss is due to the degradation of hemi-cellulose, cellulose and lignin [22]. Final or four stage, residue weight is ash observed that hemi-cellulose start to decomposition at 220^0C and completely perished at 315^0C next step to start decomposition cellulose because of highly crystalline [23, 24]. After completing decomposition of hemi-cellulose and cellulose start to degradation of lignin having of tough materials. TGA curves shown that six-month sample has higher thermally stable compared with four-month sample fact of maturity.

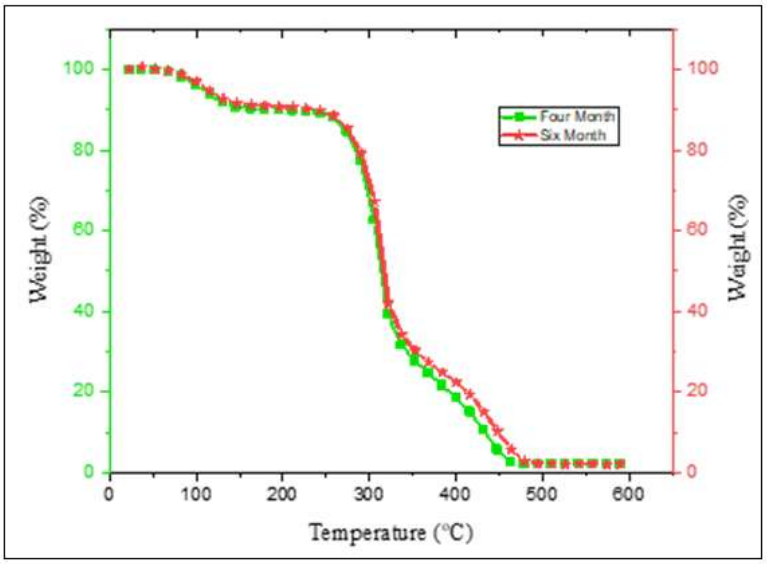

Fig-7: TGA curves of four and six month okra fiber

CONCLUSION

In this study, characterized on the physico-mechanical and thermal properties of four-month and six-month okra fiber. Bundle fiber tensile test, fineness analysis, whiteness (%) analysis, Fourier transform infrared spectra analysis and thermogravimetric analysis were carried out. The obtained result showed that the six-month sample better strength and thermally stable as compared of four-month of okra fiber. Whiteness percentage and fineness are good of four-month sample compared to six-month of okra fiber. From the FTIR studies, there was a small difference of peak intensity and peak position. This study will be carried out to collect and properly use of agro-waste okra fiber for selective purpose. Therefore, further research can be proceeded to determine the chemical compositions at different harvesting time.

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