The Potential of Abelmoschus Esculentus Fiber

Prafull P. Kolte* & Vijay S. Shivankar
SVKMs NMIMS MPSTME, Centre for Textile Functions, Shirpur, India

Abstract:
Now-a-days, natural fibers becoming out of competition for commercial applications because of the versatility of synthetic fibers and the drawbacks of natural fibers. Synthetic fibers may not be available in the future and may harm nature as they are petrochemical based and non-eco-friendly. The natural fiber availability is also limited and therefore consistancy needed to discover new natural fibers and check their potential for commercial applications. The Abelmoschus Esculentus (Okra) plant became agricultural waste after harvesting okra fruit. This okra plant waste can utilize for the extraction of Abelmoschus Esculentus (okra) fibers like other bast fibers. The efforts given for the extraction of okra fiber can produce good quality of fibers and also reduce greenhouse gaseous generated due to the burning of agricultural waste. This review article focused on the characteristics of the okra technical fiber which can be utilized for various applications. Also, create awareness about the extraction of okra fiber from the agricultural okra plant waste which can increase the per capita income of the Indian farmer. Also, invoke the researcher to develop various applications of okra fiber like that of other bast fiber.

Keywords: *Abelmoschus Esculentus fiber, Agricultural waste, Applications, Characteristics.*

***Corresponding Author:**
Mr. Prafull P. Kolte
Assistant Professor
Centre for Textile Functions,
Mukesh Patel School of Technology Management & Engineering,
SVKM's, NMIMS [Deemed to be University],
Shirpur Campus, Shirpur,
Dist. Dhule [MS].
E-mail: prafullkolte@gmail.com

1. Introduction

Abelmoschus Esculentus (Okra fiber) is the bast fiber extracted from the green stem of the okra plant. Okra plant is a monocotyledonous plant belongs to Abelmoschus esculentus family. Okra plant cultivated for the okra fruit commonly called "bhindi". Other names of the okra are mentioned in Table 1[1, 2]. Okra plant is cultivated in two seasons in a year and grows an average height of 4-7 feet. After collecting okra fruit, a huge amount of okra plants are discarded as agricultural waste. The discarded stem of the green okra plant can be utilized for the extraction of technical okra fiber.

Table 1 - Other names of okra

Scientific Name	Abelmoschus Esculentus (Hibiscus Esculentus)
Common Name	Lady Finger. Okra
Vernacular Name	Okra, Gumbo
Sanskrit Name	Tindisha, Pitali, Gandhamula
Hindi Name	Bhindi
English Name	Okra, Lady Finger, Edible Hibiscus, Ockro
Middle East	Arabic Farsi: Hebrew
	Turkish: Bamia and Bamveh
	Italian: Gombo
	French: Gombo
	Swedish: Okra

The okra fiber extracted from agricultural waste shows similar advantages like conventional plant fibers compared to their petro-based counterparts, renewable resource, low cost, low density, biodegradability, good energy recovery, low embodied energy, and CO_2 neutrality. Other than this, the production of okra fiber does not require extra use of fertilizers, pesticides, and like as these are already used for the cultivation of the main crop [3, 4]. The growth of the okra plant depends on geographical conditions, soil conditions, age of the plants, climate, variety, etc. Depending on the growth of the okra plant, the stem of the okra plant can yield about 10-25% okra fibers of the weight of the plant (dry basis) [5].

In India, okra is the main vegetable in the diet because of its good nutritional value, and a good amount of vitamin A and folic acid, besides carbohydrates, phosphorus, magnesium, and potassium [6]. India is the largest producer of okra about 73% of the total annual production of okra in the world. Therefore, it is necessary to advocate the Indian researchers and farmers about the utility of okra fiber for different textile applications like banana fiber, so that Indian farmers can gain additional income (about 10-11% of the profit gained by okra cultivation) with okra cultivation.

The technical fiber made from the okra plant can be used for a variety of applications was the main focus of this review article. Also, this review generates awareness about the ability of agricultural okra plant waste to be converted into okra fiber, which can boost the per-capita income of Indian farmers. Additionally, appeal to the researcher to discover various commercial uses for okra fiber, similar to those for other bast fibers.

2. Extraction of okra fiber

The extraction of the bast fiber can be done by various methods like dew retting, cold water retting, hot water retting, mechanical separation, chemical extraction, enzymatic extraction, and ultrasonic separation steam explosion [4, 7]. The most versatile, efficient, economical, and easy process is the cold-water retting process [8]. In this process, after the cultivation of okra fruit, the green okra plant has been collected. After collecting the fresh plant, about three months old and around 6.5 feet high, the central part of the stems was removed and kept underwater to allow microbial degradation. Within 12-15 days the stems degraded appreciably to allow fiber extraction. The fibers were isolated from the degraded stems by being washed three times, using deionized water, then tied with ropes, and dried by sunlight in the open air. The dried okra fibers (as shown in figure 1) are kept in a moisture-proof container afterward for storage.

Figure 1- The dried okra fibers

3. Chemical composition of okra fiber

The okra fiber is categorized as a lignocellulosic bast fiber that contains high cellulose content like that of other bast fibers viz. banana, jute, hemp, and ramie [9]. Physically, the okra fiber is bright, shiny, strong, and naturally golden in colour. The okra bast fiber chemical composition is very similar to other common plant fibers such as jute, flax, hemp, etc. [10, 13]. The main chemical constituents of the okra fibers (as shown in Table 2) are cellulose, hemicellulose, and lignin along with pectins, fatty and wax matters, and protein [10, 11]. The chemical composition of the fibers varies on the species and geographic location, age, climate, soil condition, and fiber extraction method [11, 12]. Since the major components of plant fiber are cellulose, hemicellulose, and lignin, the fiber structure and properties are depended on those components [12].

Table 2 - The okra fiber chemical composition

Sr. No.	Composition	Weight%
1	α-Cellulose	60-70
2	Hemicellulose	15-20

3	Lignin	5-10
4	Pectins	3.4
5	Fats and waxes	3.9
6	Water-soluble compounds	2.7

4. Physical structure of okra fiber

The okra fiber is polygonal in shape that varies from irregular to circular shape. The range of diameter of the okra fiber varies from about 60-100 µm. The average diameter and standard deviation of all the fibers were 80 ± 20 µm. The cell wall thickness and lumen diameter vary typically between 1 to 10 µm and 0.1 to 20 µm, respectively. As a consequence of it, the considerable difference in the diameter values of the single fiber and lumen, and their rough shape strongly affect the mechanical and dimensional properties of okra fibers. The fineness of the okra fiber is not uniform throughout the length and it is about 4-10 tex. The length of the okra fibers is about 10-50 cm depending on the physical behavior of the okra plant. The density of the okra fiber is about 1.15-1.40 gm/cc which is lower as compared to other bast fibers. Therefore, it is lighter in weight. The length-to-breadth ratio of the okra fiber is 153-280 [8, 13-15].

5. Thermal properties of okra fiber

The thermal properties of okra fiber have great importance to decide the suitability of the fiber for various applications. The weight loss of okra fiber is done in three stages and thermal decomposition is done in two stages. In the first stage of weight loss, about 8-9% weight loss of the okra fiber was observed due to water vaporization in the temperature range of 30-100 °C. In the second stage of weight loss and the first stage of thermal decomposition, about 16% weight loss of the okra fiber was observed in the temperature range of 220-310 ^{o}C due to thermal depolymerization of hemicellulose, pectin, and the cleavage of glycosidic linkages of cellulose. In the third stage of weight loss and the second stage of thermal decomposition, about 67% weight loss of the okra fiber was observed in the temperature range of 310-390 ^{o}C due to the degradation of the α-cellulose present in the fiber [14]. The decomposition of lignin, owing to its complex structure, occurs slowly within the whole temperature range. Furthermore, the residual weight percentage was observed at about 7.5%. In an inert atmosphere, the final products of the degradation of cellulose consist of carbonaceous residues and possible undegraded fillers [16]. It is important to know the thermal degradation of the okra fiber because processing at high temperatures and longer times can be caused fiber degradation [13].

6. Mechanical properties of okra fiber

Okra fiber is not uniform in diameter; therefore, it is very difficult to analyze the mechanical behavior of the okra fiber. The okra fiber possesses brittle behavior like that of jute. Okra fiber is lighter fiber as the its density is 1.15-1.4 gm/cc. Therefore, mechanical performance of okra fiber is also nearly like that of jute fiber [11]. The tensile strength of the okra fiber varies from 230-550 MPa. The bundle strength of the okra fiber is about 6.5 to 10.9 Kgf. The tenacity of the okra fiber is 25-45 gpd, whereas the elongation is 1.6-3.2%. Young's modulus is 12.8-16.9 GPa [8]. The tensile strength and Young's modulus are varies with respect to the diameter of okra fiber. Both properties reduce as an increase in diameter in all natural fibers. The same behavior is followed by the okra fiber according to the diameter of the okra fiber. The okra fiber possesses a relatively high modulus and significantly lower elongation compared to coir and husk fiber. The overall mechanical behavior of the okra fiber is similar to jute and sisal fiber [14, 17].

7. Moisture absorbency of okra fiber

All the plant fiber has good moisture absorbency, which was one of the drawbacks for certain types of plant fiber applications like fiber-reinforced composites [17]. The okra fiber possesses about 15-20% amorphous structure which is responsible for 7-8% moisture content of the okra fiber. The tendency of moisture absorbency can be increased or decreased by various treatments on the okra fiber. These treatments on the okra fiber were implemented according to end use of the okra fiber. The moisture absorbency behavior of the okra fiber is also similar to jute and sisal fiber [13, 14].

8. Applications of okra fiber

The okra bast fiber properties are similar to other bast fibers like jute and sisal. Therefore, the potential area for the okra fibers are [8, 13, 14, 17]:

1] Home Textiles: Multi-coloured /bleached, dyed, printed, and processed okra or okra/cotton upholstery and upholstery fabrics, tapestry, wall coverings, floor coverings, floor mats, soft suitcases, aprons, hats, gloves, folder

covers, shoes, tablecloths, fashion accessories Lace, patchwork and weaving, gift boxes, and other handicrafts made from okra fibers, yarns, and fabrics. Environmentally friendly okra upholstery fabrics and tarpaulins made from okra or okra mixtures.

2] Geotextiles: Okra Geotextile is used to control surface soil erosion on slopes and plains, as well as embankment stability, road subsoil reinforcement, river and waterway embankment protection, underground drainage, soft ground reinforcement, and other applications. As a result, the okra geotextiles bear the burden. During the construction phase, it serves as a separator, acts as a filter, and controls cross-scattering, subsidence, and landslides.

3] AgroTextiles: Okra fabrics are now used as sunscreens, plant nets, windscreens, harvest nets, field nets for crop protection from birds, weed control, seed mulch, soil conservation, semi-arid forest development, nursery pots, and so on.

4] Fiber-reinforced composite material: Okra fibers are lighter, have less elongation%, have good stiffness, are durable, have good thermal stability, and have good tensile behavior therefore it has the potential to use for fiber-reinforced polymer composites for commercial applications. Okra fiber can be used in paper-fiber composites and paper-fiber laminates.

9. Future scope of okra fiber in India

- The research on okra fibers will prove its potential for various commercial applications.
- The research of various after treatments on okra fibers will improve the properties of okra fibers for the specified application.
- The research on standard okra fiber extraction process will help agriculturist to increase per capita income with okra farming like banana farming.

10. Conclusion

The research so far on okra fiber proves its potential for commercial textile application. The characteristics of the okra fiber are analogous to the jute and sisal bast fiber which concluded that okra fibers can be utilized for applications where jute and sisal fibers are generally used. The under-utilization of the okra plant for fiber extraction is mainly due to appropriate awareness, knowledge, facility, and technology availability. The augmentation in a commercial application will solve this problem. The chemical composition, physical properties, thermal properties, mechanical properties and moisture absorbency of okra fiber reviewed in this paper prove the suitability of okra fiber like jute, sisal, and banana fibers for commercial applications. The improvement in the commercial application of okra fibers creates scope to improve the per capita income of the farmer and also reduce the emission of greenhouse gaseous generated due to burning of the agricultural okra plant waste.

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