Extraction of Fibers from Moringa Oleifera Pods and Evaluation of itsProperties

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Abstract:

The growing biological, social & economic awareness, global warming, concepts of sustainability & new environmental regulations have stimulated the research for green materials compatible with the environment. The problem of waste disposal & depletion of non-renewable resources is attracting textile researchers & manufacturers' interest in environmentally friendly products. Natural cellulosic fibers are likely to increase in importance due to their eco-friendlynature, soil erosion preventive & bio-degradable character, low price & availability. Most of natural fibers with their excellent mechanical properties are beneficial in developing many products. In the scenario, the use of natural fibers and enzymes for textile processing is being encouraged hence possibility of discovering certain non-conventional sources for natural fibers is being explored. "Moringa oleifera fiber is one such lignocellulosic fiber that has the likelihood for use in the textile industry. It can be extracted from the epidermis of fruits of the moringa oleifera plant by various methods. In this study, the fibers extracted by various methods were tested for properties like diameter, fineness, tensile strength and elongation, chemical structure, and properties also for electrical conductivity, and anti-microbial characteristics with ASTM standards. Overall propertiesof the fibers found similar to bast, leaf, and fruit fibers.

Keywords: *Crystallinity, Lignocellulose, Moringa Oleifera, Retting*

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1. Introduction

Cellulose is a natural biopolymer and can be obtained from a large variety of plant life.The resulting fiber is renewable and biodegradable [1]. Cultivation of fiber crops and rearing of silkworms and sheep have been the traditional methods of obtaining cellulose and protein fibers, respectively. However, fiber crops are not just sources for clothing, but the byproducts generatedare major sources of food and means for substantial income. Recent statistics reveal that while the annual world production of natural fibers has been about 50 million tons, the production of these fibers in India has been almost 15 million tons. Increasing consumption, especially in developing countries, constraints on the natural resources required to produce fibers, and the inability to increase the supply proportionate to the demand are expected to make most of the current fibers either too expensive or unavailable for commodity applications [2,3]. Eco-friendly, biodegradable, and recyclable products are gaining importance in the market which has brought natural fiber into focus. As mentioned earlier the earth is abundantly populated with several varieties of plants that might possibly have the potential to yield valuable fibers but they are yet to be explored.

The present study consequently focuses on the exploration of moringa oleifera Fiber for textile applications. The common name of moringa oleifera is a drum stick plant that belongs to Kingdom - Plantae Botanical name-Moringa oleifera Family name- Moringaceae English name - Drumstickplant, with large number of species is native of India but cultivated in various parts of the tropical and sub-tropical regions as a vegetable which has medicinal and health benefits [4,5]. In India, 380 square kilometers of land area are used for cultivation in which production is 1.1 to 1.3 million tons of drumsticksproduced. The yield could be around 50-55 tonnes of pods/ha. (220 pods/tree/year) [6,7].

The fruit is a hanging, three-sided brown capsule of 20–45 cm size which holds dark brown, globular seeds with a diameter of around 1 cm [8-10]. The seeds along fleshy gum are used for food purposes whereas the outer epidermis contains sticky fibrous portions.

Figure 1: Moringa oleifera plant

Figure 2: Moringa Oleifera beans (fruits)

2. Materials and Methodology

Fruits of Moringa Oleifera beans of green (immatured), half ripened (half matured), fullygrown (matured) of good numbers were collected from the nearby fields, sorted, and extraction wascarried out in two steps viz. Retting and separation of fibers are as follows.

Retting involves the removal of plant tissue from around the fibers by immersion in water, whichcauses and promotes microbial growth (water-borne bacteria) which breaks down the cellulose tissue and gums surrounding the fibers.

a. Clean Water Retting

Water Retting of drumstick fruits is brought about by a natural pectinase produced by bacteria. A small tank in which enough water is taken in sucha way that all the drumsticks must be fully deep in water. Pods are allowed 10 days for retting.

b. Pond Water Retting

For the preparation of natural countryside pond water, soil, and cow dung are added in tap waterwhich will enhance faster bacterial growth. The drumsticks are kept in water for 10-12 days according to requirements.

c. Boiled water retting

Drumstick beans are boiled at 100^0C for 2 hours in a pressure cooker and allowed to cool down, excess water removed, and pods are opened to extract seeds and fleshy pulp, and the epidermis is allowed to dry.

d. Fiber Extraction

For the first two methods beans after retting washed in flowing water to clean gel and the outer epidermis is peeled off manually and sticky fibers are separated by plastic or metallic combs and allowed to dry for 5-6 days in a shed to release excess moisture. For boiled water skeleton is addedinto soft water with M/L ratio1:3 to which 20 % concentrated caustic soda and sodium sulphite are mixed, then boiled for 2 hours and dried to remove the lignin a non-fibrous material. Fibers areseparated in a trash analyzer which is flexible, smooth & lustrous and has similar burning characteristics to other known cellulosic fibers due to the dissolution of lignin. Total nine samples were produced as shown in Table 1.

Table 1: Design of the experiment

Sr.	Methods/Pods	Retting Method		
		Clean water	Pond water	Chemical
1	Immatured	I_1	I_2	I_3
2	Half matured	H_1	H_2	H_3
3	Matured	M_1	M_2	M_3

e. Testing of fiber properties

Fiber structure was observed by Xpert pro P analytical X-ray diffraction with wavelength($1.540598A^0$) of Cu-K-Alpha method. The crystinallity Index calculated by Segal crystinallity index method calculated by,

$$Segal\ crystanallity\ Index\ \% = I(0.02) - I(18)\ I\ (0.02)\ *\ 100.$$

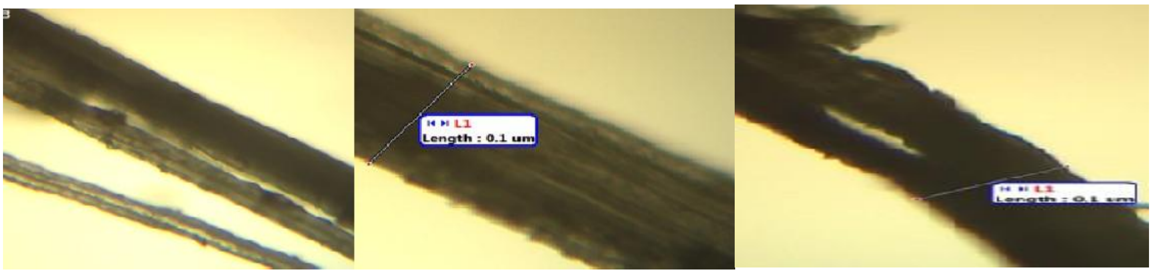
The longitudinal structure was observed under a scanning electron microscope with a magnification level of 1000folds. Fiber length was measured by the oil plate method as per ASTM standard D5103. Fiber diameter measurement was carried out by microscopic method. The linear density was measured by the gravimetric method as per ASTM standard D1577-0. Tensile characteristics were measured on Instron tester 5655 according to ASTM standard D3379. The chemical composition of fibers and the effect of chemicals were studied by standard procedure. The antimicrobial test was carried out by positive and negative gram method.

3. Results and Discussion

3.1 Structural Properties

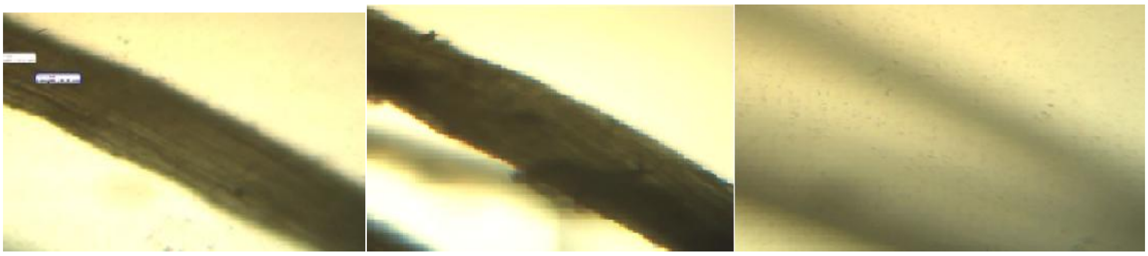
3.1.1 Longitudinal Structure

A longitudinal view of the Moringa Oleifera fiber found a rough surface with tiny pits, sometimes striations, and dark patches spread across the section like the bark of the stem. The Colour of the fibres depends on the retting method adopted and the age of the beans. Immatured pods have blackish Colour fibres due to green beans which are yet to be developed. In the case of partially and ripened pods fibers are less dark to brownish in colours. Fibres extracted by chemical retting are lighter in colour due to the removal of non-cellulosic ingredients.



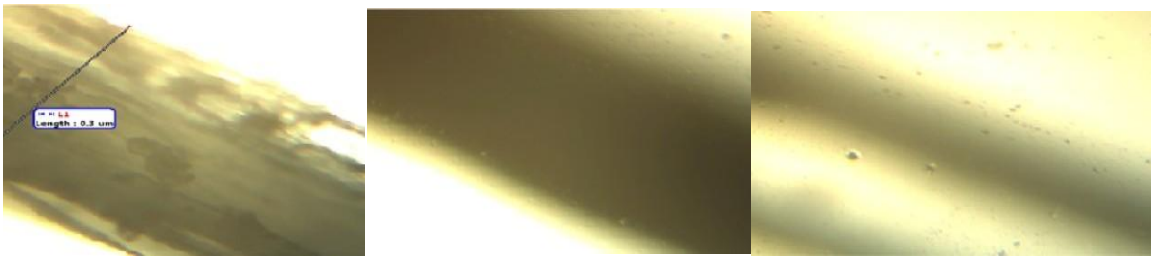
I_1-Clean water **I_2-Pond water** **I_3-Chemical**

Figure 3: Immatured fibers



H_1-Clean water **H_2-Pond water** **H_3-Chemical**

Figure 4: Half matured fibers



M_1-Clean water **M_2-Pond water** **M_3-Chemical**

Figure 5: Matured fibers

3.1.2 Crystinallity Index

Drum stick Fiber structure observed by X-ray diffraction method and Crystallanity index calculated by Segal crystinallity method was found 58.21% and amorphous region is 48.79% is better than coir and leaf fibers.

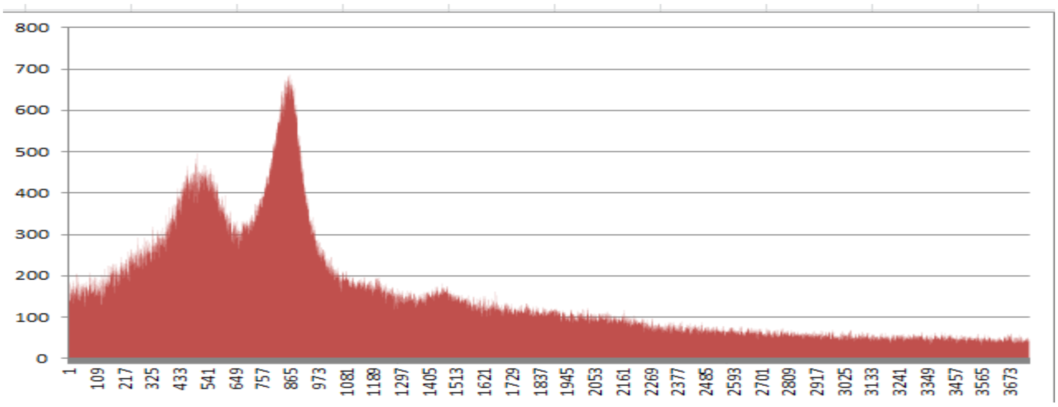


Figure 6: Crystanity Index (X-axis Diffraction Intensity(%),Y-axis 2Theta)

3.2 Chemical Analysis

Fiber chemical analysis was carried out to understand cellulose content.It was observed that,

1. Cellulose Content : 75.1%
2. Lignin Content : 10.68%
3. Wax Content : 0.42%
4. Moisture Content : 13.01%
5. Ash Content : 0.3%

Cellulose content is much better than bast, leaf, and coir fibers. Lignin content is lower than jute, kenaf, seed, flax and higher than ramie, sisal, and abaca. Wax and ash content is similar to that of bast and leaf fibers [11,12].

3.3 Physical properties

Table 2: Physical properties of fibre

Sr. No.	Fiber Properties	
1	Length of fibers	5-20cm
2	Fiber diameter	0.1-0.3micrometer
3	Density of drumstick fiber	1.327g/cc
4	Moisture Content	13.01%

The length of fiber depends on the varieties and length of fruit. Fiber is much finer than coir, pineapple,jute, and ramie. Density is more than coir and lesser than flax ramie and sisal fiber.

3.4 Electric properties

Electrical property tested with conductivity method found thatconductivity of fiber is very poor in a dry state.

3.5 Tensile characteristics

Tensile strength characteristics much resemble coir fibers but much lesser than bast and leaf fibers whereas Extension at break is similar to other fibers except coir [11,12]. The breaking strength of chemical retted drumstick fibers of all pods is lower than clean water and pond retting [Figure 7]. This may be due to the removal of noncellulosic binders and the weakening of fibers by boiling of fibers. The extension at break [Figure 8] is lowest in the case of chemical retted green pod fibers and highest in the case of half matured fibers. Here I, H and M indicates Immature, Half mature and Mature fibers respectively.

Table 3: Tensile characteristics of Moringa Oleifera fibers

Retting Methods	Clean Water Retting	Pond Retting	Chemical Retting

Types of Pods	I_1	H_1	M_1	I_2	H_2	M_2	I_3	H_3	M_3
Breaking Force (Gf)	236.93	232.72	192.01	226.66	236.67	229.86	130.4	136.5	99.01
Breaking Extension (%)	1.67	2.4	1.56	1.85	2.13	1.62	0.78	1.79	1.48

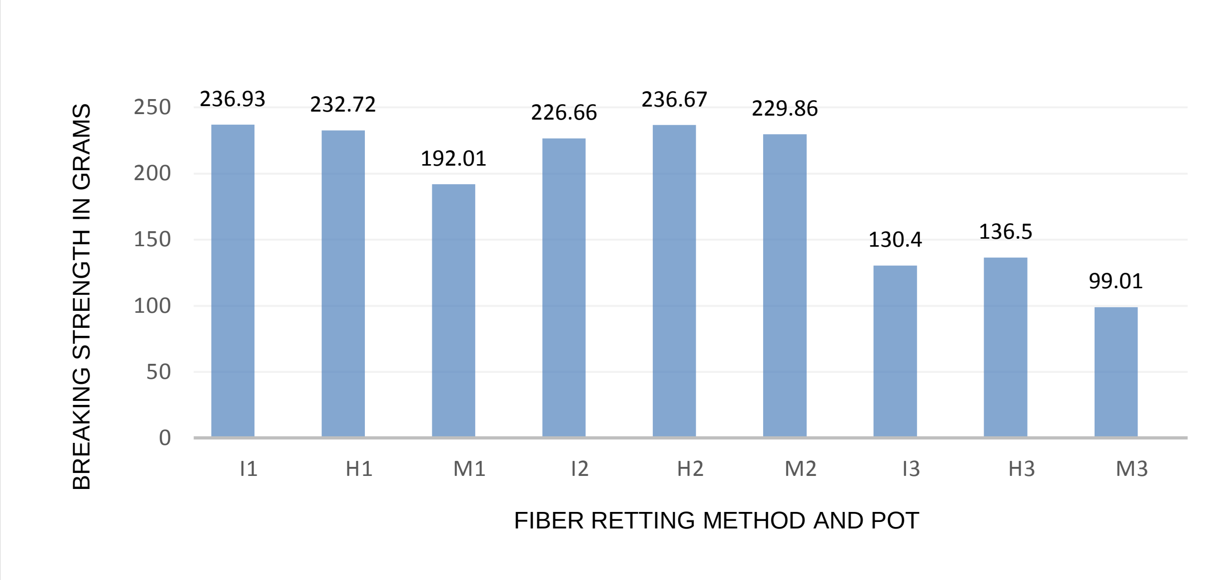


Figure 7: Breaking strength of Moringa Oleifera fibers

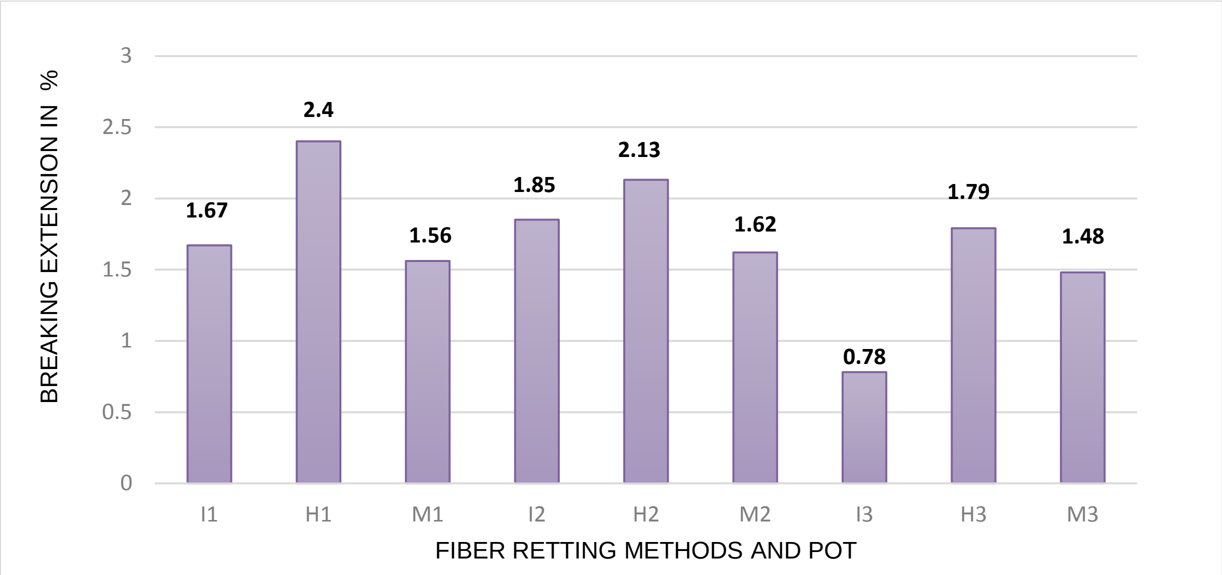
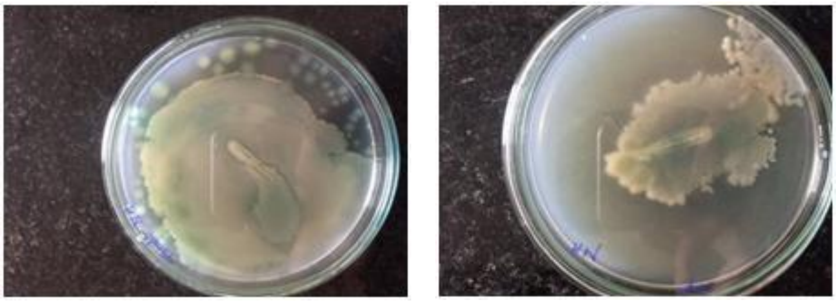


Figure 8: Breaking Extension of Moringa Oleifera fibers

3.6 **Chemical properties:** Drumstick fibers were tested for solubility test with various chemicals, it was observed that it dissolves in 70% H_2SO_4 whereas insoluble in concentrated hydrochloric Acid, Nitric Acid, Acetone, M-cresol, Glacial acetic acid, O-Chlorophenol, and Dimethylformamide.

3.7 **Burning Test:** Burning test was carried out with a flame burning procedure. Fiber burns slowlyand gives black ash and a paper-like burning smell.

3.8 **Antibacterial Test:** Antimicrobial properties tested for both positive and negative gram bacterial attacks show good resistance to other natural fibers. The inhibition area in both cases is quite wider however more resistance to found in the case of negative gram bacteria than a positive one.



Staphylococcus aureus **Pseudomonas**

Figure 9: Antimicrobial test

4. Conclusions

Crystallanity index is better than coir and leaf fibers. The cellulose content in this fiber is more than bast, leaf, and coir fibers also lignin, wax, and ash content is less. Fiber density is similar to other plant fibers. Tensile characteristics resemble the coir fibers except for extension at the break. Moisture content is up to 13.01%. Dry fiber has poor electrical conductivity. Moringa Oleifera fiber has very good resistance to chemicals. Antimicrobial resistance is also good. Overall fiber properties of fibers were found good compared to other leaf and fruit fibers.

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