NATURAL GRASS FIBERS EXTRACTION PROCESS AND PROPERTIES: A REVIEW

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ABSTRACT: Presently, the investigation of natural fibers as reinforcement in composites focuses on examining the extraction procedure, physical characteristics, chemical characteristics, and mechanical characteristics of natural fibers. Researchers are drawn to natural fiber due to its high specific strength, light density, low cost, favorable mechanical qualities, nonabrasive nature, environmental friendliness, and natural biodegradability. This paper provides a comprehensive assessment of many types of grasses including Elephant grass, Mendong grass, Snake grass, Kusha grass, Broom grass, Sisal, Corn husks, *Sansevieria ehrenbergii*, *Sansevieria cylindrica*, *Sansevieria trifasciata*, *Arundo donax L* and Napier grass.

KEYWORDS: *Extraction process, chemical properties, mechanical properties, grass fiber.*

1.0 INTRODUCTION

Over the past decade, the use of natural fiber-reinforced composites in the engineering field has increased due to their abundant availability, low processing costs, lightweight nature, good mechanical properties, nonabrasive quality, eco-friendliness, and biodegradability [1]. Natural fibers are extensively used as composite reinforcement in marine applications, the automotive industry, handicrafts, and household appliances [2,3]. In contrast, synthetic fibers like fiberglass, aramid, and nylon have been used as composite reinforcements for over fifteen years. However, these synthetic fibers have significant drawbacks, particularly from an environmental perspective, such as long decomposition times, high costs, irritation, and toxicity when burned [4].

Consequently, many researchers have been exploring natural fibers as an alternative to synthetic fibers by enhancing the physical and mechanical properties of composite materials [5]. Natural fibers are generally extracted from the bark, stem, fruit, leaf, and roots of plants [6-9]. The chemical structure of natural fiber cellulose varies based on the origin, age, and plant part (roots, fruits, stems, bark, leaves) from which it is taken. The cellulose in the fiber is surrounded by several non-cellulose elements, such as hemicellulose, lignin, and wax. Various types of natural fibers, such as Mendong grass [10], Elephant grass [13], Snake grass [14], Sansevieria ehrenbergii [15], Wild cane grass [16], Broom grass [17], Kusha grass [18], Sisal [19,20], Sansevieria cylindrica [21], Arundo donax L. [22], Sansevieria trifasciata [23], and Corn husk [24], have been investigated as reinforcements in polymer composites. However, continued research on new natural fibers is necessary to expand the alternatives to fiberglass as reinforcing materials in polymer composites. It has a diverse range of plants that have the potential to produce natural fibers, including various types of grasses. One such grass is Napier grass. This paper will describe the extraction process, chemical properties, and mechanical properties of various types of grass, including Napier grass.

2.0 METHODOLOGY

2.1 Grass fibres Extraction Process

The process of fiber extraction entails the separation of fibers from different plant components, including stems, fruits, leaves, bark, and roots. Typical extraction techniques comprise mechanical extraction and retting. Following the extraction process, the fibers undergo a thorough washing procedure prior to being dried. Effective drying is essential as the moisture content has an impact on the quality of the fibers; artificial drying produces superior-grade fibers in comparison to sun drying. In order to prevent discoloration caused by exposure to direct sunshine, the fibers are dried in a shaded area. After the fibers have dried, they are meticulously combed, categorized into various grades, and then tightly packaged into bales. Mechanical extraction involves the utilization of either human or mechanical force to remove fibers from various plant components. The plant material is introduced into a corticator machine, comprising two grinding gears propelled by either human or mechanical energy. The gears in this process crush the plant components in order to recover the fibers. The fibers are subsequently washed with clean water to eliminate any contaminants [19]. During the water retting process, various plant components such as stems, bark, leaves, seeds, and fruits are immersed in water for a designated duration, facilitating the liberation of fibers. Subsequently, the fibers are rinsed with clean water and subsequently dehydrated.

The fiber extraction technique for different types of grass fibers is summarized in Table 1.

Table 1: Grass fibers extraction process

Fibers	Extraction process	Reference
Mendong grass	The water retting process was involved. The Mendong straw was vigorously pounded and Subsequently washed with water. Subsequently, the fibers were immersed in water for a duration of 7 days. The fibers were collected, purified, and left to air dry.	[10]
Snake grass	The process of water retting was utilized. The fiber was immersed in water for a duration of 4 days, after which it is manually removed and let to dry in the air for a period of 8 hours. Subsequently, it is subjected to an oven treatment at a temperature of 160°C for a duration of 60 minutes.	[14]
Kusha grass	The process of water retting lasts for 28 days, followed by drying at room temperature for 7 days.	[18]
Arundo donax L	The utilization of a decorticator in a mechanical procedure.	[22]
Sansevieria ehrenbergii	The utilization of a decorticator in a mechanical procedure.	[15]
Sansevieria cylindrica	The mechanical procedure of decortication involves washing the fiber with water and subsequently drying it in the sun for a duration of 24 hours.	[21]
Elephant grass	The stems of elephant grass were dried in a shaded area for one week. The object were immersed in water for approximately 10 days.	[13]
Sansevieria trifasciata	The process involves soaking the material in water for a period of 5 days, followed by manually agitating it using the hand scrutching method. Afterwards, the material is rinsed with water and let to dry under the sun.	[23]

Broom grass	The process involves soaking the fibers in water for 4 hours, physically extracting the fiber, and then drying them for 7 days at a temperature of 70°C in an oven for 2 hours.	[17]
Corn husks	The process of water retting involves immersing maize husks in water for a duration of 16 days. Afterward, the fibers are extracted using a plastic comb and left to dry naturally in the air.	[24]
Sisal	The process involves water retting, followed by scraping and mechanical extraction using decorticators.	[19]
Napier grass	The process of water retting takes 14 days, followed by drying at normal environmental conditions for 24 hours.	Present work

From Table 1, it is evident that the process of extracting grass fibers varies. Grass fiber extraction methods can be categorized into three types: water retting, mechanical processing, and a combination of mechanical processing with water retting. The most common method for extracting grass fibers is water retting, as it is straightforward, easy to perform, cost-effective, and yields good results. The soaking time in the water retting process depends on the type of fiber, ranging from 4 hours (Broom grass) to 28 days (Kusha grass), with an average soaking time of 7 days. Some fibers can be separated during the water retting process, while others need to be air-dried at room temperature for several days. The drying process for the separated fibers can be grouped into three methods: sun drying, natural air drying, and oven drying.

2.2 Chemical Properties

Typically, natural fibers are composed of lignin, hemicellulose, and cellulose layers. The outermost layer of the fiber is usually comprised of lignin, followed by hemicellulose, while cellulose forms the innermost layer. Cellulose is crucial in natural fibers due to its exceptional adhesive qualities with the matrix during composite manufacture. Fibers that have a high cellulose content typically demonstrate favorable mechanical characteristics. Table 2 displays the quantities of cellulose, hemicellulose, and lignin found in different types of grass-based natural fibers, together with their moisture content. The table reveals that certain fibers, such as broom grass, Sansevieria trifasciata, elephant grass, and snake grass, have not undergone chemical property testing, indicating a need for additional research in this area. The cellulose content of grass fibers varies from a low of 43.2% (Arundo donax L) to a high of 80% (Sansevieria ehrenbergii). The hemicellulose percentage ranges from 10% (in sisal) to 33.7% (in maize husk). The lignin content varies between 3.44% (found in Mendong grass) and 17.35% (found in Arundo donax L). The moisture content of each fiber ranges from 6.08% (Sansevieria cylindrica) to 11.96% (corn husk).

Table 2: Chemical properties of grass fibers

Fibers	Cellulose	Hemicellulose	Lignin	Moisture (wt %)	References
Mendong grass	72.14	20.2	3.44	-	[10]
Snake grass	-	-	-	-	[14]
Kusha grass	70.58	-	14.35	8.01	[18]
Arundo donax L	43.2	20.5	17.2	-	[22]
Sansevieria ehrengergii	80	11.25	7.8	10.55	[15]
Sansevieria cylindrica	79.7	10.13	3.8	6.08	[21]
Elephant grass	-	-	-	-	[13]

Sansevieria trifasciata	-	-	-	-	[23]
Broom grass	-	-	-	-	[17]
Corn husk	46.15	33.7	3.92	11.961	[24]
Sisal	78	10	8	11	[20]
Napier grass	45.9	35.03	10.08	-	Present work

2.3 Mechanical Properties

The tensile test is a highly prevalent method for testing materials. The tensile test involves subjecting a test material to a pulling force until it reaches its breaking point.

$$\sigma = \frac{F}{A}$$

σ represents the tensile strength of the fiber, measured in megapascals (Mpa). F is the force applied to pull the fiber, measured in newtons (N). A represents the cross-sectional area of the fiber, measured in square millimeters (mm2). Table 3 displays the quantitative characteristics of grass fiber's mechanical properties.

Table 3: Mechanical properties of grass fibers

Fibers	**Tensile Strength (Mpa)**	**Young's modulus [GPa]**	**Elongation at break (%)**	**References**
Mendong grass	452 ± 47	17.4 ± 3.9	-	[10]
Snake grass	278.82	9.71	2.87	[14]
Kusha grass	-	-	-	[18]
Arundo donax L	248	9.4	3.24	[22]
Sansevieria ehrenbergii	50-585	2.5-7.5	2.8-21.7	[15]
Sansevieria cylindrica	658	7.6	10	[21]
Elephant grass	185	7.4	2.5	[13]
Sansevieria trifasciata	-	-	-	[23]
Broom grass	297.58	18.28	2.87	[17]
Corn husks	160.49 ± 17.2	4.57 ± 0.54	21.08 ± 2.86	[24]
Sisal	536-640	9.4-22	3-7	[20]
Napier Grass	29.1-50.7	1.20-3.31	3.0-3.4	Present work

The objective of this tensile test is to ascertain the precise value of the material's tensile strength. There is a direct correlation between the tensile strength value of a material and its strength. A greater tensile strength number indicates a stronger material, while a lower value indicates a weaker material. Based on the information provided in table 3, further investigation is required to ascertain the mechanical properties of Kusha grass and Sansevieria trifasciata. The tensile strength of grass fiber ranges from 29.1 MPa in Napier grass to 640 MPa in Sisal. The range of Young's modulus varies from 1.2 GPa (Napier grass) to 18.28 GPa (Broom grass). The elongation at break ranges from 2.5% (Elephant grass) to 21.08% (Corn husks). Mechanical strength is determined by the values of tensile strength, Young's modulus, and elongation at break. The mechanical strength of materials is a crucial factor that designers consider while designing products in the business.

3.0 CONCLUSION

The extraction process can be categorized into three types: water retting, mechanical processing, and a combination of mechanical processing and water retting. The duration of soaking in the water retting procedure ranges from 4 hours to 28 days. The separated fiber can be dried using three methods: sun drying, natural air drying, and oven drying. The cellulose content of grass fiber exhibits a range of chemical properties, with the lowest recorded value being 43.2 (Arundo donax L) and the highest value being 80 (Sansevieria ehrengergii). The cellulose concentration ranges from a minimum of 10 (found in Sisal) to a maximum of 33.7 (found in Corn husks). The lignin content ranges from a minimum of 3.44 (found in Mendong grass) to a maximum of 21.63 (found in Napier grass). The moisture content of each fiber ranges from 6.08% (Sansevieria cylindrica) to 11,961% (corn husks). The tensile strength of grass fiber ranges from 29.1 MPa (Napier grass) to 640 MPa (Sisal). The range of Young's modulus is from 1.2 GPa (Napier grass) to 18.28 GPa (Broom grass). The elongation at break ranges from 2.5% (in Elephant grass) to 21.08% (in Corn husks). Mechanical strength is determined by the values of tensile strength, Young's modulus, and elongation at break. The mechanical strength of materials is a crucial factor that designers consider while designing products in the business.

ACKNOWLEDGMENT

The authors would like to thank Universiti Teknikal Malaysia Melaka and Ministry of Higher Education Malaysia for the financial support through Fundamental Research Grant Scheme (FRGS/1/2023/FTKIP/F00548).

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