Chapter 4

Study of Some North African Grasses (*Ampelodesma mauritanica* and Esparto Grass)

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.70001

Abstract

Ampelodesma Mauritanica, commonly called Diss in Arabic very fibrous, is a plant of the family Poaceae, a plant native of northern Africa and southern Europe, is perennial and luxuriant, growing spontaneously in the wild state. Esparto grass in arid and semi-arid regions of North Africa; fight against the turning into desert regions form and was an important contributor in animal grazing and paper making. Natural fibers from plant are nowadays increasingly employed for replacing the synthetic materials due to economic and/or environmental considerations. A. Mauritanica and esparto grass fibers are cellulose-based fibers extracted using alkaline procedure to remove noncellulosic substances such as pectin, lignin, and hemicelluloses. The characterization of extracted fibers from both grass was based on the measurement of the morphological structure, chemical analysis, infrared spectroscopy, X-ray diffractometry, thermal analysis. The use of the natural fibers for composite materials, exhibits many benefits as it is low in weight, ecologically biodegradable, renewable, and cost-effective; it may have a role in local sustainable development in north Africa countries by valorizing these grass. Therefore, these grass materials could be a worthwhile choice for cellulosic fiber supply, and can lead to different useable products in order to improve the grass fiber added value.

Keywords: *Ampelodesma mauritanica*, esparto grass, fibers, chemical treatment, fiber extraction, cellulose

1. Introduction

Decreased and depleted petroleum resources coupled with augmentation of environmental problem through the world provides the alternatives for new biomaterials that are compatible with the environment and their development is independent of petroleum-based resources. A composite materials made from natural fiber reinforced with biodegradable polymer are in growing constantly the use of environmentally friendly materials [1].

Currently, numerous research groups have explored the production and properties of biocomposites where the polymer matrices are derived from renewable resources. They are the materials that have the capability to fully degrade and compatible with the environment.

At present, cellulose is the most abundant polymer available worldwide and a representative of renewable resources. In recent years, a number of bast-extracted fibers, alternative to the most used ones, such as jute, flax, hemp and kenaf, have been also proposed as reinforcement for plant fiber composites; these fibers are mainly from herbaceous plants. In general, trying to broaden the number of botanical species from which fibers are extracted may present interest.

The main purpose of this work is to characterize *Ampelodesma mauritanica* and esparto grass fibers in order to use them as reinforcement for structural composite materials. This choice is supported by the multiple advantages of natural fibers: they are available, renewable, and biodegradable, and they have a low price and represent an economic interest for the agriculture sector and different industries for different types of applications such as textiles, automobile constructions, medicines, paper industry and develop new products with vision and aim of sustainability.

1.1. Ampelodesma mauritanica (Diss)

A. mauritanica (Diss), family of Poaceae, is a plant native of northern Africa and southern Europe and is perennial and luxuriant growing spontaneously in wild state around the Mediterranean basin. The antiparasitic property is the only traditional use of this plant [2]. This plant previously was used in the realization of the old homes of North Africa regions because of its mechanical qualities. Possibly the use of such a fibrous plant in cements paste offers resistances very interesting, which make this material as an excellent filling lightweight for structures subjected to seismic [3]. Antibacterial and antifungal activities of alcohol extracts of aerial parts of Diss plant were examined. Phytochemical analysis shows that this plant rich in flavonoids and saponins, which might be responsible for its antimicrobial activity.

The hypoglycemic effect and antioxidant activity of the methanol extract of *A. mauritanica* roots were studied.

The levels of the total phenolic and the total flavonoid content in *A. mauritanica* roots, and also its antioxidant capacity were determined. The Methanol root extract could be a valuable source of hypoglycemic compounds; the phytochemical screening revealed the presence of flavonoids, saponins, cardenolides and tannins. It is observed that in some regions of Algeria, *A. mauritanica* has been used for reducing the blood glucose levels in diabetics [2, 4].

1.2. Esparto grass (*Stipa tenacissima* L.)

Stipa tenacissima L. (esparto grass or alfa grass) belongs to the Graminacies family; the scientific classification is shown in (**Table 1**); esparto grass is a perennial tussock grass widely distributed in semi-arid ecosystems of the southern and western Mediterranean basin. The esparto grass is a typically Mediterranean perennial herb, which grows in clumps about 1m to 1m20 high, thus forming large sheets. It grows spontaneously. Particularly in arid and semi-arid environments, it delimits the desert, where the esparto grass (alfa) stops, the desert begins [5]. It has a short fiber length which produces a paper of bulk; esparto wax has been a by-product of esparto used in furniture and boot polish manufacture.

http://dx.doi.org/10.5772/intechopen.70001

Kingdom: Plantae
Order: Poales
Family: Poaceae
Genus: *Macrochlora* or *Stipa*
Species: *M. tenacissima*
Binomial name: Macrochloa tenacissima

Table 1. Scientific classification of esparto grass [6].

Esparto grass includes an underground part and an aerial part. The underground part, called the Rhizome, is formed as a complex network of highly branched roots about 2 mm in diameter and about 30–50 cm deep, ending in the young shoots (**Figure 1**).

The aerial part consists of several branches carrying cladding in the others, surmounted by limbs ranging from 30 to 120 cm in length.

The underside of the limbs is slightly shiny and the upper side carries strong ribs. Both are covered with an insulating wax which allows the plant to withstand drought.

The stem is hollow and cylindrical, and regularly interrupted at the node by entanglements of the bundles. The leaves are cylindrical, very tenacious, 50–60 cm long. The flower is protected by two glumes of equal length. The upper glume seems to be partially separated into two parts and the lower glume is finer. Generally, flowers appear in late April and early May and are green in color. The fruit is a caryopsis (a kind of grain) that is 5–6 mm long. Its upper part is brown and often carries dried traces. Fibers from leaves and stems are very strong and used in making paper; also the plant is a source of vegetable wax [7].

The Alfa, which is the Arab name of esparto grass (*Stipa tenacissima*) plant, is a hardy perennial grass from the family of the grass.

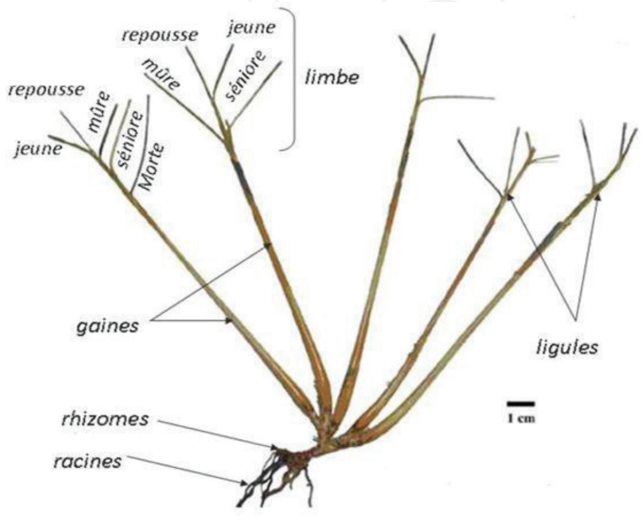

Figure 1. Morphology of esparto grass.

It is constituted of stems with a cylindrical shape which have a maximum height of about 1 m. Fiber differentiation is closely related to the vegetative cycle. The fibers are short and wide at the leaf base (basal level) and grow longer and thinner above the leaf [8]. The alfa stem is built of strong, stiff, and light cellulosic fibers which are mostly used in the production of high quality papers and for decoration, cigarettes, and dielectric applications for condensers; the stem is also used traditionally to manufacture ropes and carpets. The more recent information estimated that the esparto covered surface in hectares was approximately 3 million in Algeria [9, 10].

Due to its short fiber length, paper from esparto grass retains its bulk and takes block letters well. The esparto grass seems to prefer the calcareous soil, not very deep and permeable, with texture dominated by high sand rate. The high quantity of cellulose fiber contained in this plant, the flexibility, the smoothness, and the mechanical resistance of its fibers confer to it the very required properties in paper making; qualities recognized for a long time [11]. In addition to their multiple uses, natural fibers have shown many efficient properties such as heaviness, resistance, or flexibility which give them wide range of applications in textile field. In fact, they are recyclable and nature-friendly and nowadays they are exploited in automobile and medical applications. The fiber wastes from esparto grass offer a certain potential of liquid absorption and may be used as an absorbent fiber in hygienic products even in blends with fluff pulp [12]. In recent years, considerable attention has been given to the development and utilization of natural fibers. The main application of these materials as composites has been directed toward the automotive industries [13]. Composite materials were prepared using unsaturated polyester resins reinforced by Alfa fibers. Esparto grass fibers were evaluated for the production of bleached pulp [14]. To propose their application in composite materials, the question of chemical treatment is crucial, a preliminary study of chemical treatments to improve the properties of composite laminates [15]. As a consequence, a profound need exists for a sounder investigation of the morphological modifications produced by a wide range of chemical treatments on esparto fibers. Chemical treatments on esparto fibers increase the number of reaction sites [16], by removing non-structural matter such as hemicelluloses, lignin, and pectin [17]. However, alkaline treatment has been recognized capable of regenerating cellulose by the addition of OH groups, dissolving microscopic pits or cracks on the fibers alkali-treatment with NaOH and bleaching with sodium hypochlorite (NaClO) are applied on the fiber bundles to obtain the technical fiber used in textile products [18]. In North Africa, the esparto grass constitutes an essential element of fight against the turning into the desert and is an essential factor in the maintenance of balance in pastoral areas, due to well-developed root system that retains and protects the ground [19].

2. Materials and methods

2.1. *A. mauritanica* plant material

The Diss (*A. mauritanica*) is a very luxuriant plant. It is a large grass widespread in north Mediterranean Africa and the dry regions of south of Greece and Spain growing spontaneously in a wild state (**Figure 2**).

It is a high perennial herb. It blooms between April and June; the leaves are resistant. Growing up to a length of 1 m and 7 mm width, the plant is extremely rough and is used as a braiding

Figure 2. *Ampelodesma mauritanica* plant (Diss).

and serves as a material for paper [20]. Furthermore, recent studies have shown that it can be used as an additive to reinforce concrete [21]. It is also used by cattle breeders as antiparasitic and traditional medicine as antidiabetic [22]. Raw *A. mauritanica* stems (**Figure 3**) were collected from Batna in the east of Algeria during September 2016. The treatment started by purifying all of the Diss stems after removing the yellow and violet limbs. The aerial parts were air dried in shade at room temperature, then washed with water and Javelle water (12°) and then crushed [23]. The proportions of fiber contents were determined by treating stems with soda and sulfuric acids concentrate to obtain lignin, the cellulose obtained by bleaching and KOH treatment, the filtrate obtained is adjusted with acetic acid to obtain hemicelluloses.

Figure 3. Raw *Ampelodesma mauritanica* stems.

2.1.1. Taxonomy of A. mauritanica

- Reign: Vegetal
- Branch: Magnoliophyta
- Class: Liliopsida

- Order: Cyperales
- Family: Poaceae
- Genre: Ampelodesma
- Botanical name: *Ampelodesma mauritanica*

2.1.2. Pretreatment of A. mauritanica

The stems of *A. mauritanica* (**Figure 3**) was first rinsed with distilled water to remove dirt on the fiber surface. Washed *A. mauritanica* stems were left to dry at room temperature and finally dried in the oven for 5 h at 60°C. Afterward, they are submerged in 35 g/l salt water for 24 h at 60°C or 12 h to dissolve the waxes, a layer on the surface protects the plant against heat by limiting the evaporation of water.

2.1.3. Chemical characterizations of A. mauritanica

2.1.3.1. Water and volatile content

Water and volatile matter correspond to the loss of mass undertaken by the sample after drying in an oven at 100°C until constant weight (for 4 hours), water content and volatile matter (denoted by w) is expressed as:

$$W = \frac{m_1 - m_2}{m_1 - m_0} \times 100 \quad (1)$$

where m_0 (g): mass of empty crucible; m_1 (g): mass of crucible and test portion before heating; and m_2 (g): mass (crucible + residue) after heating up to constant weights.

2.1.3.2. Dry matter

The dry matter is determined from a raw sample, which is introduced into ceramic crucible, then weighed (m_0) and placed in the oven at 105°C until a constant weight. After cooling in a desiccator, the crucible containing the material dry is weighed (m_1).

The moisture content is then obtained from the equation below:

$$M\% = [(m_0 - m_1)/m_0] \times 100 \quad (2)$$

where m_0 = 2 g of Diss sample was placed in the oven at a temperature of 103–105°C for 4 hours. Then, the sample was allowed to cool in a desiccator containing $CaCl_2$ and the sample obtained was weighed.

2.1.3.3. Mineral content

Content of mineral substances (including mineral ash) is determined, by calcination of the dry sample at 500°C until constant weight. The calcined residue obtained is weighed.

The content of mineral matter (M_m) is expressed by:

$$M_m = \frac{m_3 - m_0}{m_1 - m_0} \times 100 \quad (3)$$

where m_3 is the weight of the crucible and of the residue after calcination to constant weight (g) and the difference of weight between the mass of dry matter and the mass of mineral content corresponds to the mass of organic matter.

2.1.4. Chemical extraction of A. mauritanica with NaOH

Ten grams of Diss sample was put in sufficient quantity of water for 2 hours and then the samples were dried after filtration. The sample was put in 1 l of NaOH (2 wt.%) and then put in water bath at 80°C for 2 hours, on filtrate and then washed with distilled water until the neutralization of pH, the processes were repeated twice.

2.1.4.1. Bleaching

The samples obtained from NaOH extraction (brown color) were bleached using sodium hypochlorite and acid buffer solution (27 g of soda in 50 ml of distilled water and 75 ml of acetic acid completed to 1 l with distilled water). The sample was put in a solution of H_2O_2/acetic tampon/NaClO (3:1:1). It is processed in a water bath at 80°C for 2 hours, then filtered, and washed twice until a white pulp of holocellulose was obtained.

2.1.4.2. Extraction of cellulose

The holocellulose obtained was dissolved in 70 ml of KOH (24 wt.%); the mixture was kept under stirring for 15 hours; then the paste was filtrated and washed until elimination of all KOH with distilled water; second wash was done with diluted acetic acid and then with ethanol; and finally, the cellulose was obtained dried and then weighed (**Figure 4**).

2.1.5. A. mauritanica spectroscopic analysis

Analysis of extracted cellulose fibers by infrared spectroscopy (FTIR-ATR) FTIR 8300 Fourier transformed SHIMADZY, allowed us for qualitative analyses to determine the groups functional properties present in the fibers. The results obtained are presented in **Figure 5**.

Figure 4. *Ampelodesma mauritanica* after chemical treatment.

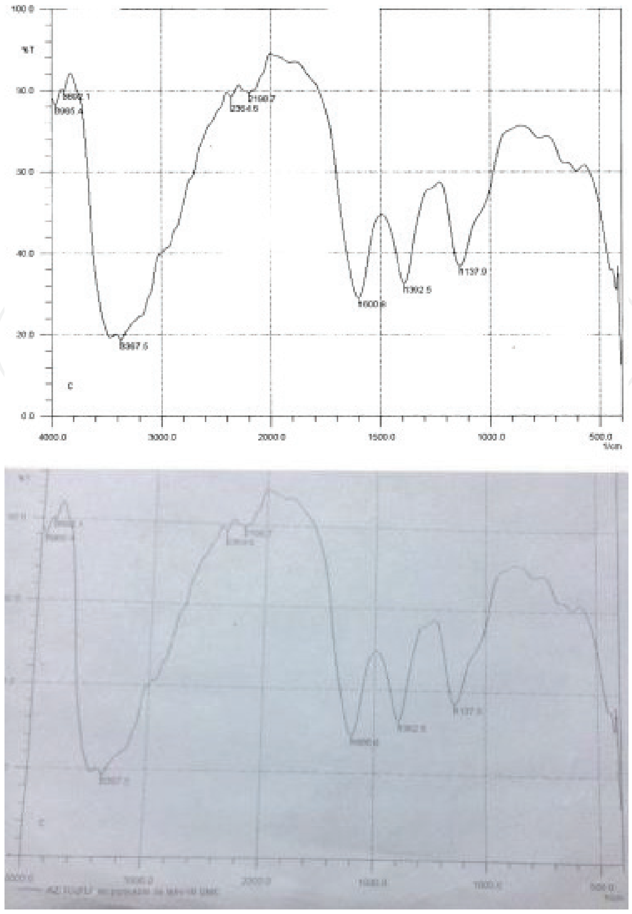

Figure 5. FTIR spectrum of *Ampelodesma mauritanica* fibers.

2.1.6. A. mauritanica X-ray diffraction

The crystalline structure (crystallinity rate) as a function of the chemical treatment studied by X-ray diffraction shown in **Figure 6**, was carried out on samples mechanically crushed using

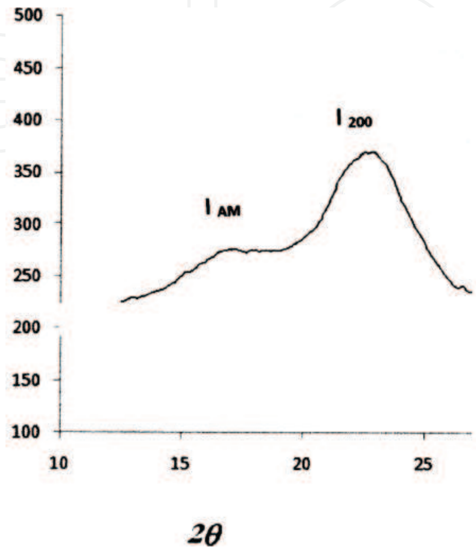

Figure 6. X-ray diffractogram of raw *Ampelodesma mauritanica* (Diss).

an electric mill, sieved to a size less than 125 μm. The diffraction was carried out by a Bruker D8 apparatus. The scanning speed is 0.2 s/step. The angle of diffraction was taken between 5 and 75°.

The monochromatic incident beam is centered on the copper Kα1 line (λ = 1.5418 A). The crystalline structure of plant fiber was studied using X-ray; the alkaline treatment of fibers improved the percentage of crystallization of cellulose in fiber. In order to ensure this, the crystallization factor was calculated according to the following equation [24]:

$$C = 100 \cdot \frac{I_{200} - I_{\text{non-cr}}}{I_{200}} \tag{4}$$

2.2. Esparto grass plant material

Esparto grass shown in **Figure 7**, is a hardy perennial grass of the grasses family, grows abundantly in dry, sunny locations along the seacoast. It bears gray-green leaves up to 1 m long and when young, provides food for cattle. Once esparto grass is mature, it becomes very tough. Esparto grass is an abundant plant in Algeria and it is used as paper paste with a low added value. The high percentage of cellulose fiber (41, 5 %) in this vegetal, the flexibility, the smoothness and the mechanical resistance of its fibers confer to him properties very required in paper making; qualities recognized since long time the esparto constitute a natural barrier which limits the expansion of the desert. The esparto grass seems to prefer the calcareous soil dominated by high sand rate. Leaf fibers are fibers that run lengthwise through the leaves of most monocotyledonous plants, such as esparto, these fibers, which are also referred to as hard fibers, are most commonly employed as reinforcing agents in plastics.

2.2.1. Pretreatment of esparto grass

The raw material shown in **Figure 8**, having been the subject of our study, comes from the Algerian steppe region.

Plant materials must be clean and free of extraneous substances, including soil and dust particles that may influence analytical results. For analyses of esparto grass, 10 g of finely crushed

Figure 7. Esparto grass (esparto, *Stipa tenacissima* L).

Figure 8. Raw esparto grass (esparto, *Stipa tenacissima* L).

plant was prepared approximately with particles of homogeneous size, sifted on sieve n° 24 and n° 27.

2.2.2. Organization and growth of the esparto grass

Esparto grass prefers the clay and silicic soil with a high rate of calcareous particles (30–40%) and a small percentage of gypsum (~2%) for its development [25]. Esparto tuft grows in a circle. The roots are at the stem's bases generally, they are not very deep. At the armpits of internodes appear the sheets, the buds, and the outlines of the future secondary roots (**Figure 9**), the stem is presented in the form of a thin ribbon, smooth, shining, solid, covered at the base with a hairy sheath.

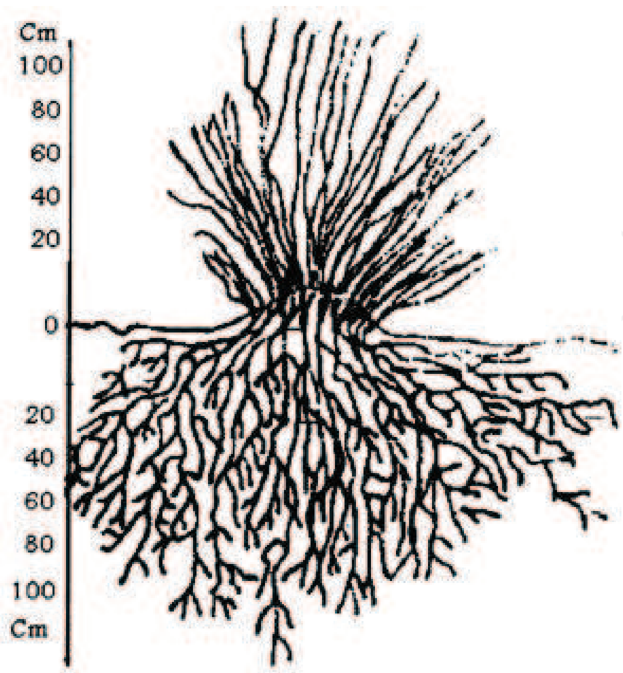

Figure 9. Radicular system of the esparto tuft.

2.2.3. Importance of esparto grass in desert regions

Esparto grass steppe habitats are important because of their ecological protection against desertification and economic (paper pulp manufacturing) interest, both on a national and international scale.

2.2.4. Esparto grass extraction procedure

First of all, the stems are being carded mechanically to refine their diameter. Before specific treatments were held, the fiber was first rinsed with distilled water to remove dirt from the fiber surface. Washed esparto fibers were left to dry at room temperature and finally dried in oven for 5 h at 60°C. Afterward, they are submerged in 35 g/l salt water for 24 h at 60°C or 12h at 80°C, to dissolve the waxes, a layer at the surface to protect the plant against heat by limiting the evaporation of water.

Esparto grass stems are treated with chemical products to degrade and eliminate the two main linking components, lignin and pectin. As the objective is to produce fibers, the hemicellulose does not need to be eliminated because it sticks the cellulosic filaments together to form fibers. Alfa fibers are cellulose-based fibers extracted from the esparto grass.

The cellulose was extracted from the esparto grass plant with 400 ml toluene/ethanol mixture **(**2/1, V/V**)** for 6 hours using a Soxhlet apparatus and treated with NaOH (1M) for 8 hours at 25°C [26], after filtration the cellulose was obtained and the filtrate contains the lignin and hemicellulose. This is mainly due to the reduction of lignin that binds the cellulose fibrils together.

2.2.5. Esparto grass plant analysis

The concentration of nutrients in Esparto plant tissues was measured in a plant extract obtained from fresh plant material, the esparto grass samples were washed in distilled water; oven dried at 60°C for 48 h, weighed, and then ground to 0.1 mm before chemical analysis. Elemental analysis was used to determine the organic, mineral and dry matter in the plant.

2.2.6. Esparto grass elemental analysis

Fibers extracted from esparto grass was characterized by different analysis methods.

2.2.7. Esparto grass characterization

Elemental analysis was used for analysis of esparto grass for its organic and mineral composition, the results for material composition of esparto grass are summarized in **Table 4** and the mineral components of esparto grass ashes are shown in **Table 5**.

2.2.8. Esparto grass FTIR analysis

A Perkin-Elmer 500 FT-IR spectrometer was used for infrared spectroscopy analysis of fibers extracted by KBr pellets.

2.2.9. Esparto grass thermal analysis

Thermal analysis (thermal gravimetric analysis [TGA] and differential scanning calorimetry [DSC]) was done for esparto grass fiber samples using Mettler TA TC 11 thermal analyzer.

2.2.10. Esparto grass X-ray diffraction (XRD)

A PW 1830 diffract meter was used to obtain the diffractogram of esparto grass fiber and the crystallinity of fibers was determined.

2.2.11. Esparto grass morphological characteristics

The dimensions of the fibers, and especially the length, are largely related to the quality of the Pulp [27], a manual method was used using a microscope equipped with an ocular micrometer. The average fiber size characteristics of the sample analyzed are summarized in **Table 6**.

2.2.12. Esparto grass scanning electron microscopy (SEM)

SEM micrographs were taken using Philips XL20 (Philips analytical Inc., the Netherlands). Samples were coated with gold before the examination (cathode dispersion). Fibers obtained from the esparto grass plant composed mainly of cellulose filaments were characterized by SEM.

3. Results and Discussion

3.1. *A. mauritanica* plant

3.1.1. A. mauritanica plant analysis

After extraction and bleaching of *A. mauritanica* plant, the cellulose fibers were obtained, fibers are better separated from one another, this causes the release of fibers encrusting substances (lignin, hemicellulose, pectin, etc.) and the chemical composition of *A. mauritanica* is shown in **Table 2**. Cellulose is the major component, followed by hemicelluloses and lignin, the smallest components are extractives and ashes.

3.1.2. Mineralogical analysis of ashes after calcination of the A. mauritanica stem

The mineral analysis (**Table 3**) of dissolved fiber ash was done using Atomic Absorption A.A-6200 SHIMADZU5.

Ampelodesma mauritanica **(Diss)**	**Wt.% for each component**
Cellulose	41.5
Hemicellulose	22
lignin	27.5
Fats and waxes	1.3

Table 2. Percentage of each component of extracted *Ampelodesma mauritanica* stem.

Elements	SiO_2	CaO	MgO	K_2O	Na_2O	Fe_2O_3
%	72.25	4.50	1.45	3.60	0.70	2.31

Table 3. Ashes mineral components of *Ampelodesma mauritanica*.

Chemical composition of *A. mauritanica* plant ash results in its very variable mineral composition. The silica is very much present in the composition of the plant; this is even one of the reasons for which the delignification of this grass is carried out by the alkaline processes.

3.1.3. A. mauritanica FT-IR spectra

In FT-IR spectrum of *A. mauritanica* plant fiber (**Figure 5**), a broad absorption band at 3367.5/cm is mainly due to OH groups in the existing structure of the fibers. We also note the presence of a band at 1137/cm, and a second one at 1600/cm which indicates the existence of single C–O and double C═O bonds. At 1392 cm^{-1} liaison C-H and CH_2 deformation vibration, pic at 2340/cm Indicate the presence of OH acid carboxylic [28].

3.1.4. A. mauritanica X-Ray analysis

Figure 6 shows a diffractogram of raw *A. mauritanica* (Diss) fibers, in which one can observe that *A. mauritanica* fibers extracted via the physical-chemical process have a very similar diffraction pattern. Crystalline peak appears at I (200) corresponding to the intensity diffracted at 2θ = 22.7°. It is understandable that the cellulose content increases, whereas the amorphous hemicellulose content decreases during the physical-chemical process. I (AM) corresponds to the intensity diffracted at 2θ = 15.2°, crystallinity index of the crude *A. mauritanica* fibers is of the order of 34.27%, it is higher than that of the plant fibers of esparto grass which is 25% [29].

3.2. Esparto grass plant

3.2.1. Esparto grass plant analysis

After the extraction and bleaching process of esparto grass, cellulose fiber was obtained (**Figure 10**, **Tables 4** and **5**).

Figure 10. Cellulose fiber obtained from esparto grass.

Composition	Percentage of dry plant
Dry matter	94.25
Organic matter	17.78
Mineral matter	1.22
Extracted with ebullient water	4.06
Crude fiber	28.75
Cellulose rate	33.81
Lignin rate	18.2
Ash cotenant	5.75
Silica	2.03
Moisture	12.3

Table 4. Raw material composition of esparto grass.

Element	%
SiO_2	32.5
CaO	7.25
MgO	2.40
K_2O	1.32
Na_2O	0.40
P_2O_5	0.60
Fe_2O_3	2.60

Percentages of humidity of Esparto fibers absorption were found to be 67% at 25°C and losses on the ignition was 48.23% at 1100°C.

Table 5. Mineral components of esparto grass ashes.

3.2.2. Esparto grass IR spectra

In esparto fiber FTIR spectrum (**Figure 11**), a broad absorption band at (3274–3500)/cm is mainly due to groups OH in the existing structure of the fibers. We also note the presence of a band at 1050/cm, and a second to 1630/cm which indicates the existence of links C-O single and double C═O. Wave number 920/cm corresponds to the vibrations of -H aliphatic chains.

3.2.3. Esparto grass thermal analysis

Thermal stabilities and degradation patterns were determined by employing thermal gravimetric analysis (TGA) and differential scanning calorimetry (DSC). To examine the thermal

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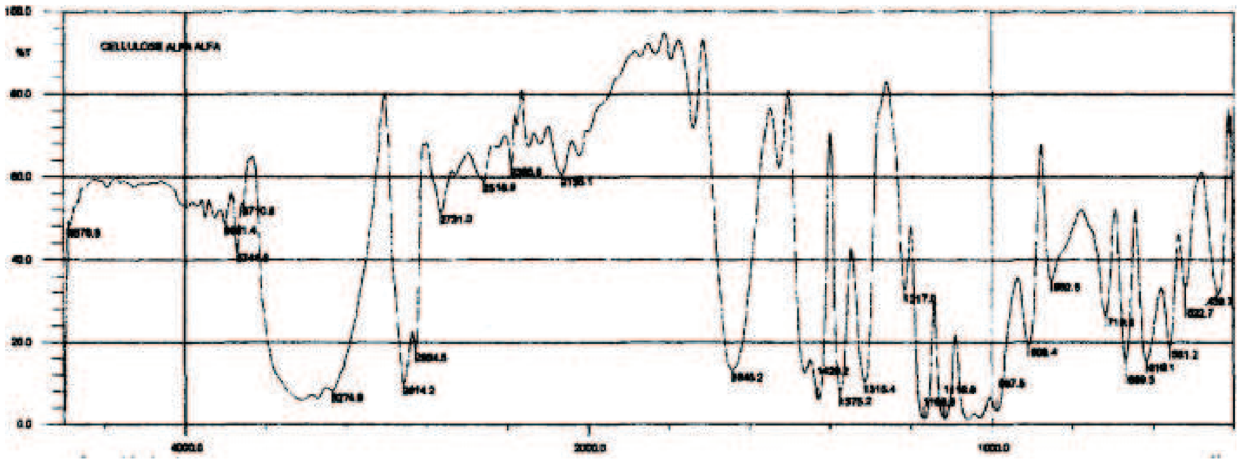

Figure 11. FTIR spectrum of esparto grass fibers with KBr.

stability of esparto grass fibers, thermogravimetric analysis under nitrogen flow was obtained.

A. Esparto grass fiber TGA curve

From esparto TGA curve (**Figure 12**), the weight loss at 70°C is due to the presence of H_2O in the sample and the degradation observed at 350°C.

B. Esparto grass fiber DSC Curve

Thermal degradation was studied by differential scanning calorimetry under nitrogen flow (**Figure 13**) and the cellulose shows one big endothermic curve at 80°C; caused by evolution of water entrapped by OH groups present in the cellulosic chains. The measured value indicate that the *decomposition of cellulose* begin at the *temperature* up than 200 °C.

3.2.4. Esparto grass X-ray analysis

From the X-ray diffractogram of extracted esparto grass fiber (**Figure 14**) the crystalline peak appears at 22.47°.

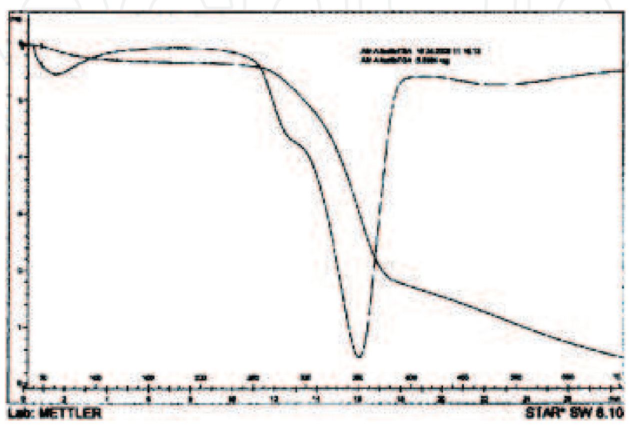

Figure 12. TGA curve of esparto grass fiber.

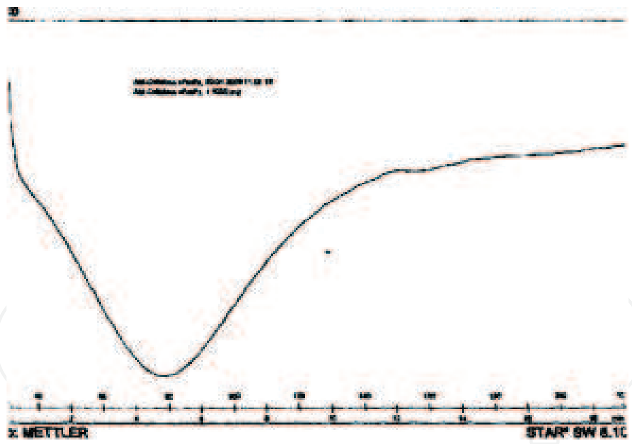

Figure 13. DSC curves of Cellulose Alfa-Alfa.

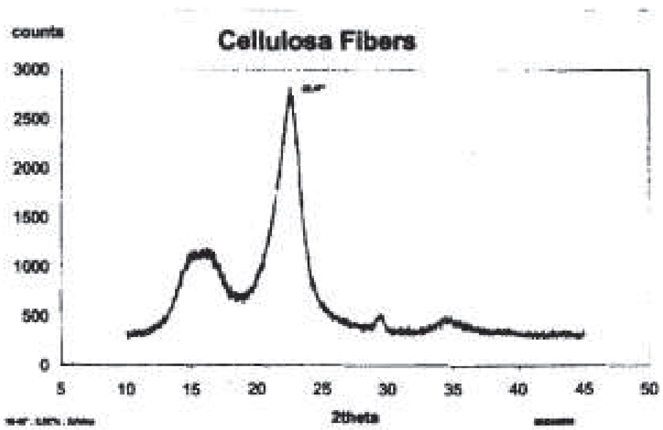

Figure 14. X-ray Diffractograms of esparto grass fiber.

This is understandable as the cellulose content increased, whereas the amorphous hemicellulose content decreased with the physico-chemical process [30]; this is in agreement with the FTIR and chemical analyses.

3.2.5. Esparto grass morphological characteristics

The average fibers sample dimensions analyzed are summarized in **Table 6**.

3.2.6. Esparto grass scanning electron microscopy (SEM)

The morphology of the esparto grass fibers was investigated by SEM as shown in **Figure 15**. Scanning electron micrographs of Esparto grass fibers and SEM micrographs (**Figure 16**)

Dimensions of esparto fiber	mm
Length	1.47
Outside diameter, *D*	0.015

Table 6. Dimensions of esparto grass fiber.

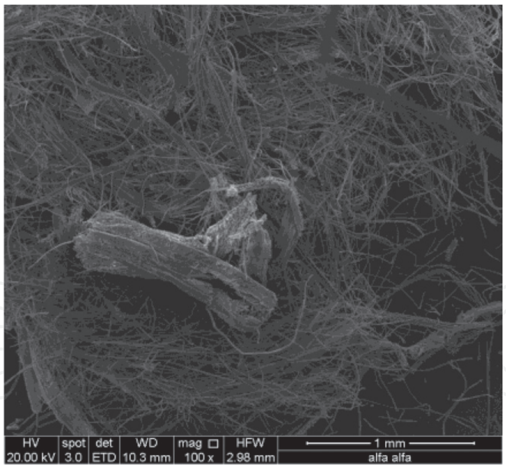

Figure 15. SEM of esparto grass fibers.

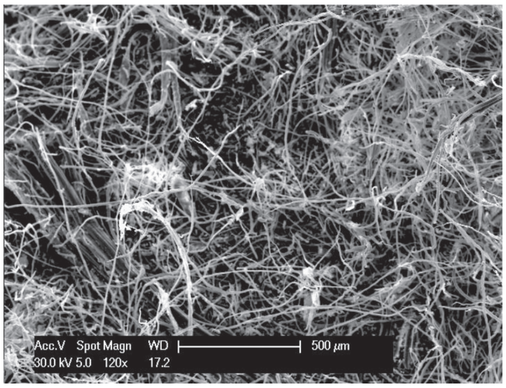

Figure 16. SEM of extracted esparto grass fibers.

of esparto grass fiber extracted, demonstrate that fibers are totally separated by chemical treatments.

4. Conclusion

This study aims to exploit new natural reinforcements for designing green composites. Cellulose fibers were extracted from *A. mauritanica* (Diss) and esparto grass (Halfa) plants for being used in different applications.

These materials are renewable, biodegradable, and very ecological. In fact, it requires a very small amount of water to grow and neither insecticides nor pesticides are needed.

Technical fibers have higher mechanical properties. However, ultimate fibers have a higher cellulosic rate.

To produce ultimate fibers, we must look for an appropriate method of extraction.

In this chapter, a method of extraction that gives cellulosic fibers without any damage was investigated; structure of *A. mauritanica* fibers is discontinuous, where cellulosic fibers are found in the matrix; this contains pectin, lignin, and hemicellulose. Fibers from esparto grass have a very short length and the structure of esparto grass fibers is discontinuous, where cellulosic fibers are found in the matrix, the obtained fibers are so fine and short. However, they have very interesting features. These fibers are then characterized through several analyses. The process of *A. mauritanica* and esparto grass fibers is simple and results in an excellent quality of fibers.

This study emphasizes the use of both fibers to different usable products in order to improve its added value.

The use of the natural fiber to prepare composite materials has major advantages like low price, low weight, biodegradable ecological, and renewable.

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