Sustainable Extraction and Characterization of Hibiscus Sabdariffa Fibre (Mesta)

Juhi Agarwal, Ela Dedhia

Abstract: Green fibres like flax, jute, sisal, kenaf, mesta which has been used for more than 8000 years are the present and the future raw materials not only for the textile industry but also for modern eco- friendly composites, cosmetics, medicine, food, fodder, bio- polymers, agro fine chemicals and energy. Potentially under optimum cultivation conditions they cause little or no detrimental effect on the eco- system and they can be grown in different climatic zones. Organically cultivated, they recycle the carbon dioxide in the earth's atmosphere. In the present study the sustainable extraction and characterization of Hibiscus Sabdariffa (mesta) were studied and documented along with the chemical composition and SEM of the fibre. The fibre was extracted from the stems by microbial retting technique and its composition was studied. The fibre was extracted immediately after harvesting and post harvesting.

Keywords: Mesta, Hibiscus Sabdariffa, Composition, microbial consortium

I. INTRODUCTION

Natural fibres of plants and animals have accompanied human existence for thousands of years. It is a highly valuable textile raw material characterized with specific usable features, friendly both for people and environment. Due to its specific properties, it has found its application in numerous sectors of economy and act as an excellent raw material for manufacturing of the so called "organic products". The most common group of natural fibres comprises lingo cellulosic bast fibres like jute, mesta, kenaf, flax etc. (Wallenberger and Weston, 2004). Mesta is one of the most important renewable, carbon neutral bast fibre which stands next to jute in production in India (Singh, D.P. retrieved from http://assamagribusiness.nic.in/mesta.pdf).

Retting is the main challenge faced during the processing of bast plants for the production of long fibre. The traditional methods for separating the long bast fibres are by dew and water retting. Both methods require 14 to 28 days to degrade the pectic materials, hemicellulose and lignin. Even though the fibres produced from water retting can be of high quality, the long duration and polluted water have made this method less attractive.

A number of other alternative methods such as mechanical decortication, chemical, heat and enzymatic treatments have been reported for this purpose with mixed findings (Tahir et.al 2011).

This describes different types of retting processes used for Mesta fibre (*Hibiscus Sabdariffa*). Mesta fibre apparently has some advantages as lower cost of production, high fibre yields and greater flexibility as an agricultural resource over other bast fibres.

II. OBJECTIVES OF THE STUDY

1) To optimize the microbial consortium employed for enzymatic retting.
2) To assess the yield of the fibre by enzymatic/microbial retting as compared to the water retting.
3) To assess the chemical composition of the fibre by anaerobic microbial retting and aerobic water retting.
4) To study the morphology of the fibre by SEM.

III. RESEARCH METHODOLOGY

1. Optimization of the microbial consortium: To maintain the sustainability of the microbial consortium all the ingredients used were locally sourced from the farmers. The ingredients used enhanced the catalytic action of the decomposition of the cellulose of the fibre.

2. Assessment of yield of the fibre: The yield of the fibre was calculated by anaerobic microbial retting and aerobic water retting.

a.) Anaerobic microbial retting was carried out in a special tank made of mud and brick stones on the farmer's field. It was closed with the help of polythene sheet loaded with mud so as to prevent the escape of air.For 20 kgs of stems a solution of 100 litres has to be prepared so that the stems are immersed properly in the solution. Following recipe was used for retting of mesta stalks:

Microbial Consortium- 20 litres
Water- 80 litres
Fruits and vegetable waste- 500 gms

The stem of *Hibiscus Sabdariffa* were immersed in the microbial consortium for 2, 4, 7, 11, 16 and 21 days. The tank was opened from one side occasionally to observe the retting.

b.) Aerobic Water retting: The water in this experiment used from a river canal in the village *Ambhora*, near Nagpur. The stalks were bundled together and tied with the rope and immersed in the water. The bundle was weighed down by a large cement stone so that it doesn't float on the surface and remain completely immersed. The mesta stems were kept immersed in water from 2, 4, 7, 11, 16 and 21 days and were tested for various physical properties.

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*Correspondence Author

Juhi Agarwal*, Department of Textile Science and Designing, S.N.D.T University, Mumbai, India. Email: juhiagarwallic@gmail.com

Dr. Ela Manoj Dedhia, Associate Professor & Head of Department Textile & Fashion Technology, Nirmala Niketan College of Home Science, Mumbai, India. elamanojdedhia@yahoo.com

3. Determination of Chemical composition of the fibre- The composition of the extracted fibres was determined to understand their behaviour under various conditions. The composition analysis of Mesta fibres was done in accordance with the Technical association of the Pulp and Paper Industry (TAPPI) standards at CIRCOT, Mumbai.
4. Scanning Electron Microscopy - the Scanning electron microscope is used to determine the fine structure, morphology and cross section of the fibre. The fibre sample was mounted on specimen stubs with double sided adhesive tape and coated with gold in a sputter coater and examined under SEM with a tilt angle of 45°C.

IV. RESULTS AND DISCUSSION

1. Recipe of the microbial consortium developed to ret 100 kgs of stems: Water- 200 litres, Cowdung- 10 kg, Cow's urine- 5 litres, Protein (Moong dal/urad dal)- 250 gms, Jaggery- 1 kilogram, Fruits and vegetable waste- 500 gms.

Figure 1: Anaerobic microbial retting

All the above-mentioned ingredients were mixed and kept under anaerobic conditions for 14 days to catalyse the development of bacteria. Fruits like Oranges, pear, guava and vegetables like cauliflower, potato, onion, and leafy vegetable waste was utilised for the consortium. Cowdung, cow's urine and jaggery was being used as manure which was considered for consortium. Few other ingredients like fruits and vegetables were added to counter the cellulytic activity of the microbes present in the cowdung and cow urine. By adding fruits and vegetables the microbes degrades the cellulosic part of fruits and vegetables rather than working entirely on the fibres.

2. Based on the yield the optimal conditions of the microbial retting (MR) are as follows: the culture temperature should be 35 degree Celsius with the ph of around 6, the time duration should not be more than 12 days (refer Figure 1). The optimal conditions for water retting (WR) are temperature 35 degree Celsius, ph 7 and duration around 21 days (refer Figure 2).

Figure 2: Aerobic water retting

Table 1: Influence of retting method on the yield of the fibre

		Initial weight (gms)	**No. of days kept for retting**	**Weight of retted and dried fibre(gms)**	**Recovery %**
Water Retting	Fresh Harvested stalks	5000	16	327	6.54
	Dried Stalks	5000	21	296.5	5.93
Microbial Retting	Fresh Harvested stalks	5000	11	355.7	7.10
	Dried Stalks	5000	16	285.2	5.70

The yield of the fibre was higher with the Microbial retting (355 gms) which was extracted from fresh harvested stalks followed by the fibre extracted from water retting (327 gms). The yield of the fibre extracted from the dried stalks was also higher in microbial retting (285.2 gms) as compared to the fibres extracted from dried stalks by water retting (296.5 gms). The anaerobic microbial retting of the fibres helps in removing the amorphous matrix of pectin, hemicelluloses, lignin and phenolic esters and help them converting into volatile fatty acids. The resulting volatile fatty acids are further converted to biogas in situ or in separate anaerobic biomethanation system simultaneously or later thereby enabling faster and complete cleaning of fibres. Anaerobic microbial retting yields more fibre bundles than the mechanical and chemical method without any harm to the environment.

Table No.1 indicates that on comparison between the dried stalks and fresh stalks, fresh stalks of mesta gave the better results in terms of all the parameters. This could be due to the water content present in the stalks during harvesting. The water retention after harvesting is higher which accelerates the process of retting i.e. loosening of the fibres and produces good quality of fibre. While there were not major differences noted between the fresh stalks retted by aerobic water retting and anaerobic microbial retting except for the strength of the fibre and the time taken for the extraction.

3. Chemical Composition is one of the important elements that influences the physical and chemical properties of a natural fibre. The common chemical content in a natural fibre is cellulose, hemi cellulose, lignin and ash. The different proportions of these contents depend upon the age of the fibre, the source and the extraction process. Table 2 shows the chemical content of the fibre. Cellulose is the main structural component and the fibre extracted by microbial retting possess 63.52% of cellulose as compared to the fibres extracted by water retting which is only 60.78%. The lignin content of the fibre extracted by microbial retting was found to be 7.6% whereas the fibres extracted by water retting were found to be 9.1%. Lignin provides the plant tissue and individual fibres with the sufficient strength and stiffness so if lignin is more it will make the fibres stiff as also told by Reddy and yang, 2005. It influences the structure, properties, morphology and flexibility of the fibre.

Table 2: Assessment of chemical composition of the fibre in percentages

	Cellulose	Hemi cellulose	Lignin	Ash
Microbial retting (16 days)	63.52	23.8	7.6	1.23
Water Retting (21 days)	60.78	26.7	9.10	2.12

4. Scanning Electron Microscope

Longitudinal View- Figure 3 and Figure 4 records the longitudinal appearance of the mesta fibre extracted by aerobic water retting and anaerobic microbial retting.

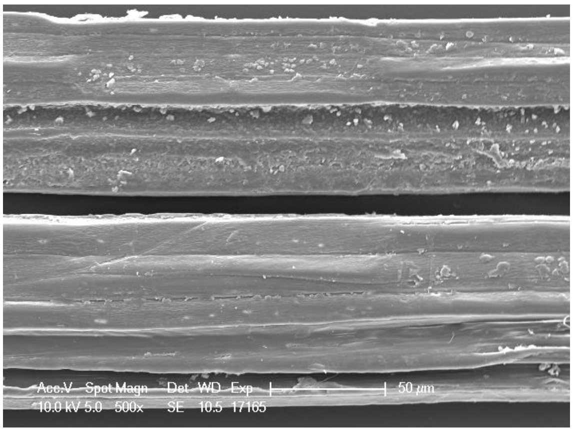

Figure 3: Longitudinal view of mesta fibres extracted by Aerobic water retting

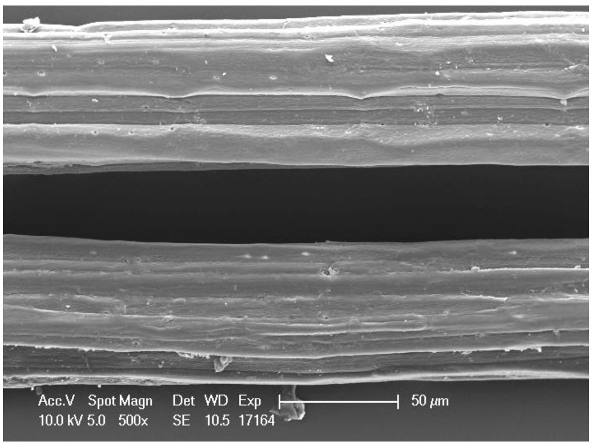

Figure 4: Longitudinal view of mesta fibres extracted by Anaerobic water retting

Figure 3 shows the structure of the fibre extracted by aerobic water retting. It shows the striations and specks of pectin and other substances sticking to it. This shows that the fibre has not been retted uniformly. The nodes are not visible here.

Figure 4 exhibits the structure of the fibre extracted by anaerobic microbial retting. The surface of the fibre appears to be smooth and free from impurities. The fibre also seems to be finer as compared to the fibre extracted by water retting. Most importantly the nodes are clearly visible which shows that the fibre has been uniformly retted.

Cross Sectional View- Figure 5 and Figure 6 shows the cross-sectional view of the fibres extracted by aerobic water retting and anaerobic water retting.

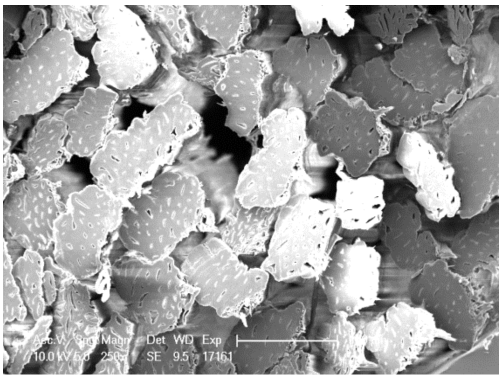

Figure 5: Cross section of mesta fibre extracted by Aerobic water retting

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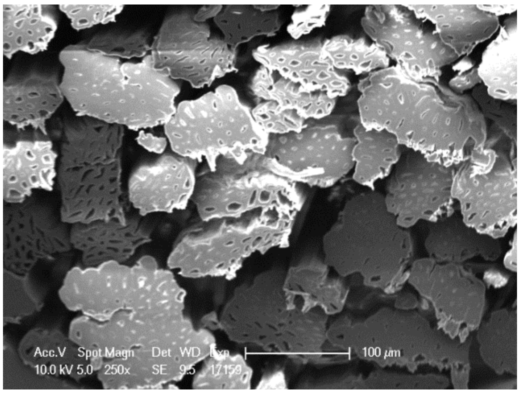

Figure 6: Cross section of mesta fibre extracted by Anaerobic microbial retting

Figure 5 exhibits the cross-sectional view of the mesta fibre extracted by water retting. Each cell is roughly polygonal in shape with the central hole or lumen which ranges between 8 or 9 to

maximum 20-25. These are firmly attached to each other laterally and the lumen is almost closed in every cell which shows the fibres have not been retted uniformly. The lumen of the fibre is seen almost very less opened up which probably shows that merely by water retting the lumen doesn't open up.

Figure 6 shows the transverse section of the mesta fibre extracted by anaerobic microbial retting. The lumen in the cells have opened up which shows the lateral adhesion between the fibres have loosened and the fibres are more uniformly retted. The lignin present in the fibres which helps in keeping the fibres intact has been removed which further helps in loosening of the ultimate fibre cells.

V. CONCLUSION

Mesta fibres being lingo-cellulosic in nature primarily contain cellulose, hemi celluloses, lignin and small amount of wax and ash. Microbially retted mesta fibres were mainly composed of 63.52% cellulose, 23.8% hemi cellulose, 7.6% lignin and 1.2 % ash. Scanning Electron Microscope longitudinal view shows the striations and specks of lignin, pectin and other substances sticking to it. This shows that the fibre has not been retted uniformly by water retting. In Anaerobic microbial retting the surface of the fibre appears to be smooth and free from impurities. The fibre also seems to be finer as compared to the fibre extracted by water retting. The plant of hibiscus Sabdariffa is mainly grown due to its calyces and its stem is generally discarded or used as a fuel but with the knowledge that fibres extracted from the bark can be put to a good use , this plant can be beneficial to improve the rural economy with ecological advantage. Hibiscus Sabdariffa can be successfully explored further for textile usages for woven, non woven and composite material end uses.

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AUTHORS PROFILE

Ms. Juhi Agarwal has done her BSc and MSc.in Textiles and Clothing from Lady Irwin College, University of Delhi. She is currently pursuing her Ph.D. from SNDT Women's University, Mumbai. She is teaching in SVT College of Home Science as an assistant professor and has an experience of about 6 years in research and 3 years in teaching. She has published few international research papers and has presented her work in national and international conferences.

Dr. Ela Manoj Dedhia acquired her MSc and PhD in Home Science specializing in Textile and Clothing. She has a 27 years of career experience in the Department of Textiles & Fashion Technology, at the College of Home Science Nirmala Niketan, and as a Visiting faculty in esteemed Fashion Institutes such as NIFT (Mumbai), PVP-SNDT and SOFT (Pune). Currently she is servicing as an Associate Professor, in the Department of Textiles & Fashion Technology, College of Home Science Nirmala Niketan, Mumbai.