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# Investigation of Physico-Chemical Properties of Non-Conventional *Sansevieriatrifasciata* Fibre with Different Extraction Methods

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***ABSTRACT***
*Natural fibres are being used forthe last few decades as an alternative to synthetic fibres for their eco-friendly nature. But still, there is a scientific gap to address cost-effective and environmentally sustainable fibre extraction method with minimum waste production. Therefore, a study was carried out on the extraction of fibre from naturallyoccurring Sansevieria trifasciata (Snake plant) adopting different extraction methods. Snake plant fibre was extracted by mechanical, chemical and biological process. Chemical extraction was carried out using ammonium oxalate at two different concentrations (8 & 10 %). The temperature was maintained at 100 ± 50$^0$C and the bath ratio maintained at 1:7 for two hours. Fibre yield was obtained 22.25 - 23.75% for both concentrations. Similarly, a biological retting process was also adopted using potential lignolytic bacterial (eg. Bacillus acidicola ) and fungal (eg. Chaetomium sp.) strains. Fibre yield in the biological process was obtained at the range 21.29 -32.41%. Proximate chemical analysis and SEM of extracted fibre were determined. Among the three different methods, the biological extraction method is found suitable in comparison to the chemical process.*

***KEYWORDS:*** ***Bacillus acidicola, Chaetomium sp, Sansevieria trifasciata, SEM***

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## I. INTRODUCTION

Plant fibres have been used by humans for millennia for both every day and technical applications. With the industrialization of our society, these fibres have been replaced by man-made fibres, mostly originating from fossil resources. Reduced availability of resources at affordable cost and the growing interest in sustainability has led to a renewed interest in biobased materials. Approximately 2,000 species of plants have been used as natural fibre reinforcements, but only a few fibres are dominating by holding 90% of natural plant fibre's market [1]. Retting is the first extraction process to obtains high-quality fibres. Several retting processes have been introduced in previous time and enzyme retting is found the most environmentally friendly due to mild retting parameters yet obtaining high-grade bast fibres. Presently there are three forms of fibre extraction, mechanical, chemical and biological respectively. In the biological fibre extraction methods, microbial action results in a release of the cellulose fibres due to modification of the pectin, hemicellulose and lignin content from parenchyma cells and middle lamellae. However, each method presents different advantages or drawbacks according to the amount of fibre produced or the quality and properties of fibre bundles obtained. In this study, the focus is putting on the extraction process of bast plant fibre, with emphasis on the microbial retting process. Numerous studies have been done on bast fibres, but there is a lack of discussion on the overview of bast fibre retting methods. Extraction is the first step to separate the desired natural products from the raw materials. Extraction methods include mechanical extraction, chemical extraction and retting process. After extraction of fibres by any of these methods, all extracted leaves are washed away before drying. Proper drying is important as the moisture content in fibre affects fibre quality.There are many fibre yielding plants in our country, which have the potential for use in the diversified field but they remain unexplored so far. The less explored natural fibres belong to leaf fibres. Hence this work an attempt has been made to extract fibres from *Sansevieria trifasciata*(snake plant) leaves and optimized the fibre extraction processes and evaluated the properties of fibres.Worldwide there are more than 12 Sansevieria species present on different continents. The common species are *S. cylindrica, S. trifasciata.S. trifasciata* is also called African bowstring hemp, leopard lily, tiger cat, mother-in-law tongue etc.[2]. They grow anywhere in anything, in full sun or light shade but thrives well in moist, fertile soil with a high organic matter content with minimum care.

## II. MATERIAL AND METHODS

*2.1 Mechanical process*

Respodar extractor machine was used in the mechanical extraction process, leaves are crushed and beaten by a rotating wheelset with blunt knives so that only fibres remain. All other parts of the leaf are washed away by water and dried under sunlight. The principle of mechanical extraction is to subject the stem to a succession of blows to break up the woody core [3].

*2.2 Chemical process*

Chemical extraction means the digestion with a suitable chemical to extract the fibres from the plants. For chemical extraction, the crashed leaf materials were digested with 8% and 10% ammonium oxalate used at a boiling temperature in an open vessel for about 3 hours. After that, the fibres were separated from the leaf matrix and washed with water to remove the excess quantity of Ammonium oxalate of the fibres were washed with distilled water and dried under sunlight.

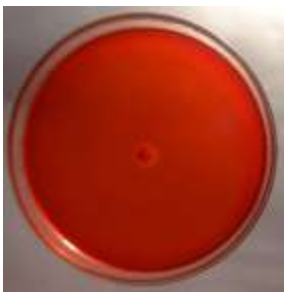
*2.3. Biological process*

The biological extraction process is a microbial process that breaks the bonds between the cellulose and lignin that hold the stem together and allow separation of the bast fibres from the woody core. For Biological extraction of fibre, different Fungal and Bacterial strains were used.

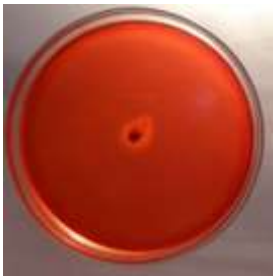
*2.3.1 Fungal strain:* In this process, the fungus is allowed to grow in the Potato Dextrose Broth (PDB) media in shaking condition for 72 hours at $28^0$C. After that, it was sprayed on collected plant materials, covered and kept undisturbed for 10-12 days. The microbes degrade the plant materials without affecting the fibre after the microbial strain applied. It was then autoclaved at 15lbs for 15 min before washing to get the fibre and then dried under sunlight. The plate screening method was followed and the following microbes are found better as they do not have cellulolytic activity.

i] LCF-30
ii] *Chaetomium sp.*
iii] *Fusarium oxysporum* NCIM
iv] *Fusarium oxysporum* view
v] *Fusarium monosporum*

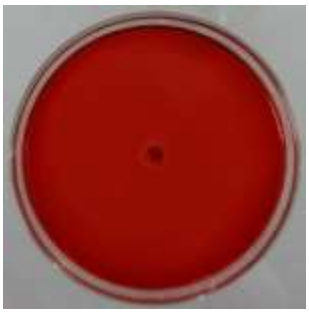
The photographs of the cellulose activity of fungus are given below...



*a)Chaetomium sp.*b)*Fusarium monosporum*



c) *Fusarium oxysporum* NCIM1281




d) *Fusarium oxysporum* view e) *LCF-30*

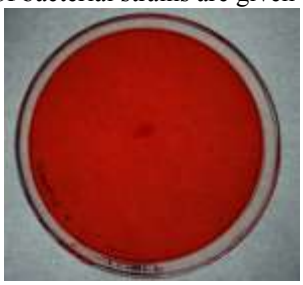
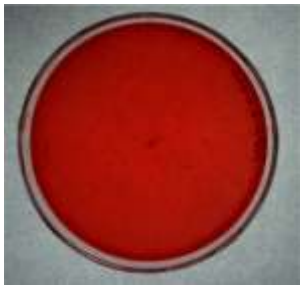
**Fig 1: Non-degrading cellulose activity of selected fungal strain using a plate screening method**

***2.3.2 Bacterial strain***: Eight numbers of non-cellulose-degrading bacteria were isolated from the eutrophic pond of Jorhat District. Bacteria were isolated using the serial dilution method and purified by the streak plate method.

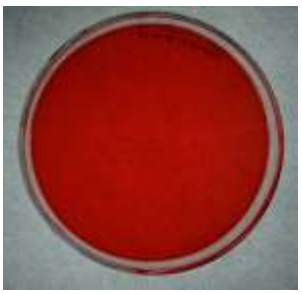
In this process, the bacteria are allowed to grow in the Nutrient Broth (NB) media in shaking condition for 24 hours at 30-35$^0$C. After that, it was inoculated on collected plant leaves and incubated for 15-20 days at room temperature. The microbes degrade the plant materials without affecting the fibre after the microbial strain applied. When the leave was completely degraded, then the fibres were extracted by removing the outer layer. Microbes were killed using autoclave at 121lbs for 15 min before washing to get the fibres. The fibres were washed properly and sundried. The plate screening method was followed and the following microbes are found better as they do not have cellulolytic activity:

- ***Streptomyces albus***
- ***Bacillus acidicola***
- ***Paenibacillus cooki***
- ***Paenibacillus sp.***
- ***Paenibacillus sp.***
- ***Enterobacteriaceae bacterium***

The photographs of the cellulose activity of bacterial strains are given below….

a) *Streptomyces albus* b) *Bacillus acidicola* c) *Paenibacillus cooki*



d) *Paenibacillus sp.*e) *Paenibacillus sp.*f) *Enterobacteriaceae bacterium*

**Fig 2: Non-degrading cellulose activity of selected bacterial strain using a plate screening method**

2.4.*Physicochemical properties analysis of extracted fibre:*Physico-chemical properties of fibres are essential to know for various end uses and the products made from it depends based on various parameters such as cellulose, hemicellulose etc.

2.5*Proximate chemical analysis:* Proximate chemical constituents of extracted fibre, was carried out using the analytical method suggested by Technical Association of Pulp and Paper Industry (TAPPI, T-21 cm-86, T-222 om-83, USA) and standard method of biochemical analysis. The fibres were washed, dried in an oven for 6-8 h at 40 ±5°C temperatures and then powdered in a Wiley mill. The powder was then screened with 40 and 60 BSS mesh and the powder fraction passed through 40 BSS mesh and retained on 60 BSS mesh was taken for different chemical analysis. Lignin content was determined by the Technical Association of Pulp and Paper Industry (TAPPI, T222 om-83) standard method. Cellulose and hemicelluloses content were determined by Standard Methods of Biochemical Analysis by S.K. Thimmaiah[4].

**2.6** ***SEM analysis:*** The fibre samples were analyzed using a ZEISS SIGMA Scanning Electron Microscope. The scanning electron microscope reveals surface morphology, a cross-sectional view of extracted fibres. Scanning electron microscope describes the impurities, wax, ash content on the raw fibre also removal of these materials on the other process.

## III. RESULT AND DISCUSSION

Table 1 shows the chemical constituents of *Sansevieria trifasciata* fibre. Lignin content was recorded for biologically extracted snake fibre 22.01, 6.58, 13.23, 10.74, 13.31, 13.85, 16.42, 13.82, 11.20 and 11.34% respectively, while 20.54% and 17.46% were recorded for chemically extracted (8 & 10% ammonium oxalate) fibre individually. The higher lignin content makes the fibre more rigid and stiff. Lignin provides plant tissue and individual fibres with compressive strength and protects the carbohydrates from chemical and physical damage. But biological process removal of lignin decreases rigidity and stiffens of the fibre and enhanced the surface roughness which will ultimately help in the compatibility of fibre to bond the other materials. Hemicellulose content of chemically extracted fibre was recorded 14-22%, while the biological extraction process was reduced to 6-12%. Among extraction process, the biological extraction process (both bacterial and fungal strain) removes a higher percentage of hemicellulose content and as a result, showed a greater exposure of cellulose has taken place and thereby increase in thermal stability. Hemicellulose is strongly bound to cellulose fibrils by hydrogen bonds. Hemicellulosic polymers are branched, fully amorphous and have a significantly lower molecular weight than cellulose. Because of its open structure containing many hydroxyl and acetyl groups, hemicelluloses are partly soluble in water and hygroscopic [5]. It acts as a matrix for cellulose microfibrils. However, it is very susceptible to thermal degradation, biodegradation and moisture absorption. On the other hand, the fibre with high contents of pectin (found mostly at middle lamella) is generally high in flexibility [6]. However, easy degradation of pectin affects the stability of fibre's performance. Therefore, the retting process tends to remove pectin components as well as releasing the bast fibres from the fibre bundle.

**Table 1: Proximate chemical analysis of *Sansevieria trifasciata* fibre**

| Extraction process | Ash (%) | Cellulose (%) | Hemicellulose (%) | Lignin (%) | Pentosan (%) | Yield (%) |
|---|---|---|---|---|---|---|
| **Biological process (bacterial strain)** | | | | | | |
| *Streptomyces albus* | 1.01±0.56 | 56.17±1.86 | 12.04±0.07 | 22.01±1.91 | 21.13±1.88 | 32.41±1.02 |
| *Bacillus acidicola* | 2.34±1.17 | 58.48±0.73 | 13.68±0.52 | 6.58±0.512 | 11.36±1.62 | 27.81±2.03 |
| *Paenibacillus cooki* | 1.23±0.34 | 60.62 ± 0.84 | 20.77 ± 1.55 | 13.23±0.618 | 21.95±1.34 | 23.10±1.11 |
| *Paenibacillus sp.* | 1.84±0.434 | 51.84±1.02 | 3.80±0.57 | 10.74±0.561 | 12.21±0.80 | 28.46±1.95 |
| *Paenibacillus sp.* | 2.01±0.459 | 55.65±1.70 | 6.69±0.52 | 13.31±1.03 | 13.96±3.86 | 30.08±256 |
| *Enterobacteriaceae bacterium* | 1.66±0.50 | 74.29±3.25 | 12.53±0.78 | 13.85±4.38 | 11.17±0.84 | 31.81±0.99 |
| **Biological process (fungal strain)** | | | | | | |
| LCF-30 | 0.54±0.126 | 54.01±3.60 | 10.36±0.66 | 16.42±0.570 | 15.69±3.27 | 32.26±1.36 |
| *Chaetomium sp.* | 0.753±0.064 | 67.63±2.12 | 11.62±0.99 | 13.82±1.13 | 22.31±0.47 | 26.79±1.92 |
| *Fusarium oxysporum* | 1.47±0.50 | 90.56±1.31 | 17.04±0.99 | 11.20±1.46 | 20.51±1.14 | 21.29±1.58 |
| *Fusarium monosporum* | 1.62±0.490 | 86.84±1.38 | 14.72±0.53 | 11.34±0.381 | 22.47±1.38 | 31.79±1.87 |
| **Chemical process** | | | | | | |
| 8% Ammonium oxalate | 3.24±0.125 | 68.57±3.28 | 21.46±0.87 | 20.54±0.695 | 31.06±1.08 | 22.08±1.25 |
| 10% Ammonium oxalate | 2.95±0.073 | 79.37±2.66 | 22.49±0.54 | 17.46±0.515 | 31.58±1.27 | 23.45±0.94 |
| Mechanically extracted unbleached | 3.64±0.269 | 70.02±2.70 | 25.78±1.32 | 15.25±1.05 | 27.01±1.09 | 19.32±1.23 |
| Manually extracted unbleached | 3.13±0.141 | 73.27±4.63 | 26.74±1.92 | 20.58±0.920 | 26.30±0.37 | 20.11±2.01 |

So also, cellulose content was recorded 51.85- 90.56% (table 1) for biologically extracted fibre, while 68.57% to 79.37% (table 1) for chemically extracted fibre respectively. The presence of hydroxyl groups of cellulose in fibre is responsible for its inherent hydrophilic nature. The biological and chemical process was done to reduce the number of free hydroxyl groups of cellulose. This would result in the reduction of the polarity of cellulose molecules and in the improvement of its compatibility with making a value-added product. Cellulose is the major component that provides stiffness, stability and strength to the fibre. Among all the processes used for modification of surface properties of fibre, the biological process showed better result in terms of quality and strength and decreases the amorphous region of the fibres increasing the crystalline portion. Because higher crystallinity of cellulose improves the bonding property as well as ultimate tensile strength. The controlled extraction process removed lignin, hemicellulose and other soluble parts like wax, tannin and other non-cellulosic polysaccharides on the surface of the fibre and made the fibre soft. The fibrils get separated from each other because of lignin, the cementing component had been removed by the action of the controlled extraction process.

Table 1 shows the characteristics of fibre produced from the snake plant obtaining using different retting process. Cellulose, hemicelluloses, pectin, lignin are the main constituents of the fibres. As shown in table1 biological retting process give a higher yield (23-32%) as compared to other processes. Due to the biological retting processes, many efforts have been focused on studying the degradation of pectic substances, lignin, hemicelluloses through enzymatic degradation. The enzymes hydrolysing the pectic substances are broadly known as pectinases, and they can be produced by a wide variety of microbial sources. During degradation, the plant polysaccharides can be attacked by several enzymes. Hence, this type of enzymatic retting process is very useful for fibres because of its without significant damage to the fibres.

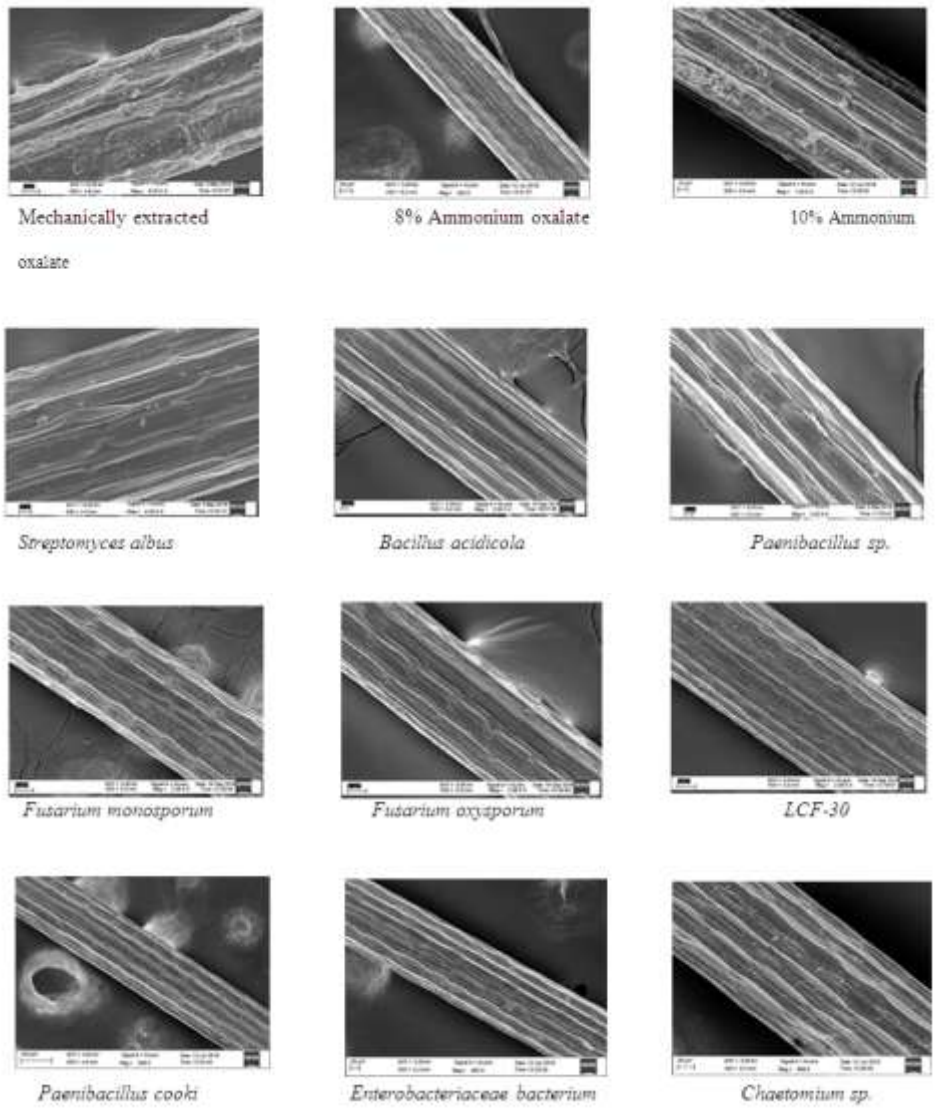



**Fig 3: SEM image of mechanically, chemically and biologically extracted snake plant fibre**

SEM micrographs of chemically and biologically extracted snake fibre are shown in Fig 3. To evaluate the changes that occur in the surface morphology of the fibre obtained different controlled process these are subjected to scanning electron microscopic studies. SEM micrograph of the mechanically extracted single fibre surface, which indicates that it is full of randomly distributed organic materials. In the mechanically extracted fibre, the damaged fibrils are protruding out of the fibre surface. It indicates the cloudy, unclear surfaces of fibre due to the presence of entangled and broken single fibres. However, in the biological extracted fibre the binding material is removed but the fibrils are intact. Chemically extracted single fibre surface, which indicates that distributed organic materials are removed and pits and fibril are exposed on the surface of the fibre. The process involves partial destruction of the intermolecular bonds, due to the penetration of chemical into the swollen amorphous regions of the fibre where the cellulose molecules are held by hydrogen bonding, which leads to the formation of sodium cellulose and sodium alcoholates. A large part of the residual hemicellulose is removed and rupture of some C–C bonds reduces the lengths of the chain [7].

## IV. CONCLUSION

In conclusion, the results of these study provide some interesting factors on fibre behaviors with different extraction methods. It is evident that enzymatic biological extraction results in higher crystalline values, hence it increases the fibre strength. whereas chemical extraction results in the lowest diameter and crystalline values. SEM analysis revealed the presence of impurities in mechanical extraction and removal of binder material in chemical and biological extraction. The overall results of this study open up new avenues for an investigation related to fibre extraction, concerning biological extraction to obtain fine fibre that could be used for the production of textile and automobile industries.

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