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Extraction of Fibre from *Furcraea foetida* Leaves and Their Evaluation

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ABSTRACT

The experiment was conducted from November to December of the year 2022 to extract the fibre from the *Furcraea foetida* leaf. *Furcraea foetida* plants are planted on the DRPCAU campus as ornamental plants and were selected for the present study. *Furcraea foetida* is a perennial subshrub plant that grows 4-6 feet tall and has the potential to extract natural, eco-friendly cellulosic fibres from its leaves. *Furcraea foetida* fibres were extracted by using the retting method in three different conditions: control (W), urea (U_1), and urea (U_2). It was observed that the U_1 completed their retting in 10 days, and also, it became more yielding. U_1 finished its retting in 12 days, while the control retting took longer. Fibre yield was higher in U_2. This indicates that the use of urea significantly enhances the retting process and improves fibre yield compared to traditional methods. The results suggested that optimising retting conditions with urea could lead to more efficient production of *Furcraea foetida* fibres for various applications. The fibre analysis revealed high cellulose, moderate lignin, and low ash content, with moisture levels progressively decreasing across samples. These compositional traits indicate strong structural integrity and reduced impurities. When retting was optimized, efficiency improved significantly, leading to higher output and better quality fibre. This underscores the importance of selecting appropriate retting techniques, as method choice directly influences productivity and material performance. Overall, the findings highlight how fibre composition and processing strategies together determine effectiveness and yield in production.

KEYWORDS: *Furcraea foetida* leaves, water retting, fibre extraction

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1. INTRODUCTION

The use of synthetic, non-biodegradable materials has led to increased environmental pollution, a major concern worldwide. Regulations limiting the use of non-biodegradable materials and promoting green alternatives are driving demand for eco-friendly and bio-renewable products (Madival et al., 2022). Increasing consumption of products made from natural fibres in the fashion-market opens the space for utilization of natural fibres (Kalita et al., 2019). Many researchers have given natural fibres serious consideration within the last ten years (Koronis et al., 2013). This is because of their combined valuable unique properties, which include low density, light weight, low cost, easy availability, recyclability, nontoxic, eco-friendly, good thermal stability, lower abrasion of equipment during processing, and biodegradability (Senthamaraikannan et al., 2016). Many researchers are creating green composites using various natural fibres, including jute, coir, flax, sisal, Grewia tilifolia, Cissus quadrangularis root, pineapple leaf, banana, Sansevieria cylindrica, and bamboo, to get around the problem of manmade fibres not being environmentally friendly (Jayaramudu et al., 2010; Indran et al., 2014; Sreenivasan et al., 2011; Sanjay et al., 2015). Natural fibres are becoming more and more popular as possible structural materials because of their unique qualities, which include being lightweight, inexpensive, and biodegradable (Pappua et al., 2016). Plant fibre characteristics vary depending on extraction procedure, plant maturity, and fibre position inside the plant. They can be taken from stems, seeds, leaves, roots, and fruits. Fibres are desirable due of their abundance, low cost, and strong mechanical qualities (Madhu et al., 2018; Yasir et al., 2021). Natural composites are fabricated using fibres that were extracted from natural resources such as plants, animals and minerals. Popular sources of plant fibres are agave, hemp, banana and sisal plants (Yashas et al., 2018). Typically, different plant parts like the leaves, stem, and roots are used to extract natural fibres. The geographic location of the plant's cultivation and the portion of the plant from which the fibres are extracted affect the fibres' characteristics (Kumar et al., 2018). It is a monocot plant in the Asparagaceae family, genus "Furcraea," and species "F. foetida". It is also known as Mauritius hemp. Additionally, the fibres obtained from *Furcraea foetida* are not only strong and durable but also biodegradable, contributing to eco-friendly manufacturing practices. Furcraea plants have grown rapidly in recent years in Indonesia, where they thrive due to ideal soil and climate conditions (Totong et al., 2021). Furcraea plants are both renewable and biodegradable. These plants can be grown with little care on wasteland. Long, leafy plants produce a higher amount of fibre. This type of unconventional lignocellulosic fibre has the potential to replace traditional natural fibre demand. This fibre will help unemployed youth earn money, and farmers can cultivate these plants on wastelands, extract fibre from the leaves, and sell it to the textile industry to double their income. Furcrea foetida is a permanent subshrub that grows to be 5 to 6 feet tall and is commonly found in India's western, eastern, and southern Ghats. These plants are primarily used for fencing to prevent soil erosion or landslides, and their root extracts are used in medicine to treat edema, rheumatism, a blood-purifying tonic, and hepatitis, among other things. The fibres extracted from the *Furcraea foetida* plant's leaves are used in household products such as twine, mats, and ropes. (De Sousa Martins, 2021). Furcraea fibre, a lignocellulosic material from Furcraea foetida (Mauritius 9810 hemp), is commonly extracted in India using water retting, where leaves are soaked for 15–20 days. This study selected middle yellow and side green leaves to extract fibres through retting and evaluate their physical and mechanical properties.

2. MATERIALS AND METHODS

The experiment was conducted from November to December of the year 2022 to extract the fibre from the *Furcraea foetida* leaf. *Furcraea foetida* plants are planted on the DRPCAU campus as ornamental plants and were selected for the present study.

2.1. Extraction of Furcraea foetida fibre from leaves

2.1.1. Collection of raw leaves

Furcraea foetida leaves were collected from the Dr. Rajendra Prasad Central Agriculture University campus, Samastipur district, in the year 2022 for carrying out the present experiment. It was planted as an ornamental plant in the university garden. The mature leaves of *Furcraea foetida* were chosen from the university garden, and the leaves were almost of the same color and size. The leaves are wedge-shaped and look like two-sided swords, with lengths ranging from 116 to 133 cm and widths (widest part) ranging from 14 to 20 cm.

2.1.2. Harvesting of leaves

The *Furcraea foetida* plant leaves were cut near the stalk base using a large, sharp sickle and/or knife, and then bundled all leaves to bring to the textile lab of the Apparel and Textile Science department, College of Community Science, for fibre extraction.

2.1.3. Cleaning of leaves

After the harvesting of *Furcraea foetida* leaves, the dirt was cleaned using a brush and then washed with water. The sharp spines that encircled the leaves were removed and discarded. Hard portions of leaves were beaten through stones for proper water penetration.

2.1.4. Length, width, and weight measurement of each selected leaf

Length and width measurements of each collected *Furcraea foetida* leaf were taken by measuring tape, and the weight of the leaf was taken by a digital weighing balance scale (DELTRON).

2.1.5. Retting of furcraea foetida leaves

To obtain fibre from the leaves of *Furcraea foetida*, retting of the leaves has to be done to remove the pulpy portion and separate the fibre. In this study, three baths were prepared to carry out the retting of leaves and to determine the best and fastest retting methods for getting the fibre from *Furcraea foetida* leaves. Retting of the *Furcurea foetida* leaves was carried out under three different conditions: the first is control (W), the second is 0.37 g of urea l^{-1} of water, and the third is 0.75 g of urea l^{-1} of water. Urea increases the wetting action of water and enhances the growth of microbes in water; therefore, urea is added for quick retting (Dhanalaxmi and Vastrad, 2013). The retting was done in the month of November with an atmospheric temperature of 21°C±2.

2.2. Water retting (W)

Four leaves (weight 3240 g) of *Furcraea foetida* were immersed in 40 L of water, completely submerged in a water tub. The leaves were regularly checked by using a finger to ensure the fibres were loosened. After the extraction of fibre by the water retting method, all the extracted fibre was washed away to remove pulp before drying. Extracted fibre takes 2–3 days to dry in the sun. The total time taken for water retting is 15 days.

2.3. Urea retting (U_1)

Four *Furcraea foetida* leaves (weight 2890 g) were immersed in 40 L of water for total immersion, and then 15 g of urea was also added to the water tub for fast retting. The water tub was regularly checked by using a finger to ensure the leaves became soft and the fibres were loosened. After completion of the retting process, the fibres were separated from the pulp and washed with running water. Extracted fibres dried in the sun for 2–3 days; the total time taken for retting is 12 days.

2.4. Urea retting (U_2)

Four leaves of *Furcraea foetida* (weight 3389 g) were immersed in 40 L of water for total deep immersion, and then 30 g of urea was also added to the tub for checking the fast retting. The water tub was regularly checked by using a finger to ensure the leaves became soft and the fibres were loosened. After completion of the retting process, the fibre was separated from the pulp and washed with running water. Extracted fibres and dried in the sun for 2–3 days; the total time taken for retting is 10 days (Plate 1-6).

3. RESULTS AND DISCUSSION

Many fibre-yielding plants are available in our country; they have potential for use in diversified fields, but they remain unexplored. The less explored natural fibres belong to the leaf fibre. An attempt has been made in this study to extract fibre from the leaf of the *Furcraea foetida* plant. Leaves were harvested, and they were grouped into three groups of four leaves for three retting methods.

Plate 1: *Furcraea foetida* plant

Plate 2: Harvested mature leaves of *Furcrarea fotida*

Figure 3: Box plot showing the mean variation of COD and BOD across 10 sampling stations

Palate 4: *Furcraea foetida* leaf extraction

Plate 5: *Furcraea foetida* fibre after drying

Plate 6: *Furcraea foetida* fibre after combing

and then leaf length, width (the widest part), and weight measurements were taken. It is evident from Table 1 that the mean weight, length, and width for the first group of leaves were 810 g, 119 cm, and 17.5 cm; for the second group, it was found that the mean values of weight, length, and width were 722.5 g, 124.75 cm, and 18 cm, followed by 847.25 g, 123.5 cm length, and 18 cm width. Widyasanti (2020) found that the length and width of sisal fibre were 89.03 cm and 14.85 cm.

3.1. Lignin contents

Lignin is important in the formation of cell walls, especially in wood and bark, because it lends rigidity and does not rot easily. Lignin is a class of complex organic polymer that forms a key structural material in the support tissues of vascular plants and some algae. Lignin is cross-linked to hemicelluloses via a cell wall protein called extension. It is evident from Table 2 that the lignin contents of control (w) fibre were found to be 26.72%, followed by 15 g urea-retted (U_1) fibre (25.72%), and 25.13% in the 30 g urea-retted (U_2) fibres. According to Hulle (2015), lignin content was found in agave americana fibre, 5–17%. Naveen (2019) found lignin content in the sisal fibre 9.9–14%. A higher lignin percentage in *Furcraea foetida* fibre acts as a defensive agent against biological attack. Manimaran (2018) found that the lignin % decreased in treated samples; this was mainly due to the detachment of individual fibres from the bundle after lignin removal.

Table 1: Mean weight, length, and width measurements of *Furcraea foetida* leaves

Sl. No.	Sample code	Weight of leaves (g)	Mean wt. (g)	Length of leaves (cm)	Mean length (cm)	Width of leaves (cm)	Mean width (cm)
1.	W (R)	620	810	116	119	17	17.5
2.	W (G)	910		120		18	
3.	W (B)	870		120		17	
4.	W (Y)	840		120		18	
5.	U_1 (R)	840	722.5	133	124.75	17	17.2
6.	U_1 (G)	600		130		18	
7.	U_1 (B)	630		120		17	
8.	U_1 (Y)	820		116		17	
9.	U_2 (R)	620	847.25	113	123.5	14	18
10	U_2 (G)	950		120		18	
11.	U_2 (B)	999		125		20	
12.	U_2 (Y)	820		116		20	

Table 2: Chemical composition of *Furcreaea foetida* fibre

S1. No.	Sample code	Lignin (%)	Cellulose (%)	Ash (%)	Moisture (%)
1.	W	26.72	53.29	0.816	10.48
2.	U_1	25.76	54.26	0.940	9.43
3.	U_2	25.13	54.45	1.830	8.98

3.2. Cellulose contents

It is clear from Table 2 that the values of cellulose content were 54.45% for control retting, 53.29% for 15 g urea retted (U_1) fibres, and 54.45% for 30 g urea retted (U_2) fibre, respectively. It can be said that urea treatment significantly improved the cellulose content of fibres, as shown in Table 2. Higher cellulose content enhances the strength of the fibre. Hulle (2015), cellulose content was found in agave americana fibre 68.80%. Naveen (2019) reported cellulose content in the sisal fibre to be 65-68%. Manimaran (2018), the cellulose content of the *Ff* fibre was 68.35%.

3.3. Ash contents

Table 2 shows that the ash content of the control fibre was 0.816%, the fibre treated with 15 g of urea had an ash content of 0.940%, and the fibre treated with 30 g of urea had an ash content of 1.830%, which is the same as *Furcraea foetida* fibre. Mishra (2000) also reported that the value of the ash content in flax fibre (a bast fibre) was 1.3%. Manimaran (2018) found that the ash content Ff fibre was 6.53%.

3.4. Moisture contents

Moisture content has a direct impact on the properties of textiles, such as tensile strength, elasticity, fibre diameter, and friction. A drop in the equilibrium relative humidity of a textile may cause it to be weaker, thinner, less elastic, and therefore more brittle. One direct effect is that the density of the dry fibres will be different from the fibre that has absorbed moisture. This change in density affects not only the mechanical properties of the textile but also its overall performance in various applications. Consequently, understanding moisture content becomes crucial for industries that rely on textiles, as it influences durability and functionality. For most fibres, when the amount of absorbed moisture increases, the fibre becomes weaker, the specific breaking stress is reduced, and the percent breaking extension increases. It is evident from Table 2 that the moisture content of *Furcraea foetida* fibre was 10.48% for the control, followed by 15 g of urea-retted fibre (9.43%) and also 30 g of urea-retted fibre (8.98%). Moisture content is mainly responsible for the spinning of yarn. The above results confirm that these fibres have a wide scope in the field of textile applications. Manimaran (2018), found that the Ff fibre was 5.43%. Hulle (2015), Moisture content was found in the agave americana fibre 8%. Naveen (2019) moisture content was found in the sisal fibre 10–22%.

According to Figure 1, 63.3% of the respondents visually evaluated the *Furcraea foetida* fibre and felt that its luster after scouring was moderately increased. 26.66% thought it had slightly increased, only 6.6% thought it had increased significantly, and 3.33% thought it had not changed. 56% of respondents thought the smoothness of the fibre had greatly improved, 40% thought it had improved moderately, and 3.33% thought it had improved slightly. Furthermore, 45% of respondents rated the fibres ' color as moderately enhanced, 40% as slightly increased, and 15% as highly increased.

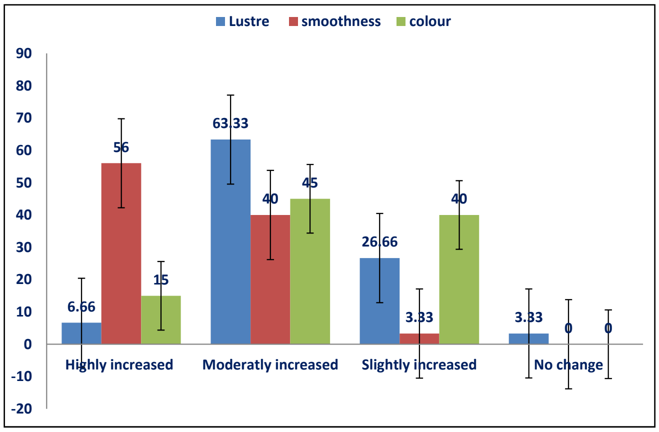

Figure 1: Visual evaluation of *Furcraea foetida* fiber after scouring (%) N=30

The overall result showed that 63.33% of the respondents thought that luster moderately increased, 56% reported that smoothness highly increased, and 45% of respondents found that it moderately enhanced the color of the fibre when compared to untreated fibre. This suggests that the treatment applied had a significant impact on the aesthetic qualities of the fibre, leading to improved visual appeal and texture. Such enhancements may encourage further exploration into the application of this treatment in various textile industries. Hulle (2015) found that the visual evaluation of agave americana fibre color ranges from off-white to yellowish, and the luster is semi-dull in appearance.

For the retting bath, we divided the leaves into four groups. Retting was carried out in three conditions, which were control (only water), 15 g of urea, and 30 g of urea in 40 l of water for complete submerging. The retting was done at room temperature (21±2). The bath ratio was 20 g l^{-1}. The urea-to-water ratio was 0.37 g l^{-1} and 0.75 g l^{-1} of water. Omenna (2017) followed a 25% and 50% urea retting process for fibre extraction. Table 2 records that the retting time was longer for control retting. It was found that 30 g of urea retting in 40 L of water took less time, and the fibre yielding capacity was higher. Widyasanti (2020), it was found that the yield of dry extracted fibre was 38.45±4.30%.

Table 3 displayed the yielding of *Furcraea foetida* fibre in three groups; the mean weight and length for the first group (U_2) were 16.566 g and 121.4 cm, and for the second group (W), it was found that the mean values of weight and length were 14.494 g and 126.25 cm, followed by the third group (U_1) at 14.067 g and 122.5 cm length. These results indicate a variation in fibre yield among the different groups, suggesting that growth conditions or genetic factors may influence the characteristics of *Furcraea foetida* (Figure 4). Further analysis is necessary to determine the underlying causes for these differences and to optimize fibre production. Optimising fibre production will require

Table 3: Observations recorded after retting of leaves under three conditions

Sample code	Bath ratio (g l^{-1})	Urea and water ratio (g l^{-1})	Room temperature (degree)	Duration of retting (days)	Total wt. (Yielding) of fibres from 4 leaves of each group (g)	Observation
W	20 l^{-1}	Control	21°C±2	15	57.594	Fibre quality was good, and also observed that slow retting compared to 15 g and 30 g urea retting.
U_1	20 l^{-1}	0.37 l^{-1}	21°C±2	12	56.27	Fibre quality was good, and it was observed that fast retting compared to the control.
U_2	20 l^{-1}	0.75 l^{-1}	21°C±2	10	66.266	Fibre quality was good and it was observed that fast retting compared to control and 15 g urea retting

W: control/40 litres; U1: 15 g/40 l, U2=30/40 l

Table 4: Mean weight and length measurement of extracted *Furcraea foetida* fibre

Sl. No.	sample code	Weight of *Ff* fibre (g)	Mean weight (g)	Length of *Ff* fibre (cm)	Mean length (cm)
1.	W (R)	19.002	14.494	121	121.4
2.	W (G)	9.462		122	
3.	W (B)	10.129		124	
4.	W (Y)	19.001		119	
5.	U_1 (R)	9.858	14.067	133	126.25

Table 4: Continue...

Sl. No.	sample code	Weight of *Ff* fibre (g)	Mean weight (g)	Length of *Ff* fibre (cm)	Mean length (cm)
6.	U_1 (G)	18.000		130	
7.	U_1 (B)	16.000		119	
8.	U_1 (Y)	12.412		123	
9.	U_2 (R)	9.872	16.566	116	122.5
10.	U_2 (G)	19.280		124	
11.	U_2 (B)	18.099		135	
12.	U_2 (Y)	19.015		115	

not only a thorough understanding of the environmental influences but also an investigation into the genetic diversity within the species. By identifying the specific traits that contribute to enhanced growth and fibre yield, researchers can potentially develop targeted breeding programmes to improve overall productivity. Widyasanti (2020), it was found that the length of sisal fibre was 81.60±11 cm. Totang (2021), found that the average length of *furcraea foetida* fibre was 70.80 cm.

4. CONCLUSION

F*urcraea foetida* was a perennial subshrub that grew 4–6 feet tall and offered potential for eco-friendly cellulosic fibres from its leaves. The research aimed to extract and evaluate fibre, assessing environmental advantages that showed sustainability. U_2 retting finished in 10 days with higher yields, while U_1 took 12 days. Control retting was slower with lower yields. The fibre contained high cellulose, moderate lignin, and low ash, with moisture decreasing across samples. Optimized retting improved efficiency and output, highlighting technique selection.

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