Original Research Article

The Analysis of fibre properties of water retted *Sansevieria trifasciata* with sodium hydroxide

Abstract: In the last decade, natural fibres have been in high demand because of their strength, high efficiency, and biodegradability easy availability for nature and improved textile properties than synthetic fibre. So, the increasing preference towards natural and green textile products rather than synthetic products has increased the attraction of tourists to the local as well as outside markets. Therefore, the present paper focused on the analysis of sodium hydroxide on the fibre properties of water-retted snake plant fibres. The extraction of fibres from snake plant leaves was conducted by using water water-retted method. Three different time periods were selected i.e. 10, 15 and 20 days for water retting. After water retting, the selected fibres were treated with an alkali i.e. NaOH. The optimum conditions for alkali were chemical concentration, material to liquor, time durations, treatment temperature and pH for standardization of the process of alkali treatment. The effect of sodium hydroxide was analyzed on fibre properties such as fibre yield, fineness, bundle strength, and elongation at the break. As a result, a gradual fibre yield was to be increased to decrease after being treated with alkali (NaOH). The alkali-treated fibres showed the fibre yield, fineness and bundle strength recorded to be (0.84±0.02 g), (23.51±0.39 denier) and (47.97±0.13 g/tex). Elongation of the alkali-treated fibres was reported to be 5.02±0.007 per cent, respectively. The resulting fibre properties were found suitable for other textile products such as apparel, reinforcement material composite etc.

Keywords: Green products, optimization, standardization, chemical treatment and water retted

1. Introduction

Recent statistics revealed that the annual world production of natural fibers has been about 45.5 million tons; production of these fibers in India has been almost 14.5 million tons. Increasing consumption, especially in the developing countries, constraints on the natural resources required to produce fibers, and inability to increase the supply proportionate to the demand are expected to make most of the current fibers either too expensive or unavailable for commodity applications **(Kanimozhi 2011)**. Recently, due to the improvement of people's living standards and need for environmental protection, the demand of natural biodegradable, sustainable, nontoxic and eco-friendly fibres is rising worldwide day by day. Ramie, flax, hemp and some other vegetable fibres have been used as textiles materials. But some plant yielding fibres species are still unexplored, these plant species can largely contribute to economic upliftment of local people through development of Research and Development programmes suitable for small scale industrialization. Natural fibres provide a number of benefits as compared to synthetic fibres, including low weight, low density, low cost, acceptable particular qualities, and the fact that they are recyclable and biodegradable. They're also renewable and have a good strength-to-stiffness ratio. Eco-friendly, biodegradable, and recyclable textile products are gaining popularity in the world market, bringing natural fibre into the spotlight. The earth is densely populated with a variety of plants that may have the potential to generate valuable fibres, but they have yet to be studied. Longer leafy plants appear to have a higher fibre generating capacity **(Kant and Alagh 2015).** *Sansevieria trifasciata* leaf is found abundantly in India and this (family-*Ruscaceae Agavaceae* and genus-*Sanseveria*). *S. trifasciata* (Species) is an evergreen herbaceous perennial plant forming dense stands, spreading by way of its creeping rhizome, which is sometimes above ground, sometimes underground. Its have stiff leaves grow vertically from a basal rosette and mature leaves are dark green with light gray-green cross-banding and usually range between 70-90cm in length and 5-6cm in width **(Kumar *et al.*, 2011).** Retting of natural plant fibres is a microbiological process that removes non-cellulosic components such as pectin, hemicelluloses, lignin, waxes, and lipids and separates the fibre from plant materials. Hence microbial action requires both moisture and a warm temperature for degumming process **(Hulle *et al*. 2015).** Mechanical processing removes non-fibre components from individual fibres. Under-retting or insufficient retting gives poor results i.e. inadequate separation of non-fiber components (such as shive) from fibres, lowering fibre production, processing efficiency, and overall fibre quality. Over-retting, on the other hand, might result in poor fibre quality. In terms of fibre yield and quality, retting is critical **(Brunsek *et al.*, 2019).** To optimize the conditions for fibre extraction from snake plant using conventional degumming and analyze the fibre properties of extracted fibre.

2. Experimental design

2.1 Materials

Matured green leafy leaves purchased from Agritourism Centre CCSHAU, Hisar, sodium hydroxide (NaOH), acetic acid (CH_3COOH), hydrogen chloride (HCl) chemicals used were of textile laboratory.

2.2 Methods

2.2.1 Collection of raw materials: Green matured snake plant leaves were collected from the Agri-tourism centre of Chaudhary Charan Singh Haryana Agricultural University, Hisar.

2.2.2 Fibre extraction from SPL: The fibres from snake plant leaves (SPL) were firstly extracted through water retting process.

2.2.3 Water retting process: 10, 15 and 20 days of duration during the month of June and July with atmospheric temperature were used for water retting process and Changed the water after every two days. After 10, 15 and 20 days of duration, the fibres were separated from the biodegraded leaves by means of hand rubbing. The extracted fibres were washed with clean running water, dried at ambient temperature and weighed. On the basis of visual analysis, selected fibres for treatment with sodium hydroxide were 15 days.

		
10 days retted SPL fibres	**15 days retted SPL fibres**	**20 days retted SPL fibres**

Picture 1 : Water retted dried SPL fibres

2.3 **Treatment of water retted SPL fibres and optimization parameters of treated SPL fibres:** Water retted fibres were subjected to alkali treatment at different parameters and conditions to assess the different fibre properties of the water retted SPL fibres. The different parameters and conditions were i.e. 2.5, 5.0 and 7.5 g/L concentrations of sodium hydroxide; 1:10, 1:20 and 1:30 material to liquor ratios at 80^o, 90^o and 100^o C temperature for 60, 90 and 120 minutes time duration and 6, 7 and 8 pH. Alkali treated samples were sent to NITRA Ghaziabad, Uttar Pradesh and Central Institute of Research for Cotton Technology (CIRCOT), Sirsa for testing of physical and mechanical properties and the data was analyzed statistically.

Table 1: Optimized selected parameters for alkali treatment

Treatment / Parameters	Sodium hydroxide (alkali)
Concentration (g/L)	5.0
Material to liquor ratio	1:20
Temperature (^{o}C)	90
Time (minutes)	90
pH	7

Hence, the most suitable selected parameters were 5.0 g/L concentration of the solution, 1:20 material to liquor ratio, 90 ^{o}C temperature, time and pH 90 minute and 7, respectively.

3. Results and Discussion

3.1 Determination of physical characteristics of snake plant

The physical characteristics of the selected plant species (S. trifasciata) were determined and the presented in Table 2. The average length of SPL was found to be 71.92±3.84 cm. The width of the leaves ranged from top edge 8.01±0.69 cm, in the middle portion 10.45±1.27 cm and from bottom edge was 6.64±0.64 cm. The average weight of smallest leaves and longest leaves was recorded to be 52.6±2.727 g and 68.8±1.166 g, respectively. The total numbers of leaves were 7 to 8 in a plant and weight of the whole plant was 2000-3000g approx. The maturity period of the leaves was about 2 to 3 month.

Table 2: Physical characteristics of snake plant (*S. trifasciata*)

Physical characteristics	Measurements
Length of leaves (cm)	71.92±3.84
Width of leaves (cm) At the top At the middle At the bottom	8.01±0.69 10.45±1.27 6.64±0.64
Weight of leaves (g) Smallest leaves Longest leaves	 52.6±2.727 68.8±1.166
Number of leaves in a plant	7-8
Weight of the whole plant (g)	2000-3000 approx.

Maturity period of leaves (months)	2-3

* Mean and * Standard deviation (+ increase and - decrease values)

3.2 Optimization of water retting process of SPL fibres: In order to optimize the retting process for extracting SPL fibres, three different time durations were selected i.e. 10, 15 and 20 days. From the Table 3, it was evident that the yield of fibre after 15 days of retting was 260 g whereas the lowest yield was estimated i.e. 254 g after 20 days of retting. It was found that the quality of the fibres was good, soft and free from impurities after 15 days of retting. 15 days water retted fibres were selected for further treatment with alkali. It was observed that the 15 days water retted fibres were found more suitable for both treatments i.e. NaOH.

Table 3: Observation recorded during water retting process

Material weight (Kg)	Bath ratio (M:L, g/L)	Time duration (days)	Temperature (^{o}C)	Yield of fibre after drying (g)	Recorded Observation
12.5	1:70	10	41^o C±2	258	Fibre was stiff with partial removal of fleshy and leaf portions
12.5	**1:70**	**15**	**41^o C±2**	**260**	**Fibre quality was good, soft and free from impurities**
12.5	1:70	20	41^o C±2	254	Fibre quality was good but lose the strength

3.3 Effect of NaOH concentration on fibre yield of SPL fibres

It can be elicited that the water retted SPL fibres were treated with three different concentrations of NaOH solution i.e. 2.5, 5.0 and 7.5 g/L at 90^o C. The treatment time was kept at 60, 90 and 120 minutes at 90^o C and material to liquor ratio was taken 1:20. After various treatments the fibre yield was calculated. Figure 1 showed the loss in weight of SPL fibres after alkali treatment with different concentrations, time periods and pH. The fibre yield was calculated to estimate the quality of fibres obtained after alkali treatment. As the concentration of sodium hydroxide 2.5 to 7.5 g/L, there was a sharp increase in loss of fibre weight percentage after applied of 2.5 g/L of NaOH concentration. As the concentration increased to 5.0 g/L of NaOH concentration, there was a marked increase in the weight loss of fibres. The weight loss of fibres also decreased with increased in time periods i.e. 60 to 90 minute then the fibre yield also increased from 0.87 to 1.00 per cent and weight decreased i.e. 0.78 per cent with pH 7 for 120 minutes.

Statistically, it was found that the effect of chemical concentrations at 2.5 and 5.0 g/L of NaOH concentrations was significant while at 7.5 g/L of NaOH concentration was non-significant at 5 per cent level of significance in respect of fibre yield. At 2.5 and 5.0 g/L of NaOH concentration, the mean and coefficient values was observed 0.84±0.038 per cent with CV%-5.612 and 0.884±0.025 per cent with CV%-3.475. Likewise, at 7.5 g/L of NaOH concentration was noticed to be 0.766±0.090 per cent (CV%-14.420) with decreased fibre yield. A gradually decrease in fibre yield was reported after successive increase in alkali concentration.

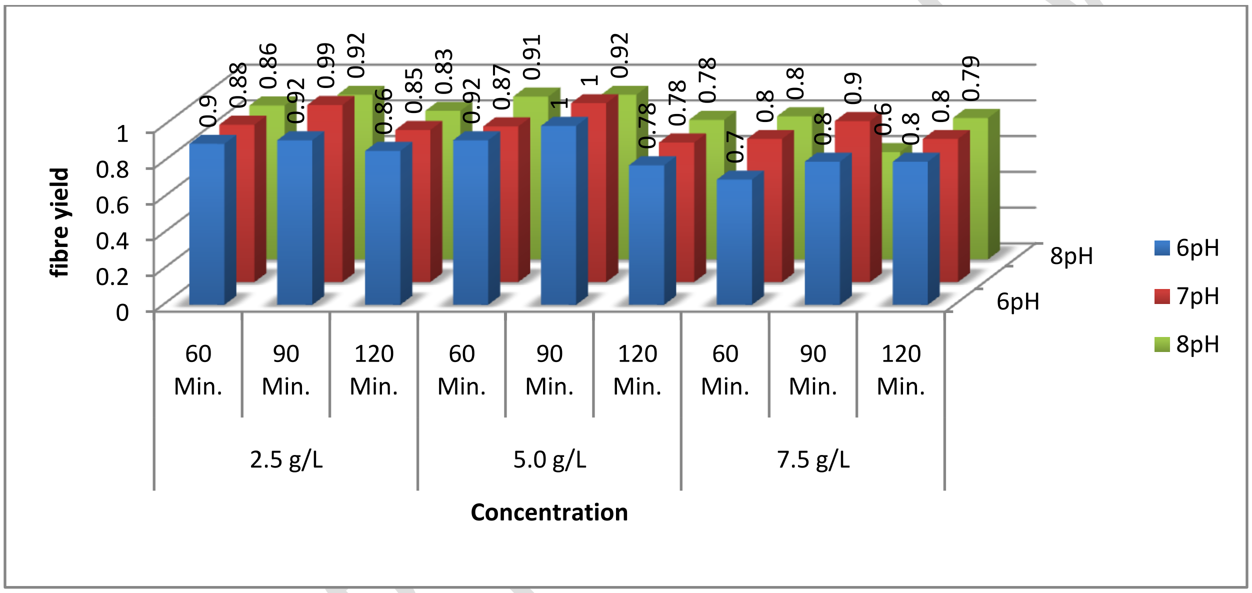


Figure 1: Effect of NaOH concentration on fibre yield of SPL fibres

3.4 Effect of NaOH concentrations on fibre fineness of SPL fibres

The data indicates that the water retted SPL fibres were treated by using different chemical concentration of alkali i.e. 2.5, 5.0 and 7.5 g/L of NaOH at different treatment times and pH of cooking bath. The fibres were digested with 2.5, 5.0 and 7.5 g/L of NaOH solution on the basis of material to ratio 1:20 for treatment times i.e. 60, 90 and 120 minutes with pH 6, 7 and 8 baths at 90^{o} C. After each digestion, the fibres were washed and neutralize with acetic acid to free from chemical and then dried in hot oven. The fibres treated in 2.5 g/L of NaOH solution showed the minimum fibre fineness i.e. 69.78 to 40.72 denier as per treatment time periods with different pH of digestion, while fibres treated in 7.5 g/L of NaOH solution obtained the moderate fineness i.e. 68.75 to 45.91 denier (Figure 2). The fibre fineness obtained to be 60.109±6.236 denier with CV%-12.707 at 2.5 g/L of NaOH digestion for different time and pH, the fibres was inferior in quality. The fibre fineness was noticed to be 45.729±11.923 denier with

CV%-31.737 at 5.0 g/L NaOH solution and 58.588±7.510 denier with CV%- 15.698 at 7.5 g/L of NaOH solution, respectively. The quality of the fibres was obtained soft and with adequate handling properties. The fineness of fibres was observed at 2.5 g/L of NaOH solution, the fibres obtained were not soft enough to handle. At higher concentration of NaOH (7.5 g/L), the fibres were obtained much deteriorated. The effect of different concentration i.e. 2.5, 5.0 and 7.5 g/L, time 60, 90 and 120 minutes with pH 6, 7 and 8 were observed statistically non-significant at 5 per cent level of

Significance in respect of fibre fineness.

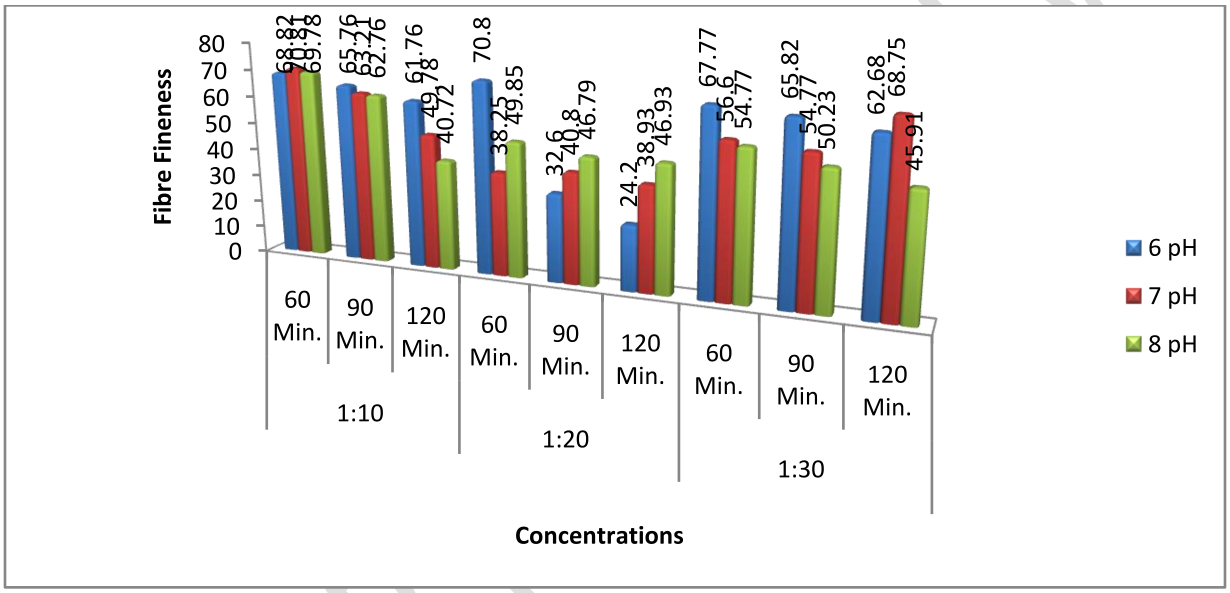


Figure: 2 Effect of NaOH concentrations on fibre fineness of SPL fibres

3.5 Effect of NaOH concentrations on bundle strength of SPL fibres

It is obvious from the results depicted in Figure 3 that water retted SPL fibres were treated by using different chemical concentration of alkali i.e. sodium hydroxide at different time and pH of cooking for bundle strength. The fibres were digested with 2.5, 5.0 and 7.5 g/L of NaOH solution keeping material to ratio 1:20 for 60, 90 and 120 minutes with pH 6, 7 and 8 at 90^{o} C and 6 pH. The highest bundle strength was discerned 49.29 g/tex at 5.0 g/L of NaOH concentration for 60 minutes time period at 90^{o}C as compared to the fibres obtained lowest bundle strength i.e. 40.11 at 2.5 g/L of NaOH digestion for different time and pH 7. Probably, the bundle strength got affected adversely at longer treatment time due to cellulose backbone being attacked along with the hemicelluloses and lignin. The colour of fibres was noticed greenish yellow, soft and smooth texture at 5.0 g/L concentration which was suitable for further extraction of fibres.

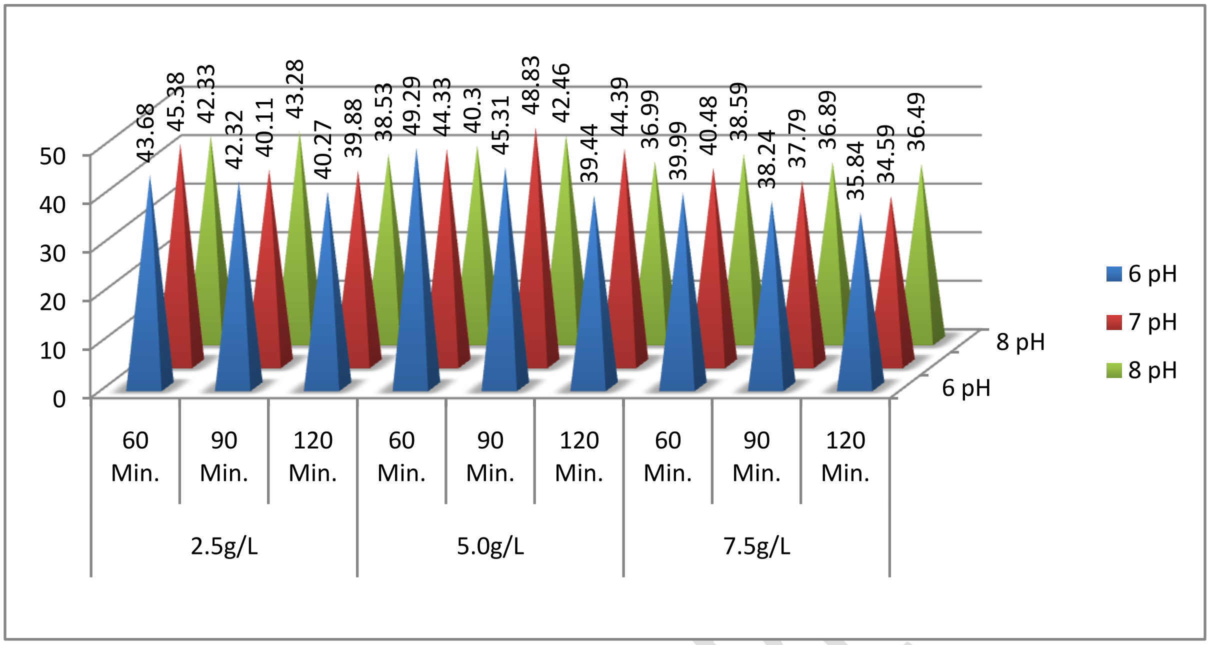


Figure: 3 Effect of NaOH concentrations on bundle strength of SPL fibres

3.6 Effect of concentration of alkali on elongation of snake plant leaves fibre at 90^{o} C

The shown data elucidates that when alkali treatment was carried out at 90^{o}C boiling temperature, the elongation at break was decreased to increase at 2.5 g/L of sodium hydroxide concentrations at different time periods and pH. The fibres were digested with 2.5, 5.0 and 7.5 g/L on the basis of keeping material to ratio 1:20 (MLR) for treatment time periods i.e. 60, 90 and 120 minutes with pH i.e. 6, 7 and 8 at 90^{o} C. After each digestion, the fibres were washed and neutralized to remove the excess chemical, and then dried in hot oven. The data indicates that the higher elongation (5.21 per cent) was found in case of 5.0 g/L of sodium hydroxide concentration followed by elongation 4.27 per cent at 90^{o}C at different treatment time periods and pH (Figure 4). Conclusively, it could be stated that the percentage of critical difference in the elongation was observed non-significant at 5 % level of significance.

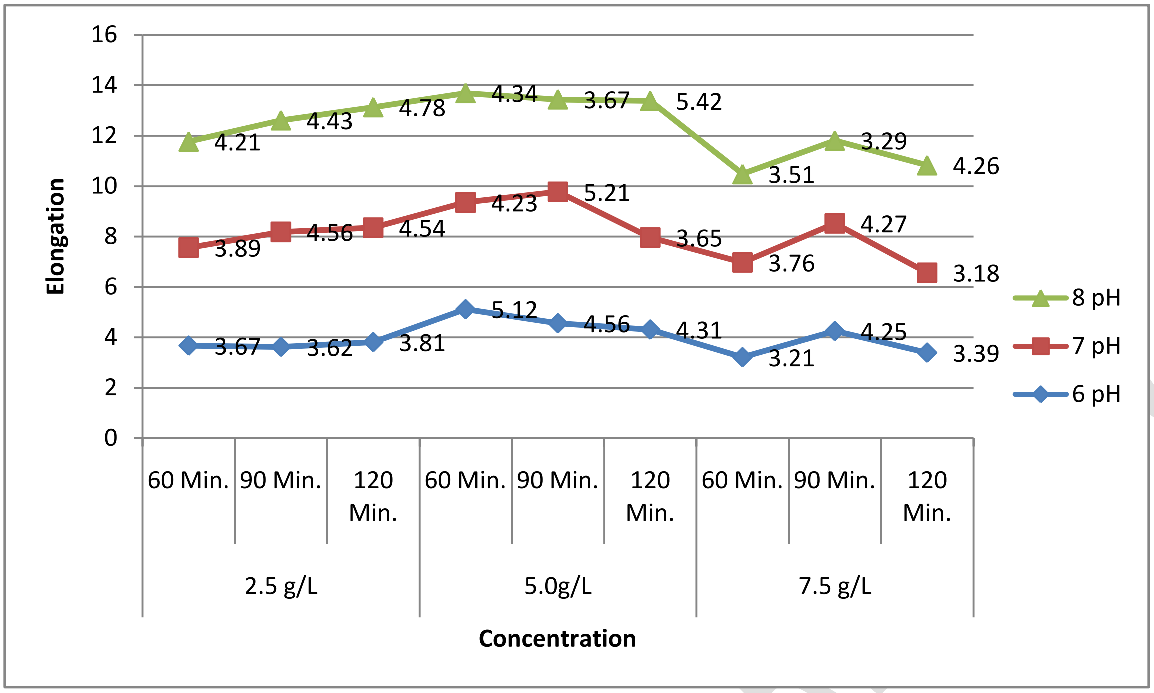


Figure: 4 Effect of concentration of alkali on elongation of snake plant leaves fibre

3.7 Effect of material to liquor ratio with NaOH (5.0 g/L) on fibre yield of SPL fibres at 90°C

The graphical representation (figure 5) indicates that the treatment of water retted SPL fibres were carried out by using different material to liquor ratios (owf) i.e. 1:10, 1:20 and 1:30 with 5.0 g/L of NaOH concentration at different time and pH for fibre yields. The fibres were digested with 5.0 g/L of NaOH solution at 90° C with different time i.e. 60, 90 and 120 minutes and pH 6, 7 and 8. The fibres were washed and neutralized to remove the excess amount of chemical after each digestion and then the fibres were dried in hot oven. It was evident that good quality of fibres were not obtained while digesting with 5.0g/L of NaOH concentration with bath ratio 1:30 at different time intervals and pH. Acceptable quality and fibre yield were obtained by digesting with 1:20 material to liquor ratio at 90°C using 5.0g/L of NaOH concentration at 90 minutes and pH 7.

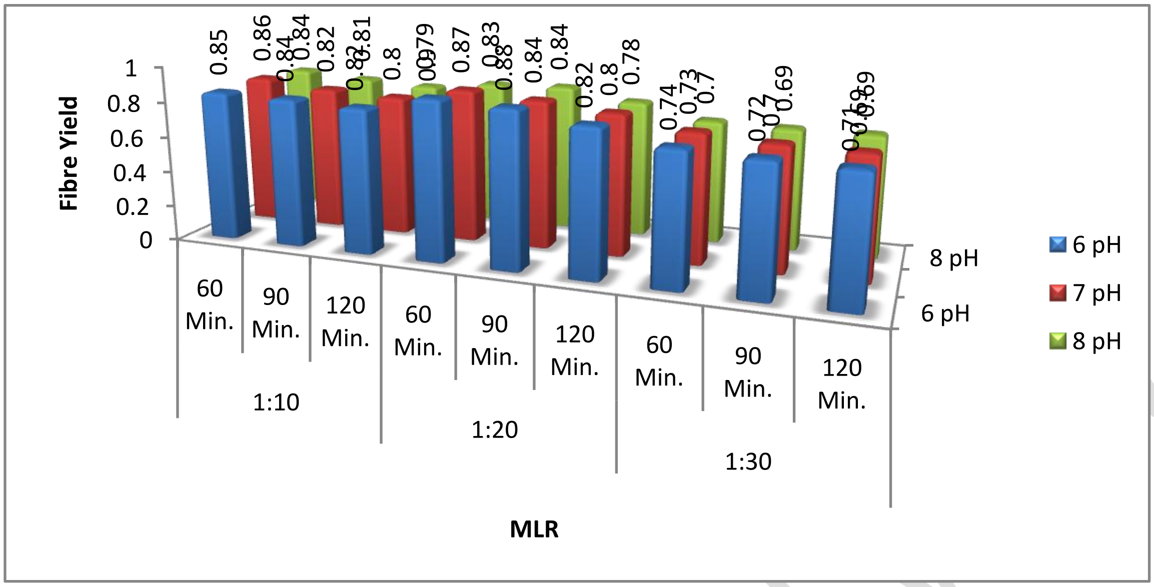


Figure: 5 Effect of material to liquor ratios of alkali on fibre yield of snake plant leaves fibre

3.8 Effect of material to liquor ratio with NaOH (5.0 g/L) on fibre fineness of SPL fibres at 90^{o} C

The data presented data indicates that the treatment of water retted SPL fibres were carried out at three different material to liquor ratios (owf) i.e. 1:10, 1:20 and 1:30 at three different time and pH of bath cooking in figure 6. The fibres were digested with 5.0 g/L of NaOH solution at different time 60, 90 and 120 minutes at 90^{o} C with different pH 6, 7 and 8. The fibres were washed and neutralized to remove the excess quantity of chemical after each digestion and then the fibres were dried in hot oven. At 1:10 material to liquor ratio, the maximum fibre fineness was noticed to be 46.06±7.106 denier with CV%-18.894. After increasing chemical concentration it was recorded the fibre fineness was decreased 43.997±2.488 denier with CV%- 6.926 at 5.0 g/L of NaOH concentration to 53.993±2.991 with CV%-6.785 at 7.5 g/L of NaOH concentration given to water retted fibres. Different alkali treatments had a change in fibre fineness of treated SPL fibres which was non-significant at 5% level of significance at 1:10 and 1:30 material to liquor ratio. At 1:30 material to liquor ratio, the fibre fineness of treated fibres was significant at 5% level of significance.

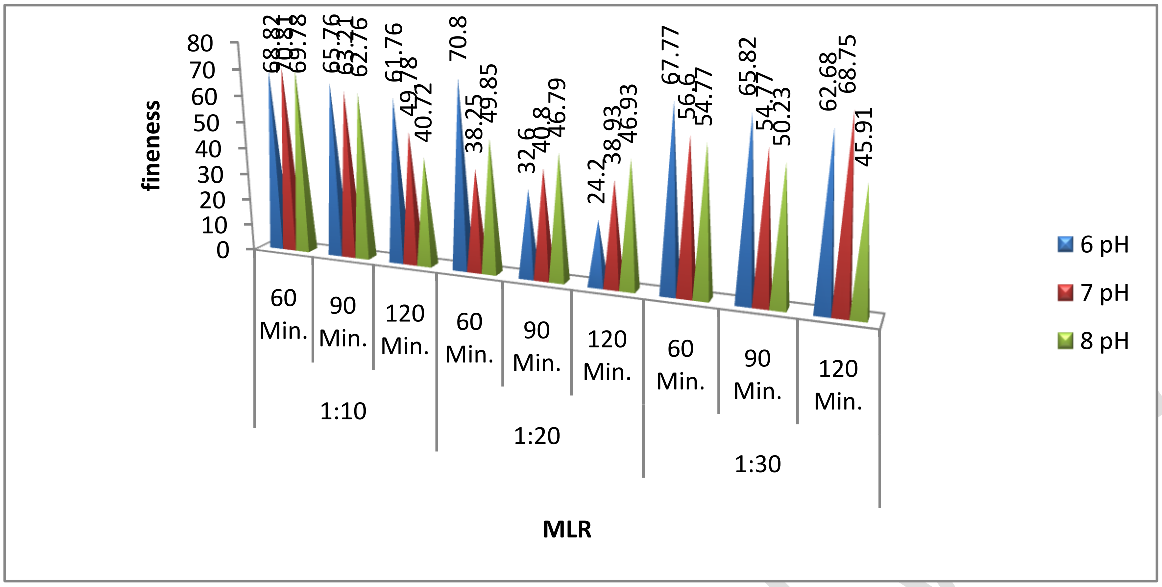


Figure: 6 Effect of material to liquor ratios of alkali on fibre fineness of snake plant leaves fibre

3.9 Effect of material to liquor ratio with NaOH (5.0 g/L) on bundle strength of SPL fibres at 90° C

It can be elucidated that the water retted SPL fibres were treated by using different material to liquor ratios for alkali treatment at 90°C. The different material to liquor ratios (owf) were used i.e. 1:10, 1:20 and 1:30 with 5.0 g/L of NaOH for different time duration 60, 90 and 120 minutes and pH 6, 7 and 8 at 90° C (figure 7). It is evident from the table that at 1:10 material to liquor ratio, the highest mean value for bundle strength was found to be 45.092±2.006 g/tex with CV%-5.449. As the material to liquor continuously decreased from 1:20 to 1:30 (MLR), the bundle strength was decreased from 43.663±4.467g/tex with CV%- 12.531 to 37.204±3.097g/tex with CV%- 10.194. As a result, the bundle strength of SPL fibres decreased with increasing of material to liquor ratio, time and temperature of treatment.

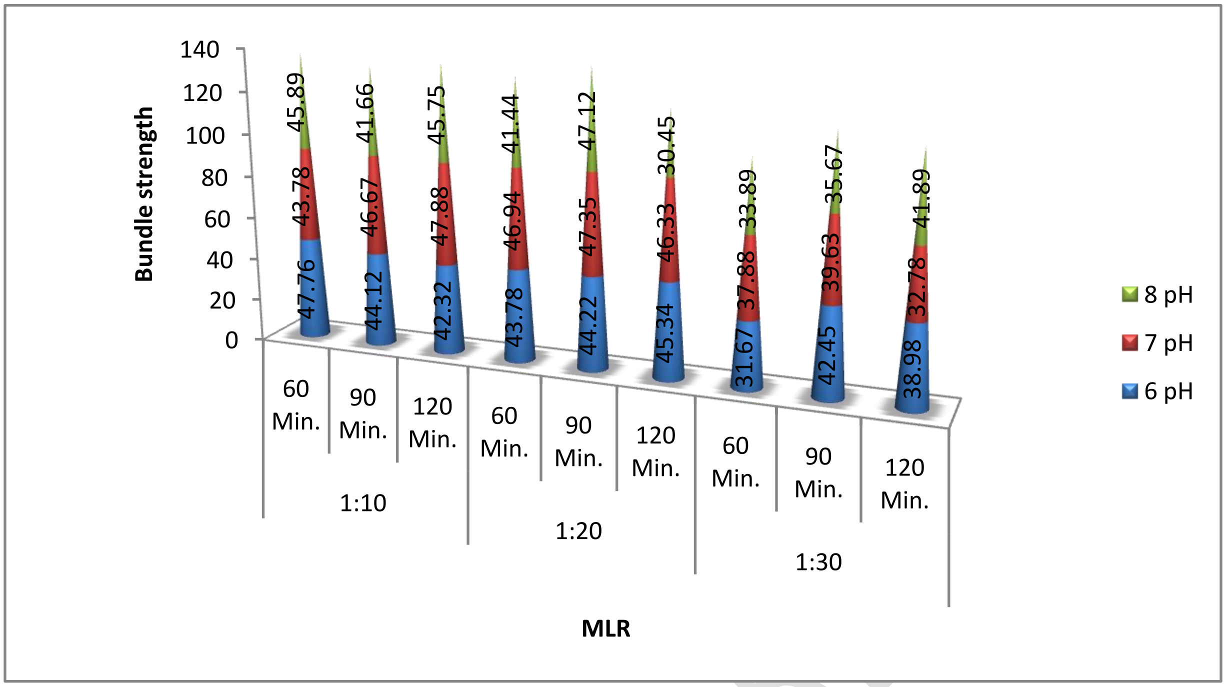
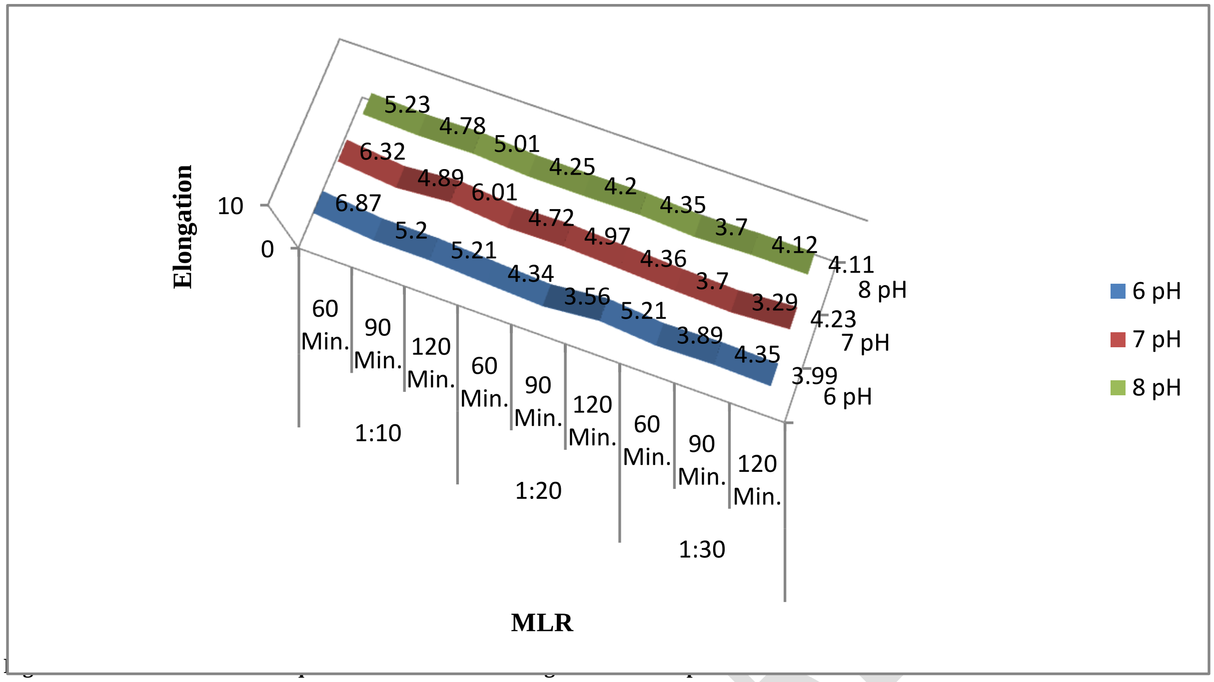


Figure: 7 Effect of material to liquor ratios of alkali on bundle strength of snake plant leaves fibre

3.10 Effect of material to liquor ratio with NaOH (5.0 g/L) on elongation of SPL fibres at 90° C

The effect of treatment on SPL fibres were carried out by keeping different material to liquor ratios (owf) i.e. 1:10, 1:20 and 1:30 MLR at different time and pH of cooking is given in the figure 8. The fibres were digested with 5.0 g/L of NaOH on the basis of time 60, 90 and 120 minutes at 90° C with pH 6, 7 and 8. After each digestion, the fibres were washed and neutralized with acetic acid (CH_3COOH) to remove excess chemical and then dried in hot oven. At 1:10 material to liquor ratio, the highest elongation at break was observed to be 6.87 per cent at 6pH for 60 minutes respectively. After there was an increase in the material to liquor ratio of treatment bath increased from 1:20 to 1:30 MLR, there was a considerable decrease in elongation at break from 4.97 per cent to 4.35 per cent for 90 minutes at different pH i.e. 7 and 6 respectively for alkali treatment at 5.0g/L of NaOH concentration. The highest mean values of elongation at break at 1:10 material to liquor ratio was noticed as 5.502±0.477 per cent with CV%-10.619. The lowest mean values of elongation at break was found to be 4.44±0.423 per cent with CV%-11.662 at 1:20 material to liquor ratio followed by 1:30 material to liquor ratio had 3.931±0.274 per cent with CV%-8.530.



Conclusion

Results of this study have proven that the non-conventional plant material such as snake plant ideal source for fibre extraction. Thus, the water retting is the best for natural plants to extract the fibres. The presented data was tested by NITRA Ghaziabad, Uttar Pradesh and Central Institute of Research for Cotton Technology (CIRCOT), Sirsa for testing of physical and mechanical properties. The fibre properties i.e. fibre yield, fineness, bundle strength, elongation were tested with three different parameters. It was noted that at concentration of 5.0 g/L sodium hydroxide with 1:20 material to liquor ratio and a temperature of 90^{o}C for 90 minutes with pH 7 for alkali treatment were found to enhance the fibre properties of SPL fibres.

Data Availability

The research data used to support the findings of this study are included in the article. Data in figures and table formats are included within the article and also provided in separate MS-Word format. Additional data used to support the findings of this study will be available from the corresponding author upon request. Apart from the data collected from experiments previously reported data were used to support this study and are cited at relevant places within the text as references.

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