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Research Paper

Effect of retting methods on properties of *Dhaincha* fibres

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■ **ABSTRACT :** The dried ribbons of *Sesbania aculeata (Dhaincha)* plant were retted by chemical and biological retting methods. In first chemical retting method, the fibres were treated with the combination of EDTA and NaOH whereas in second method pretreated with HCl followed by NaOH; In biological retting method both the stagnant and running water methods were utilized. The retted fibres were tested for physical properties such as, moisture content and weightloss. The percentage weight loss was found to be more in case of chemically retted fibres owing to the enhanced digestibility of lignocellulosic material by the alkali. Contrary to this, biological retting showed higher moisture content due to the presence of non cellulosic matter. Overall, the properties exhibited by *Sesbania aculeata* fibres obtained after 15 days of stagnant water retting was comparatively good as compared to other retting methods in terms of weight loss and moisture content.

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■ **KEY WORDS:** *Sesbania aculeata*, *Dhaincha*, Fibre, Retting, Weight loss, Moisture content

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Bast fibres offer the advantage of renewability and biodegradability that is essential for making environment friendly textile products. Some scientists have also suggested agricultural waste or byproducts for utilization in natural fibre based textile industry as a supplement added in the existing bast fibre demands. Certain agricultural plants which produce high biomass after harvesting are found to be suitable substitute for some fibre based industries. Reduced availability of resources at affordable cost and the growing interest in sustainability have led to a renewed interest in natural materials in current situation. The celebration of year 2005 as international year of natural fibres further strengthened the concept of sustainability. India is primarily an agricultural country. The favorable climatic condition facilitates the growth of wide variety of plants. The underutilized fibres are available in abundance and till now, have not received much economic importance owing to their harshness, brittleness and coarseness. Amongst numerous underutilized natural fibre sources in Uttarakhand state, one such potential source of textile fibres is *Dhaincha (Sesbania aculeata)*, popular as a green manure, useful in nitrogen fixation and wind barriers. These fibres need a renaissance, not only for old industrial products but also for manufacturing new types of products, required in the various fields of technical textiles. However to increase their uses and achieve good quality bast fibres, the appropriate extraction and processing methods are required. Now-a-day, various extraction methods *i.e.* water retting, chemical retting, dew retting and enzymatic retting are used. These methods yields fibres with varied set of physical properties, environment-friendliness and cost effectiveness. Further, studies revealed that water retting yield good quality uniform fibres and the chemical methods makes retting to complete in an hour or two that normally takes 14-28 days in case of water retting. Here an attempt was taken to study the effect of different retting methods on the weight loss and moisture content of *Sesbania aculeata (Dhaincha)* fibres.

■ RESEARCH METHODS

The materials and methods used in the study are mentioned and described below:

Raw materials collection :

The plantation of crop was done in the month of May in a farm at Ramnagar, Uttarakhand. The harvesting of plant, for stalk collection was done in the month of September plantation in a farm at Ramnagar, Uttarakhand. The branches, leaves and pods were removed from the fresh *Dhaincha* plant and the bark was peeled out from the stems and allowed to dry. The dried bark was used to study the effect of different retting methods on the properties of *Dhaincha* fibres.

Retting :

Retting of *Sesbania aculeata* was done by water and chemical to study the effect of extraction on fibre properties such as weight loss, moisture content and whiteness index. The retting was done in the month of September at a temperature and relative humidity in range of 30^0C - 37^0C and 75 per cent - 85 per cent, respectively.

Water retting :

The retting of fibre was done both in stagnant and running water for same duration. 50 g each dried ribbons of *Dhaincha* were submerged in water filled plastic tubs and in water stream for 15 days. This method of retting is one type of biological retting, in which the microbes present or developed on dried bark underneath water and helps to dissolve the cementing matter *i.e.*, lignin that lead to separation of fibres.

Chemical retting :

In this method, generally dried bark was treated with different concentration of acid and alkalis for 1 to 3 hours at 60-100^0C. 50 g of dried ribbons were treated with two different chemical methods. For the present study, two chemical methods were utilized, in first method the fibres were pretreated with 0.5% HCl solution at 40^0C for 30 minutes and then boiled with 5% NaOH for 60 minutes in separate beakers (Das *et al.*, 1976) while in second method, the ribbons were boiled with the combination of 0.05% EDTA and 5% NaOH for 60 minutes (Kundu *et al.*, 1996). The treated fibres were neutralized with 2% acetic acid for 10 minutes at 60^0C.

Then fibres were washed washing under running water to remove slimy matter and excessive chemical and separated by hand while washing and laid on flat surface for drying in the open air under shade. The fibres of *Sesbania aculeata (Dhaincha)* were combed manually using combing brush to open the fibre bundles, and to remove remnant vegetative matter adhered to the surface. The fibres obtained after retting were assessed for weight loss, moisture content, and SEM analysis was also done.

Assessment of physical properties :

The properties like moisture content and weight loss of *Dhaincha* fibres was assessed in Department of Clothing and Textiles College of Home Science, GBPUAT Pantnagar. SEM analysis of fibres was done at IIT Kanpur. One way ANOVA was applied using statistical software " SPSS 20".

Weight loss :

The weight loss was defined as the percentage of mass between non retted and retted dhaincha fibres to calculate the yield of fibre. The fibre yield obtained from different retting methods was calculated as the ratio of difference in weights before and after the retting method used to the original weight of the samples (Saravanam *et al.*, 2010). The retted fibre samples were kept in the laboratory over night and were weighed until constant weights were obtained using the formula:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight (Oven dried)} - \text{After weight (Oven dried)}}{\text{Initial weight (Oven dried)}} \times 100$$

Moisture content :

The standard procedure used for estimation of moisture regain of *S. aculeata* (*Dhaincha*) fibre was according to AATCC Test Method 20A-2008. In this procedure, 1g of fibre specimen was weighed and kept in an oven maintained at 105-110°C for one and half hour. After that the fibres specimen were removed from oven and allowed to cool down inside the dessicator and again weighed. This procedure was repeated further after every 30 min until a constant weight was obtained. The per cent loss was calculated as per the following formula:

$$\text{Mositure regain (\%)} = \frac{\text{Original weight of fibres} - \text{Oven dry weight of fibres}}{\text{Oven dry - Weight of fibres}} \times 100$$

SEM Analysis :

The effect of different retting methods on *Sesbania aculeata* fibres was also investigated by Scanning Electron Microscope (SEM). It was done on FEI Quanta 200, at an accelerating voltage of 15KV with the resolution of 100 μm and magnification ranging from 1000- 1200X. Prior examination, the samples were glued on an aluminium stubs and sputter coated with carbon to avoid charging. After that, the samples were kept inside the instrument and the images were observed at different magnifications.

■ RESEARCH FINDINGS AND DISCUSSION

The physical properties of retted fibres in form of mean ± SD are given in Table 1.

Weight loss :

The weight loss represents the amount of material removed during the process of retting. The weight loss in form of mean ± SD are given in Table 1. It can also be envisaged from Table 1 that percentage weight loss was observed in fibre after different type of retting. According to Jankauskienë and Gruzdevienë (2013), during the retting process the stems of fibrous plants lose weight.

It can be affirmed from Table 1 that the weight loss of fibres was highest in case of chemically retting (HCl + NaOH) method *i.e.,* 59% whereas fibres obtained from 15 days of stagnant water retting exhibited lowest weight loss (42.1 %). Kaur *et al*. (2013) also found that the chemical assisted natural retting [$Zn(NO_3)_2$ solution for 116 hours] caused highest loss in weight and also at the cost of maximum loss in tenacity.

Pallesen (1996) also mentioned that excessive retting of plant lowers the yield of fibres owing to the degradation of the material. Further it can be observed that the weightloss in case of running water was more as compared to stagnant water. This might be due to the action of more number of microbes present in running water as compared to the limited number of microbes and bacteria in stagnant water.

Significant difference was found between the weightloss of *S. aculeata* (*Dhaincha*) fibres extracted from different retting methods. The p value for weight loss is smaller (p=.000) than 0.05, hence it can be concluded that the loss in weight differs with varies with the retting methods (Table 2). It can be concluded the weight loss of fibres differ with difference in retting method.

Moisture content :

It can be envisaged from Table 1 that the moisture content of *S. aculeata* (*Dhaincha*) fibres was found higher in case of fibres extracted from stagnant water biological retting *i.e,* 8.61%, followed by moisture content of fibres extracted by running water method (8.12%).

The fibres pretreated with HCl and treated with NaOH exhibited higher moisture content (7.94 %) as compared to fibres extracted from combination of EDTA and NaOH (moisture content 7.44 %). The moisture content values exhibited by chemically extracted fibres in present study are similar to the finding of Singh and Rani (2013) who affirmed that the *Sesbania aculeata* fibres treated with NaOH showed moisture content value of 7.3%.

According to Berthold *et al*. (1998) and Celino *et al.* (2014), the moisture absorbing properties in plant are due to the presence of cellulose, hemicellulose, pectin and lignin. Therefore the amount of removal of these matters was responsible for the difference in the moisture content of fibres extracted from different retting methods. Further Lewin (2007) stated that the presence

Table 1 : Weight loss and moisture content of *Sesbania aculeata* fibres obtained from different retting methods

Sr. No.	Retting method	Retting variables	Weight loss (%)	Moisture content (%)
1.	Biological retting (Running water method)	15 days	48.6 ± 0.613	8.61± 0.052
2.	Biological retting (Stagnant water method)	15 days	42.1± 0.766	8.12 ± 0.182
3.	Chemical retting (Pretreated with 0.5% HCl)	5% NaOH	59 ± 0.80	7.94± 0.022
4.	Chemical retting (Along with 0.05 % EDTA)	5% NaOH	53.66 ± 0.56	7.44 ± 0.03

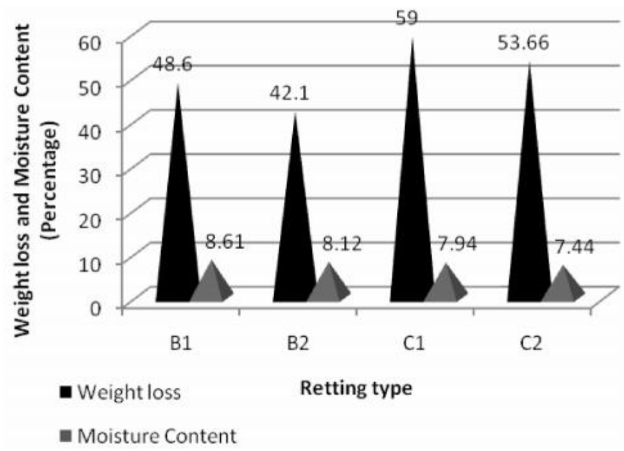
of lignin decreases moisture absorption due to its hydrophobic nature. The difference in moisture content of the extracted fibres may be due the non-uniform removal of the lignin by the biological and chemical retting processes.

It can be further affirmed that the moisture content of biologically retted fibres is greater than chemically retted fibres. It might be due to excessive removal of hemicelluloses from fibre surface by the action of chemical agents. Davies and Bruce (1998) also explained that hemicelluloses constitute the major part of the amorphous phase in plant fibres play an important role in the storage of moisture.

Significant difference was found between the moisture content of *S. aculeata* (*Dhaincha*) fibres extracted from different retting methods. The p value for moisture content is smaller (p=.000) than 0.05, hence it can be concluded that the moisture content varies with the retting methods (Table 3). It can be concluded that the type of retting procedure (chemical and biological retting method) affects the moisture content of fibre.

Effectiveness of retting method on fibre properties:

From Fig. 1, it can be envisaged that the stagnant water retted fibres exhibited better properties as compared to other retting methods. According to USDA, 2014 water retting produces more uniform and high-quality fiber. Umoro *et al*. (2014), further explained that the chemical retting is a quicker process than the natural processes (dew, water and enzymatic) but it affects several properties, including a loss in tenacity, colour, and luster. According to Van sumere (1992) the process of water retting yields high quality fibres. The bacterial method is relatively better than chemical, because it gives better fibres quality and lower pollution whilst chemical retting requires huge energy and generates costly wastes.



Note: B1: 15 days stagnant water retting; B2: 15 days stagnant water retting; C1: chemical retting (HCl+NaOH); C2: chemical retting (EDTA + NaOH)

Fig. 1 : Comparison between the physical properties

Hence, the *Sesbania aculeata* fibres obtained after 15 days of stagnant water retting yielded best fibres in terms of moisture content, and weightloss. Ahmad *et al*. (2001) and Bengtsson (2009), also affirmed that the water retting is the cheapest and universally practiced that gave the best fibre quality when visually determining the quality parameters such as length, colour and smoothness Water retting is biological fermentation process which produces biodegradable waste. This enhances the soil nutrient without harming the environment. Therefore this process was selected for further study.

SEM :

The surface morphology fibres obtained from different retting methods are shown in Fig. 2. Comparison

Table 2 ANOVA table for percentage weight loss

	Sum of squares	df	Mean square	F	Sig.
Between groups	617.119	3	205.706	428.769	.000
Within groups	5.757	12	.480		
Total	622.876	15			

Table 3 : Anova table for moisture content

	Sum of squares	df	Mean square	F	Sig.
Between groups	2.800	3	.933	830.82	.000
Within groups	.013	12	.001		
Total	2.814	15			

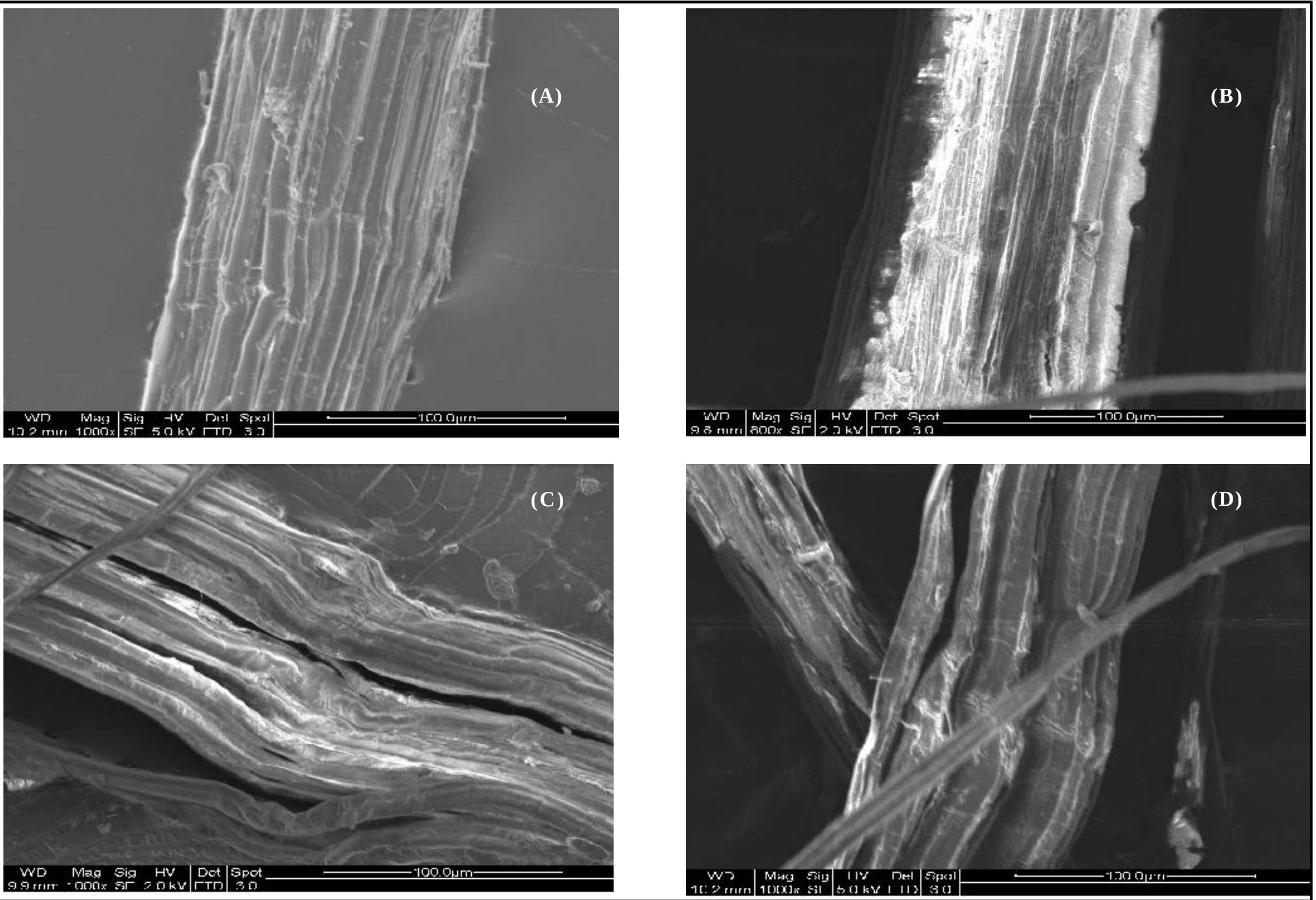


Fig. 2 : SEM Analysis of Retted Fibres
[(a) After 15 days stagnant water magnification X 1000 (b) After 15 days running water magnification X 800 (c) With HCl and NaOH magnification X 1000 (d) with EDTA and NaOH magnification X 1000

shows that the longitudinal views of stagnant and running water retted fibres were cylindrical in shape and surface was smooth owing to the less removal of vegetative matter that results in the joining of fibres at various places with pectin and lignin present in them.

On comparing 15 days stagnant and 15 days running water retted fibres with fibres treated with NaOH + HCl and EDTA + NaOH , it was observed that chemically retted fibres showed more opening of fibres leading to finer structure evident increased weight loss and decreased moisture content owing to the removal of non cellulosic matter. Further it can also be attributed to the removal of lignin content after the alkali treatment. Balogun *et al*. (2015) also affirmed that NaOH treatment can completely remove lignin without leaving any residue left on the fibre, but the rate of lignin removal is dependent on the NaOH concentration.

Stagnant retted fibres show minimal damage to fibre structure, fibres appear clean and smooth though intact because separation of individual fibres did not occur as in case of chemical retting. Whereas in fibres retted in running water, it shows uneven surface suggesting negligible opening of fibres and removal of pectin and lignin. Hosseine *et al.* (2014) also claimed that alkali treated fibres have a finer fibre bundle with rougher surface compared to those of the untreated ones.

Conclusion :

Global trends towards sustainable development have brought natural, renewable, biodegradable raw material, into the focus. *Sesbania aculeata* (*Dhaincha*) can be a promising agricultural waste for the replacement of petroleum based fibres in technical textile sector. For this reason, there is a need to search for the extraction method to remove the non-fibrous components and completely free the fibres from other impurities. Out of the two retting method, biological retting fibres exhibited better properties in term of weight loss and moisture content. The weight loss was also comparatively lower than the fibres obtained from chemical retting. Hence, the properties exhibited by fibres extracted from biologically were considered good for technical textile used therefore stagnant water was considered as ideal medium of retting. It can be concluded that the quality of the fibre depend on the manner of the retting conditions, therefore it is an essential to choose appropriate retting method according to the ultimate use of fibres in different industrial applications as a potential source of fibres for technical textiles.

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