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Extraction of Semal (*Bombax ceiba*) fibres and their physico-chemical properties

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Abstract
Semal (*Bombax ceiba*) is one of the oldest deciduous trees and have immense potential for provide valuable bast fibres. Semal (*Bombax ceiba*) plants are abundantly available in Tarai region of Uttarakhand state. Semal is easily propagated and drought tolerant plant species and this also balances the forest ecosystem. The main constituents of semal fibres are cellulose, hemicelluloses, lignin, pectin etc. The longitudinal views of semal fibres were cylindrical and the cross sectional view was irregular. Semal fibres extracted by water retting in twenty five days had good physical properties and they are biodegradable therefore these fibres can be utilized for construction of union fabric as well as nonwoven. The fibres can also be used in different field of textiles and handicraft. Extraction and processing of semal fibres can be provide employment to the rural people in small scale and cottage industries.

Keywords: Deciduous, extraction, ecosystem, propagated, water retting

Introduction
India is rich heritage of natural fibres, consisting of bast fibres, seed fibres, fruit fibres and leaf fibres. It comprises large quantity of vegetable fibres which are grouped under two categories *viz*., cultivated fibres and naturally grown fibres. Cultivated fibres provide gainful seasonal employment opportunities to the rural people. Since long the people residing in rural areas prepared ropes, mats, bags, shoes, cap and cordage by using these vegetable fibres. Natural fibres can be further divided into three groups i.e. vegetable fibres, protein fibres and mineral fibres. Vegetable fibres such as cotton, sisal, ramie, hemp, jute, kenaf, kapok, pineapple, coir are classified by the part from which they are obtained. As the name implies bast fibres obtained from the dicotyledonous plant. Such bast fibres, usually characterized by fineness and flexibility, are also known as 'soft' fibres. All plant fibres are mainly made up of cellulose and other constituents which are hemicelluloses, lignin, pectin etc.
Semal (*Bombax ceiba*) is one of the oldest deciduous trees. Bark of semal looks pale ashy to silver grey, 1.8 to 2.5 cm thick. The tree reaches up to 40 meter in height and 2 meter in diameter, the young stem and branches are covered with sharp, straight, stout prickles up to 1.2 cm long with woody conical bases. Semal tree has the compound leaves which are palmate, digitate, large, spreading, glabrous which has common petiole, and the size of leaves is 15-30cm long. Five leaflets are common in one leaf but sometimes up to the seven leaflets could be found. The bright red flowers, which appear in January to March, are large, 10-12.5 cm across. It has the thick, fleshy and cup shaped sepals. It bears generally 5 petals in one flower which are 7.5 to 15 cm long oblong, recurved above, and fleshy. The pods are about 10-18 cm in length, oblong oval in shape [1]
Semal (*Bombax ceiba*) plants are abundantly available in Tarai region of Uttarakhand state. Semal is easily propagated and drought tolerant plant species and this also balances the forest ecosystem. Besides this timber and paper industry is not scarifies the total part of whole tree. However major part of the tree is left on the field as a waste since they are yet to be harvested profitably for lack of knowledge about their economic use. The waste of these plants has not been exploited fully. Bark of tree can be exploited for the extraction of bast fibres for use in textile industry. It will help to increase the constant supply of raw material to fibre based industries and cottage industries. This will be an appropriate step towards meeting the future demand of vegetable fibres.

Semal tree

Materials and Methods

The young branches were cut and dipped in stagnant water for retting [2]. Similarly chemical retting was carried out according to the procedure given by author [3] Solution was prepared by dissolving 1 g NaOH pallets in 100 ml of water. The different plant stems were cut into pieces of 8 inches and immersed in solution of chemical keeping the material to liquor ratio 1: 30 and boiled for 1 hour. The beakers were covered during boiling. After retting, fibres were rinsed thoroughly and neutralized with 1% acetic acid (CH_3COOH) solution. Then washed again under the running tap water and dried under sun.

Extraction of semal (*Bombax ceiba*) fibres from stems

Retting of stems

Separation of fibres and washing

Extracted fibres

Optimization of number of days of water retting for semal plant

Young branches/ stems of semal trees were harvested in the month of October to extract the fibres. After harvesting, the semal branches were cut and left in the ground for removal of leaves. The temperature in the month of October was minimum 22.8 to 24.9 °C and maximum 33.1-34.2 °C and humidity was 59 to 64%.When leaves were removed from the branches; the branches were tied into bundle and submerged in stagnant water and it was kept under water for 20 days, 25 days and 30 days separately. These samples of fibres obtained after retting were evaluated for their physical properties i.e. elongation, tenacity, length of the fibres and fibre fineness. Fibres sample with best properties was chosen and the numbers of days taken to decompose the pectic substances was considered as optimum retting time.

Results and Discussion

Table 1: Properties of Semal fibres extracted by water retting

S. No.	Properties	Duration of retting (days)			CD	F-value
		20	25#	30		
1	Elongation (%)	2.30	3.70	3.77	0.29	101.02**
2	Tenacity (g/d)	5.28	4.76	3.62	0.33	361.37**
3	Fineness (denier)	39.16	28.98	27.02	2.30	166.16**
4	Length of fibre (cm)	8.83	8.71	8.01	0.38	15.60*

Selected sample
**Significant difference at 1% level of significance
*Significant difference at 5% level of significance

Incomplete separation of fibres was found when semal stems were retted for 20 days that means the fibres were partially separated by microorganisms due to under retting therefore fibres showed poor elongation (2.30 per cent), good tenacity (5.28 g/ d) and fibre length (8.83 cm). The fibres obtained in twenty days were coarser (39.16 denier) than the fibres retted for twenty five days. The 20 days retted fibres were coarser may be due to the presence of non-cellulosic components of the fibre surface such as hemi-cellulose, pectin, lignin, fat and waxes which binds the fibres together and fibres became coarser. The under retted fibres became harsh and stick to each other due to presence of residual gum [4].

It is clearly shown in Table 4.2 that the fibres extracted from semal stems after twenty five days exhibited better tenacity (4.76 g/d), good elongation (3.70 per cent) and fibre length (8.71 cm). The 25 days were sufficient duration for retting; the pectin content of the fibres was dissolved in water due to action of microorganisms which might have increased the separation of bast fibres from fibre bundle. The retting is microbial separation of fibre from nonfibrous tissue [5]. The uniform retting influenced the fibre quality i.e. length, strength, colour, luster and softness[2]. The retting is a process used to remove noncellulosic substances to obtain quality textiles bast fibres [6].

The semal fibres obtained after thirty days had good elongation (3.77 per cent) and fineness (27.02 denier) with lower tenacity (3.62 g/d) than the fibres obtained in 20 and 25 days, this may be due to the over retting of the fibres, as fermentation process continued, acids are formed in the water which are harmful to the fibres. The extraction of fibres involved decomposition of the cementing material by microbes. Microbes secrete specific enzymes to dissolve pectin and lignin by forming simpler organic compounds, when the process continues for longer period of time resultant fibres were weaker [7].

The one way ANOVA shows that, there was a significant difference in the elongation, tenacity and fineness of the fibres extracted in 20 days, 25 days and 30 days at one per cent level of significance whereas the fibre length was significantly different at 5% level of significance. When CD value was calculated for different physical properties it was found that

the significant difference was found in the elongation, tenacity and fineness of the fibres when extraction time increases 20 to 25 days whereas only significant difference was found in tenacity when retting duration increases 25 to 30 days. The above statistical analysis shows that when duration of retting was increased the elongation and fineness value of the fibres were improved and tenacity and lengths of the fibres were decreased. It was obtained from the above finding that the fibre extracted in twenty five days had highest elongation; tenacity and fibre length therefore, twenty five days were selected as optimum duration for extraction of fibres from semal stems.

Physical properties of the semal bast fibres

S. No.	Properties	Unprocessed
1.	Fibre length (cm)	8.71
2.	Fibre tenacity (g/d)	4.76
3.	Elongation (%)	3.70
4.	Fineness (denier)	28.98
5.	Fibre crimp (no/5 cm)	0
5.	Fibre diameter (μ)	88.81
6.	Whiteness index (hunter equation) (illuminant D65/10 °C)	36.87

Chemical properties of semal fibres

S. No.	Properties	Unprocessed
1.	Holocellulose content (%)	78.76
	a. α-cellulose content (%)	61.67
	b. Hemi-cellulose (%)	17.09
2.	Lignin content (%)	16.54
3.	Fats and waxes (%)	1.91
4.	Ash content (%)	3.24
5.	Moisture regain (%)	8.20
6.	pH	7.37
7.	Cold water solubility (%)	2.53
8.	Hot water solubility (%)	6.26

Microscopic view

The longitudinal views of semal fibres were cylindrical. In unprocessed fibre striations were seen throughout the length of the fibres and small nodes were also found in different places. The cross-sectional view of the unprocessed semal fibres was irregular in cross section and black spots in centre are depicts the presence of fibrils.

Longitudinal view of the semal fibres

Cross sectional view of the semal fibres

Uses

Different things like shopping bag, door mat and bag were prepared by using semal fibres.

Conclusion

It is clear from the result that the retting duration has got a significant effect on the properties of semal fibres. Semal fibres extracted by water retting in twenty five days had good physical properties and they are biodegradable therefore these fibres can be utilized for construction of union fabric as well as nonwoven. The fibres can also be used in different field of textiles and handicraft. Extraction and processing of semal fibres can be provide employment to the rural people in small scale and cottage industries.

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