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Research Paper

Effect of chemical processing on physical properties of hemp (*Cannabis sativa*) fibres

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■ **ABSTRACT :** Chemical processing is essential for proper separation of individual bast fibres from fibre bundles. Hemp fibres were subjected to different scouring agents and their effect on tensile strength, elongation, fibre fineness and per cent fibre weight loss was studied. Alkalis were found effective in improvement of fineness but alkali scoured fibres exhibited less tensile strength in comparison to acid scoured fibres. Fibres of selected scouring method were bleached to improve their appearance, colour and softness. After each chemical processing, fibre fineness and whiteness value increased but tensile strength and elongation decreased gradually.

■ **KEY WORDS:** Hemp fibres, Retting, Scouring, Bleaching

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Hemp (*Cannabis sativa*), an annual plant producing bast fibres was one of the known textile material to man from centuries. Farmers were growing the crop commercially for fibre, seed, and oil for use in a variety of industrial and consumer products, including food. It has several desirable properties. It is four times more durable than cotton, and is naturally UV resistant, offering more protection than other natural fibres (Blade *et al.*, 1999). Today it is considered a renewable and eco-friendly natural fibre resource because it requires little to no pesticides and herbicides for plant growth. Fibres had inherent anti bacterial properties. But there are certain problems associated with the processing of fibres for textile application. Fibres are less pliable and difficult to spin into yarns. Textiles made out of these appear fuzzy and feel rough. The presence of noticeable amount of non cellulosic materials (lignin, pectin and hemicellulose) in the fibres affects their spinnabiliy. Improvement in fibre properties can be achieved by means of chemical processing to a great extent.

In the present study scouring treatment was done with different agents and its effect on tensile, elongation and fineness properties of fibre was studied. Bleaching of fibres was also carried out to enhance the colour value of fibres. Physical properties of fibres were also tested after each step of processing.

■ RESEARCH METHODS

The hemp fibre ribbons were collected from the hills of Uttarakhand state, India. The fibre ribbons utilized for extraction of fibre were separated manually from the dry stems of the hemp (*Cannabis sativa*) plant. These bark ribbons were utilized for extraction of fibre. The ribbons were retted with chemical retting method by treating with 1 per cent NaOH and 0.5 per cent EDTA solution for 1 hour at boil (100^0 C). Retted fibres were given after treatment in acetic acid (CH_3COOH) solution to neutralize the effect of alkali. The retted fibres were used as raw material for further processing. The chemical composition of hemp was also analyzed by the researcher according to the prescribed procedures (Pan *et al.*, 1999). The composition of hemp was 73.2 per cent cellulose, 20.9 per cent hemicelluloses, 4.6 per cent lignin and 2.83 per cent pectin.

Scouring of fibre samples :

The three types of scouring methods were applied on

Table A - Experimental methods for scouring

Sr. No.	Method	Method no.	Amount of chemicals	After treatment	Time and temperature
1.	Alkali scouring	Method 1	NaOH (2g/l) + non ionic detergent* (1 ml/l)	CH_3COOH (2ml/l) for 10 min	60 min @ 100 ^oC
		Method 2	NaOH (2g/l) + Ammonium oxalate (1 g/l)	H_2SO_4 (2ml/l) for 10 min	60 min @ 100 ^oC
2.	Acid scouring	Method 3	H_2SO_4 (1 ml/l)	Hot water for 10 min	30 min @ 100 ^oC
		Method 4	CH_3COOH (1ml/l)	Hot water for 10 min	30 min @ 100 ^oC
3.	Enzymatic scouring	Method 5	Pectinase (10g/l) in acetate buffer solution of pH 4	–	45 min @ 40 ^oC

*Triton x 100 from Himedia Lab Pvt. Ltd. was used as non ionic detergent

Table B : Experimental method for bleaching

Chemicals	
Hydrogen peroxide (H_2O_2)	6 % (owm)
Sodium silicate	3 % (owm)
Soda ash (Sodium carbonate)	0.9 % (owm)
Sodium hydroxide	0.5 % (owm)
Dyeing conditions	
Temperature	80-85 ^0C
Time	1-2 h
MLR	1:30

Owm – on weight of material

the retted fibres. The methods included, alkali, acid and enzymatic scouring. The experiment details for scouring are shown in the Table A. The material to liquor ratio was kept 1:30 for all the treatments. All fibre samples were washed properly after scouring treatment under tap water and dried in the shade.

Bleaching of scoured samples :

Hydrogen peroxide, a universal non chlorine bleaching compound, was selected as bleaching agent. The hemp fibres scoured by the selected scouring method were bleached with hydrogen peroxide as per the method (Shenai, 1980) given in Table B. The bleached fibres were washed thoroughly with cold water followed by neutral wash with acetic acid (2ml/l). After neutralization, bleached fibres were finally rinsed with tap water and dried in shade.

Assessment of physical properties of processed fibres :

All processed fibres (scoured and bleached) were first separated manually and then combed with hand carding brushes. The combed fibres were used for the assessment of physical properties namely fibre fineness, tenacity and elongation at break. Fifty fibres of each sample were tested and average value was considered as mean result. Fibres' weight loss during scouring treatment with different agents was also noted to observe fibre wastage during processing. The whiteness value of retted (raw material), scoured (selected) and bleached sample was also measured.

Fibre fineness was measured on Vibrodyn-400 instrument as per ASTM test standard, D 1577:07 (Annual Book of ASTM Standards, 2006). Vibroscope-400, was used to measure the tensile strength and per cent elongation at break of retted and processed hemp fibres as per ASTM test standard, D 3822:07 (Annual Book of ASTM Standards, 2006). Whiteness index of retted and processed (scoured and bleached) fibres was measured with the help of Hunter Lab Colour Meter.

Fibre weight loss :

Fibre weight loss per cent was calculated for each scoured fibre sample, after scouring treatment. Initial weight of fibre sample before and after scouring treatment was taken into account to calculate the weight loss per cent with the following formula:

$$\text{Fibre wt. loss (\%)} = \frac{(\text{Initial wt. of fibre} - \text{wt. of fibre after scouring})}{\text{Initial wt. of fibre}} \times 100$$

Statistical analysis :

Data was expressed as mean and comparison between the physical properties (fineness, tenacity and elongation at break) of fibres after different processing was analyzed by Fotron programme with two way ANOVA. $P<0.01$ were considered to be significant.

■ RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of different scouring methods on physical properties of hemp fibres :

Retted hemp fibres were scoured with different methods and fibres were tested for various physical properties. The physical properties of scoured fibre are presented in the Table 1. Fibres scoured with method 4 (acetic acid scouring) exhibited maximum tenacity as well as per cent elongation at break, whereas fibres scoured with method 3 (sulphuric acid scouring) exhibited minimum tenacity and per cent elongation at break. This may be due to the reason that mineral acids (sulphuric acid) cause weakening of interpolymer structure of cellulosic fibres, as a result, fibres become weak and exhibit low strength.

It can be inferred on the basis of results that fibres scoured with acetic acid exhibited better tenacity and elongation as compared to fibres scoured with other methods. This may be attributed to the reason that deterioration of cementing material of fibre bundles by acid occurred without affecting the cellulose of fibres. Acids with low concentration do not cause any noticeable changes in the fibre strength (Sadov *et al.*, 1973).

In case of fibre fineness, finest fibres with minimum value of denier were obtained from method 1 (NaOH + non ionic detergent scouring) and coarser fibres with maximum value of denier were obtained from method 3 (sulphuric acid scouring). Alkali scoured fibres were found finer as compared to the other fibres scoured with other methods because alkalis are more effective in dissolving cementing materials of plant fibres than acids. Alkali scouring removes large amount of non-cellulosic substance, provides clean fine fibres as well as it removes not only non-cellulosic gummy material but also the cellulosic part of the fibres in a non specific manner (Kashayp *et al.*, 2001). As a result finer fibres with low strength were obtained from the alkali scouring.

Fibre fineness was not the major concern for selection of fibre in the present study thus on the basis of fibre tenacity and elongation at break, acid scouring *i.e.* method 4 (acetic acid) was selected.

Statistically the effect of scouring methods on physical properties of scoured hemp fibres was found to be significant at one per cent level of significance. It indicated that there was significant difference in the properties of all scoured fibres due to different treatments.

Effect of different scouring methods on fibre weight loss per cent :

Extracted hemp fibres were scoured with different scouring methods and fibre weight loss per cent after each scouring treatment was calculated. As evident from the Fig. 1 that minimum weight loss per cent (7.4) was observed in fibres scoured with method 4 (acetic acid scouring) and maximum (10.6) in fibres scoured with method 1 (NaOH + non-ionic detergent). The reason may be that the non-cellulosic substances in the fibres were not fully dissolved by the acid as concentration of acid was low in the treatment. Sodium hydroxide was used for retting of fibres also prior to scouring. In alkaline scouring, NaOH was used again which further removed the non-cellulosic impurities as well as hemicelluloses from the fibres. Thus, alkali boiling exhibited maximum weight loss in the scoured fibres.

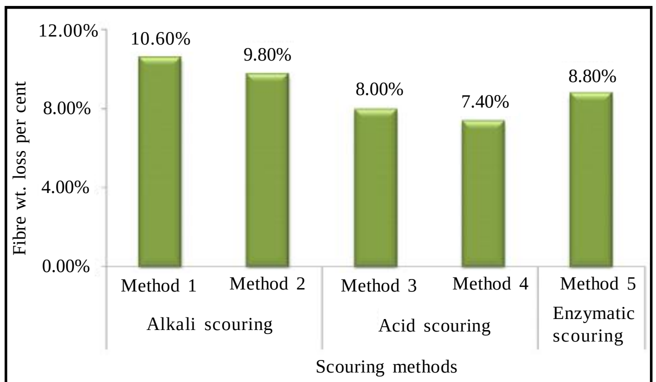

Fig. 1 : Fibre weight loss per cent of hemp fibre samples after different scouring methods

Effect of bleaching treatment on physical properties of hemp fibres :

Hemp fibre scoured with selected method (acetic acid scouring) was bleached with hydrogen peroxide bleach (H_2O_2) using the prescribed recipe (Shenai, 1980) and assessed for

Table 1 : Physical properties of hemp fibres scoured with different scouring methods

Sr. No.	Method No.	Type of scouring method	Fibre properties		
			Fibre denier	Tenacity (g/denier)	Elongation at break (%)
Alkali boiling					
i.	Method 1	NaOH + Detergent (non ionic)	12.95	2.54	2.34
ii.	Method 2	NaOH + Ammonium oxalate	13.31	2.83	2.03
Acid scouring					
iii.	Method 3	Sulphuric acid	21.19	2.33	1.75
iv.	Method 4	Acetic acid	18.15	3.69	2.73
Enzymatic scouring					
v.	Method 5	Pectinase	16.17	3.67	2.19

physical properties. It can be observed from Table 2 that fibres became finer after bleaching as evident from denier value which was found to be reduced from 18.15 denier to 6.96 denier.

Values of tenacity and elongation per cent at break were also found to be reduced after bleaching treatment. This may be due to the reason that bleached fibres had also undergone alkaline retting and acidic scouring treatment as a result pectins and lignin were reduced from the fibre bundles and each one separated from others easily. It was also observed in different studies that bleaching process reduced the tensile strength and elongation of fibres (Saxena, 1986).

Results of ANOVA indicated that effect of bleaching treatment on each physical property of hemp fibres was significant at one per cent level of significance.

Comparison of physical properties of raw (retted), scoured and bleached hemp fibres :

The comparison between the physical properties of hemp fibres from selected retting, scouring and bleaching method was done to assess the effect of different chemicals used in the processing method on physical properties of fibre. Fibre fineness, tenacity and elongation per cent at break gradually decreased after scouring and bleaching process. Not much more difference was found in the tenacity value of retted fibres (4.26 g/d) and bleached fibres (3.22 g/d). At the same time elongation per cent at break of fibres decreased from 4.08 per cent (retted fibres) to 2.44 per cent after bleaching process. Large difference was observed in the values of fibre fineness; bleached fibres were finer (6.96 denier) as compared to retted ones (19.93 denier) (Table 3). This may be due to the reason that, processing removed the noncellulosic and waxy substances from the layer of the fibres. Fibres separated from the bundles and exhibited lower denier value. The results were also in line with the statement that values of tenacity and elongation at break of fibres decreased gradually with each chemical treatment (Ugbolue, 2005).

On the other hand, processing also improved the colour of fibres. The whiteness value of retted fibres was 4.2, which indicated its colour towards blackness but after bleaching it was observed as -4.6 which signifies the whiteness of fibres. Bleaching removes the colouring pigments and cementing materials from the surface of fibres, thus whiteness value of fibres increased after each processing.

Effect of different processing treatments on properties (tenacity, elongation at break and fineness) of fibres was found statistically different at 1 per cent level of significance. This signifies that properties of fibres were affected by each processing.

Conclusion :

The result of study reveled that the values of tenacity, fineness and per cent elongation at break of hemp fibres changed with the treatment using different scouring agents. Alkali scouring produced the finer fibres but also reduced the tenacity as well as elongation per cent. On the other hand, acid scouring produced fibres with good tenacity and elongation. Use of alkali in scouring increased fibre weight loss per cent, whereas acids specifically organic acid (acetic acid) caused very less weight loss in fibres. Bleaching reduced the tenacity and elongation but increased the fineness and whiteness of fibres.

It can be concluded from the study that in the case of bast fibres, processing is essential to make the fibres finer, cleaner and softer; which finally improves the spinnability of the fibres. Proper processing treatment will definitely increase the end uses of hemp in the textile industry. Cultivation of hemp is banned in most countries as it contains negligible amount of THC (tetrahydrocanabinol), which is used in drug industry. There is need of awareness in the society that presence of very little amount of THC in plant would not affect its use in other industries because *C. sativa* is not a narcotic variety. Narcotic varieties are different from the fibre yielding varieties. The governments of various countries are trying to remove the legislations on hemp. Thus, application of hemp fibres in textile industry will definitely be improved.

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Table 2 : Physical properties of bleached hemp fibres

Sr. No.	Fibre sample	Fibre properties		
		Fibre denier	Tenacity (g/denier)	Elongation at break (%)
1.	Control (retted and scoured)	18.15	3.69	2.73
2.	Bleached (H_2O_2)	6.96	3.22	2.44

Table 3 : Comparison between the physical properties of hemp fibres from selected retting, scouring and bleaching method

Sr. No.	Fibre sample	Fibre properties			
		Fibre denier	Tenacity (g/denier)	Elongation at break (%)	Whiteness index
1.	Retted	19.93	4.26	4.08	4.2
2.	Retted and scoured	18.15	3.69	2.73	3.5
3.	Retted, scoured and bleached	6.96	3.22	2.44	-4.6

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