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Research Paper

Softening of Barky Root Cuttings of Jute by Pectinolytic Bacterial Strains for Better Spinability and Industrial Uses

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ABSTRACT

Jute is a very important commercial fibre and cash crop in India. India is the largest producer of jute in the World. The jute fibre available in the market sometimes contains a lot of barky portions. The barky portions of jute cause serious processing difficulties in the industry. As a result barky part is either cut off before processing or the jute reeds used for product development like thick yarn & rugetc. The cut-off portions of jute are called root cuttings and are generally considered as waste material. Forty six bacterial isolates were screened having pectinolytic activity. Two best strains were selected based on the potency index. The bacterial consortium within 1:1 ratio had effectively removed (75-88%) the barky root portion of jute fibre in both 1:10 (10 days) and 1:20 (7 days) liquor ratio. The treated fibre recorded good bundle strength (17-18cN) and spinnable to make 12lb/spy yarn having a tenacity of 7.88 cN/tex. The treatment time was reduced to 5 days (50% reduction) with mechanically softened fibre. Mechanical softening can be used to omit the media supplement of 0.5% Di-ammonium phosphate.

HIGHLIGHTS

- Barky root in jute is a serious issue for the processing of raw jute.
- High bark/ root content in jute fibre often reasons for the rejection of the lower portion of the fibre before the processing in Mills.
- A bacterial consortium developed at ICAR-NINFET (AS11 & AS20 in 1:1 ratio) had effectively delineated issue for treatment of the barky root portion of jute fibre.
- The treated fibre recorded good bundle strength and was spinnable to make yarn with good tenacity.

Keywords: Barky root cuttings, pectinolytic bacteria, softening, spinability

Jute is the second most important natural fibres grown in India. It sustains more than 4 million people in the country. However, improper retting of jute often produces inferior quality of fibres, and farmers suffer huge economic losses (Ray *et al.* 2015a; Ray *et al.* 2015b, Ray *et al.* 2016). Due to improper retting, a large quantity of jute fibre produced in India in the water scarce areas are of very inferior quality having 10 - 25% cuttings in basal portions of the fibre, which have no use until it is processed further to remove the barks (Ahmed, 1963, 68). As a result, farmers are deprived of getting fair price due to low grade produce and the jute industry in the country is also losing the fibre as waste material.

Removal of hard barks from jute fibres by microbial retting is a process essentially similar to that of retting of green jute plant but not identical because of dried barks (Majumder *et al.* 1996). The retting process also involves pectinolytic activity mediated

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by micro-organisms and their enzymatic actions. The microbes and the enzymes which carry out the decomposition of pectic substances have also been studied by many workers. The enzymes have been found to be mostly of pectin polygalacturonase and pectin methyl esterase in nature.

Few attempts were made to up-grade this low grade barky jute fibre through the application of promising fungi and bacterial culture bacteria (Basak *et al.* 1987; 1991). The hard barks were completely removed by employing the fungi *Penicillium corylophillum* within six days and were also confirmed by industrial trials. Haque *et al.* (1998) reported that the up-gradation of low grade jute fibres by two grades with wet-piling of the barky areas with the cultures of *Aspergillus* sp. and *Sclerotium* sp. within 10-12 days. Mohiuddin *et al.* (1981) had also showed softening of jute cuttings using *Bacillus megaterium.* Up-gradation of barky jute were also reported by few other workers (Mohiuddin, 1981; Ghosh and Dutta, 2008).

The present study unveiled the effect of microbial treatment on barky root portion of jute fibre for processing in mills without cutting the lower part.

MATERIALS AND METHODS

Isolation of pectinolytic bacteria

Retting liquor and soil samples from the jute site retting were collected and utilized for the isolation of pectinolytic bacteria. The samples were serially diluted and plated in a pectin agar medium containing pectin to develop colonies. The individual distinguished colonies were picked and again grown in pectin broth. All the isolated bacteria were tested for pectinase activity by measuring halo zones and then the potency index was measured. Finally two bacteria viz. AS11 and AS20 was been selected for further study (Table 1).

Table 1: Pectinase activity of bacterial strains

Bacterial strain	Colony dia. (mm)	Halo zone dia. (mm)	Potency index
AS11	1.5	6.5	4.1
AS19	8.0	10.0	1.25
AS20	2.0	8.0	4.0
AS21	7.0	9.0	1.30
AS39	5.0	8.0	1.60
AS37	4.0	5.0	1.25

Collection of barky root cuttings and its characterization

Barky root cuttings of jute were procured from Hukumchand Jute Mill, Hazinagar, West Bengal, India and they were characterized. Fibre cutting having barky root of 80% and fibre bundle strength of 18.4 cN/tex was measured by a bundle strength tester developed by ICAR-NINFET, Kolkata (Roy *et al.* 2009).

Experiment on laboratory scale

Two bacterial cultures isolated by the institute multiplied in the nutrient broth medium for 3 days and inoculated @5% in the experimental medium along with Di-ammonium phosphate @ 0.5%. A treatment medium was prepared mixing in tap water with bacterial cultures and media supplement and the barky root cuttings were immersed (20g sample) into the medium, and kept for incubation at room temperature.

Up-scaling of the treatment process

The treatment process was upscaled from 80g sample to 8 kg of root cuttings. The experiments were conducted along with control with 3 replications. The control treatment was kept only with tap water. In all treatments, 5% bacterial consortium was used along with 0.5% media supplement. The liquor ratio was 1:10. Treatment period was 10 days. Fibre bundle strength and barky root % were measured in the treated and control fibres. From the fibre 12 lb yarn was prepared for further evaluation.

Experiment on pilot scale

Twenty-five kg root cuttings were treated. The control fibre was mechanically softened in a mechanical softening machine at the Pilot Jute Mill, at ICAR-NINFET, Kolkata. Treatments were done with control as well as with mechanically softened fibre. In this experiment, 5% bacterial consortium and 0.5% media supplement added. The liquor ratio was 1:10. Here treatment period was reduced to 4 days.

Preparation of yarn and estimation of quality parameters

Industrial scale jute spinning machinery was used to produce 426 tex yarns from the treated fibre. For comparison purposes yarn from 100% treated fibre

and from 50% treated fibre and 50% TD4 grade jute fibre having a bundle strength of 17.6 cN/tex was produced. Control fibre or root cutting as such was unspinable, yarn could not be produced. The physical properties of the yarns viz. actual count, twist and quality ratio were determined. The tensile strength of the yarns was measured in an Instron tensile tester (Model No. 5567) as per BIS Standard (IS 1670:1991).

RESULTS AND DISCUSSION

Isolation of pectinolytic bacteria and their characterization

Forty-six bacteria were isolated, among them two strains AS11 and AS20 (potency index 4.1 and 4.0, respectively) were selected on the basis of efficient pectinolytic activity to develop a process or protocol for softening of barky root cuttings. The bacteria were grown in a nutrient broth medium with a temperature 28 ± 2° C in an incubator shaker for 3-5 days and this inoculum was used for the study.

Optimization of the protocol for the treatment of barky root cuttings and up-scaling of the process

It was observed in table 1 that 87% reduction in barky roots was achieved with the treatment with a bacterial consortium consisting of AS11 and AS20 in 10 days (Table 1; Fig. 1) as compared to other treatments (Table 2).

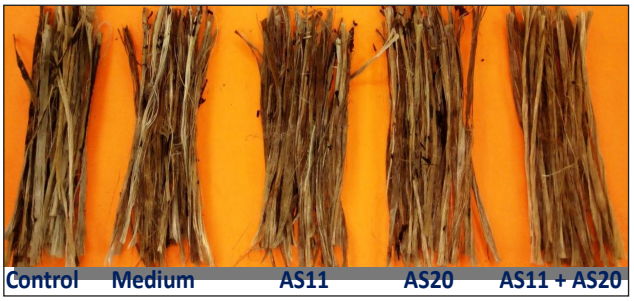

Fig. 1: Photograph of treated and non-treated barky root cuttings with bacterial consortium after 10 days

When the sample amount was increased further then consistent reductions of barky roots were achieved as compared to control (Table 3). It had also been observed from the table that as the quantity of root cuttings increases the days of treatment was also reduced using lower quantity of bacterial inoculums keeping the reduction of barky roots at a desirable level (65-70%) so that the treated fibre become easily spinnable to made yarn either with 100% or mixed with virgin jute fibre.

Table 2: Extent of removal of barky root cuttings by bacterial consortium after 10 days of treatment

Treatment	% barky jute	% decrease
Control	80	0
Water	60	25
AS11	35	56
AS20	35	56
AS11 + AS20	10	87.5

Table 3: Different treatment process and physical quality parameter of treated fibre

Sample	Root (%)	Treatment	Days	Quality parameter	
				Root remaining (%)	Bundle strength (cN/tex)
100g	90	Fibre to water = 1:20 Culture: 5% (AS11+AS20, 1:1) Media supplement: 0.5%	10	11.2 (↓87%)	16.8 (18.4) (↓8.7%)
1kg	85.5	Fibre to water = 1:20 Culture: 5% (AS11+AS20, 1:1) Media supplement: 0.5%	10	15.5 (↓82%)	16.5 (19.3) (↓14.5%)
4kg	85.5	Fibre to water = 1:20 Culture: 2% (AS11+AS20, 1:1) Media supplement: 0.5%	7	16.1 (↓81%)	18.7 (19.3) (↓3.1%)
4kg	85.5	Fibre to water = 1:20 Culture: 2% (AS11+AS20, 1:1) Media supplement: 0.5% Mechanically softened by softener	5	10.3 (↓88%)	18.5 (19.3) (↓4.1%)

Note: *Di-ammonium phosphate was used as media supplement; Values in parenthesis are the bundle strength of control fibre.*

Experiment at pilot scale

In this experiment 8 kg root cuttings were used and the liquor ratio was reduced to 1:10 to see. Bacterial inoculums were increased simultaneously which leads to achieving a 75 % reduction of barky roots in 10 days which leads led significantly higher than the control (50%). Fibre colour was improved significantly with a meagre increment of fibre fineness. Fibre bundle strength was decreased in all cases when treated with water. Fibre bundle strength of treated fibre was 16.7 cN/tex (Table 4). The treated fibre was successfully spun to make 426 tex yarn with a quality ratio of 60.5 (Fig. 2 & 3, Table 5).

Experiment at pilot scale (Up-scaled)

An up-scaling of the treatment was carried out with 25 kg root cuttings. Here bacterial consortium was reduced and liquor ratio was increased to 1:15 with the same objective to increase spinnability keeping

Fig. 2: Photographs of the control and treated barky root cuttings

Fig. 3: TPI: 4; Count: 12 lbs/spy; Gauge length = 500 mm; Speed = 300 mm/min

Table 4: Physical properties of treated fibre

Treatment	Root (%)	Strength (cN/tex)	Finenes (tex)	Colour (%)
Control	85.5	19.3	3.0	30.0
Tap water	42.7 (↓50%)	15.7 (↓19%)	3.0	41.85 (↑40%)
Treated	21.67 (↓75%)	16.7 (↓13%)	2.9 (↑3%)	56.7 (↑89%)

Table 5: Tensile properties of yarn

	Breaking load (N)	Elongation at break (%)	Tenacity (cN/tex)	Initial modulus (cN/tex	Specific work of rupture (mJ/tex-m)	Quality ratio
Mean	32.55	2.24	7.88	274	0.82	65
CV%	20.63	17.68	20.63	9.61	35.50	

TPI: 4; Count: 12 lbs/spy; Gauge length = 500 mm; Speed = 300 mm/min

in mind the inoculum cost. It was observed that the treatment period was reduced to 4 days. The treated root cuttings were spun to make two types of yarn (426 tex). One yarn are made from 100% treated fibre and another yarn had been made by mixing/batching with TD-4 grade jute fibre with a 50:50 ratio which enhanced quality ratio from 46.6 (100% treated fibre) to 68.9 (50:50 ratio) (Table 6 & 7, Fig. 4 & 5).

Fig. 4: Treated and untreated fibres with the formulations

Fig. 5: TPI: 4; Count: 12 lbs/spy; Gauge length = 500 mm; Speed = 300 mm/min

Table 6: Physical properties of treated fibre

Sample	Treatment	Days	Root (%) (Un-treated)	Fibre quality parameter	
				Root (%) (Treated)	Bundle strength (cN/tex)
25 kg	Fibre to water = 1:15	4	62.2	9.5 (↓85%)	13.9
	Culture: 3%				(19.7)
	Mechanically un-softened				(↓29%)
25 kg	Fibre to water = 1:15	4	49.8 (↓20%)	7.5 (↓85%)	15.2
	Culture: 3%		due to softening		(19.7)
	Mechanically softened				(↓23%)

Values in parenthesis are the bundle strength of control fibre.

Table 7: Properties of yarn made from treated root cuttings

Treatment/process	Breaking load (N)		Elongation at break (%)		Tenacity (cN/tex)		Quality ratio
	Mean	CV%	Mean	CV%	Mean	CV%	
Mechanically softened	24.87	24.33	1.80	19.74	6.02	24.33	46.6
Fibre bundle strength: 15.2 g/tex							
Treated fibre is mixed with TDN-4 grade fibre (50:50)	36.79	22.41	2.32	20.30	8.91	22.41	68.9

CONCLUSION

Barky root in jute is a serious issue for the processing of raw jute. Farmers are often deprived of the hard earned produce of jute due to hard gummy part in the lower portion of the jute fibre. Such barky root is often cut and rejected from smooth running in the Mill. Due to the extensive presence of defects and production of low-quality fibres, traditional use of jute in hessian and sacking is facing serious challenges which have more impact on reduction in demand as a result of dilution of JPM act. Hence, diversification has become a necessity for sustaining the jute industry. The finding of the bacterial consortium at ICAR-National Institute of Natural Fibre Engineering & Technology (AS11 & AS20 in 1:1 ratio) had effectively removed the barky root portion of jute fibre (75-88%) in both 1:10 (10 days) and 1:20 (7 days) liquor ratio. The treated fibre recorded good bundle strength (16.7-18.5 cN/tex) and spinnable to make 426 tex yarn with a tenacity of 7.88 cN/tex. The treatment period was reduced to 5 days (50 % reduction) with mechanically softened fibre. Softening media supplements (0.5% DAP) can also be reduced or avoided completely. The softening process developed with two bacterial consortia will become an eco-friendly process of up-grading barky roots and good quality yarn can be produced out of it through which the jute industry will be immensely benefitted.

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