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Research Paper

Impact of scouring on quality parameters of banana pseudostem fibres

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ABSTRACT : In recent years, the search for alternative sources of fibres has been increased due to the growing shortage of fibres, where in banana is one among them. Banana plant is highly valued for its fruit, but it also yields vast quantities of biomass. Banana fibres are the essential alternative even expanding the horizon of textiles and they are non-toxic in nature. However, the present study is the outcome of the varieties (Grand Naine and Ney Poovan) of the pseudostem. Research work carried out to know the effect of scouring on strength, elongation and fineness of banana pseudostem fibre. The fibres extracted from pseudostem of banana plant varieties (Grand Naine and Ney Poovan) mechanically using raspador machine. Scouring is one of the most essential processes that are carried out for the natural fibres to remove the unwanted impurities and then vegetable matter. It further enhances the fibre qualities like strength and lustre. The fibres were scoured with 1 per cent, 2 per cent, 3 per cent and 4 per cent NaOH solution at boiling for 45 minutes and finally treated with acetic acid for neutralization, washed thoroughly in plain water and shade dried. The samples were tested for strength and elongation using single yarn tester and fineness was tested using gravimetric method. Results revealed that the fibre scoured with 1 per cent NaOH exhibited higher strength than the control and other concentrations; whereas elongation is found to be higher in 1 per cent and fineness parameters of the treated with 4 per cent concentration of NaOH to be higher than the other samples. Fibres can be utilized in the preparation of value added products and fashion accessories using braiding and carding technique.

KEY WORDS: Banana pseudostem, Biomass, Fibre, Raspador machine, Scouring

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India being a tropical country with plenty of renewable resources obtainable from the plant kingdom. Apart from cotton, India has a large variety of other cellulosic fibres like pineapple, ramie, jute, coir and banana. Banana belongs to the family *Musaceae* of the genus *Musa.* Banana cultivation is done in all parts of the country including Uttar Pradesh, but is mainly grown in Gujarat, Kerala, Tamil Nadu, Maharashtra, Andhra Pradesh, Karnataka and Bihar. It is cultivated in about 1,86,000 hectares of land and the fibre yield is around 7.5 lakh tonnes. Banana is a non-branching, soft stemmed perennial plant of about 2-6 meters in height with a few, big leaves, it grows luxuriously, in the warm, humid and rainy climate of the tropical regions (Iyer *et al.,* 1995).

Banana is referred as “Kalpatharu”, a plant of all virtues, with each and every part of the plant being used for various purposes. The importance of banana as a food fruit crop can hardly be exaggerated adding to its multifaceted uses as food, fibre, fuel and therapeutic values.

Banana fibre, a Lignocellulosic fibre, obtained from the pseudostem of banana plant (*Musa sepientum*). The ‘pseudostem’ is a clustered, cylindrical aggregation of leaf stalk bases. For extraction of fibres from the pseudostem, the most common method followed in Indian villages is hand scrapping, *i.e.* to scrap the stem with blunt metal edge. The drawback of hand scrapping is that the fibre output is very low. The essentially hand driven process of extracting banana fibre is now set to change with the invention of the banana fibre separator machine. All varieties of banana plants abound in fibres, in the present study major variety of banana *i.e.*, Grand Naine have been selected.

Textile fibres are subjected to various preparatory processes that include scouring and bleaching. The effect of these preparatory processing on the fibre quality also needs attention. Usually, bast fibres are processed with bacterial, chemical and enzymatic methods. Chemical processing is effective for removing non-cellulose substances and improves the acceptability of the product.

Many self-help groups are in operation just for the small savings that are remainants in the family budgeting. Fewer opportunities for self employment are pertinent due to the lack of appropriate skills and knowledge of the members in value addition to the locally available resources. Therefore, the fibre from pseudostem of banana shall be utilized for product developments that are in demand among the urbanites as eco-friendly material.

■ RESEARCH METHODS

Sample :

Banana varieties: Grand Naine (V_1) and Ney Poovan V_2) grown in University of Agricultural Sciences, Dharwad, Karnataka were collected and utilized for the study (Plate A).

Stage of harvesting :

The dwarf banana crop is ready for harvesting within 11-14 months after planting. Whereas, the tall cultivars take 14-16 months for harvesting. Maturity of banana is indicated by drying of top leaves, change in colour of fruits from dark green to light green and the tendency of the floral end of the fruit to fall by a slightest touch. After harvesting the fruit, the stem was cut from the base (5” above ground) and the top leaves were chopped.

Plate A : Banana plants Grand Naine (V_1) and Ney Poovan (V_2)

Pseudostem processing :

Pseudostem is the aerial stem seen above the ground and is formed by closely packed leaf sheaths embedded in the growing tip. Each leaf has a basal leaf sheath forming a part of pseudostem, petiole and lamina. After harvesting of fruits and leaves, pseudostem is cut near to the ground level. Stems procured in the present study were dissected further for fibre extraction studies (Plate B).

Ancillary parameters :

Ancillary parameters *viz.,* stem height, stem girth (top and bottom), weight of the stem, number of leaves and sheaths were recorded. Height and girth parameters were measured using a non-stretchable calibrated measuring tape, while the weight was measured using a weighing balance. And the other parameters were counted manually. Totally five stems of each variety were considered for the study.

Sheath wise fibre extraction :

Sheaths separated from banana pseudoatems of

Plate B : Harvesting of banana pseudostem

each variety. Fibre extraction from individual sheaths was done mechanically using a raspador machine. Care was taken to remove the cellulose and other impurities from the extracted wet fibres by combing. Fibres were line dried under shade for 24 hours. Dried fibres were later packed separately in polythene bags for storage and further studies.

Scouring

Scouring is a process of removal of natural impurities of the natural fibres and can be applied to fibres, yarns knitted or woven fabrics and garments.

Recipe :

NaOH : 1%, 2%, 3% and 4%
Turkey red oil : 0.50%
Acetic acid : 0.50%
MLR (Material to Liquor Ratio): 1:20
Temp : Boiling
Time : 45 minutes

Procedure :

Fibres were pre-soaked in 0.5 per cent solution of Turkey red oil for 20 minutes. Pre-soaked fibre was scoured in varied concentrations of sodium hydroxide. Fibres were boiled in alkali of different concentrations for 45 minutes with subsequent stirring. Scoured samples were later treated in 0.5 per cent acetic acid for neutralization. The fibres were thoroughly rinsed in running water, squeezed to remove excess water and line dried in shade (Brindha *et al*., 2012).

Fibre quality parameters :

Various fibre quality parameters tested at AICRP-H.Sc. (CT) and DKTE's Textile and Engineering Institute, Ichalkaranji.

Fibre quality parameters :

Various fibre quality parameters tested at All India Co-ordinated Research Project - Home Science (Clothing and Textile) (AICRP- HSc) (CT) and DKTE's Textile and Engineering Institute, Ichalkaranji are explained in detail under different subheadings.

Sheath/layer wise separation

Raspador machine

Fibre extraction

Plate C : Extracting of banana pseudostem fibres

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 (Singh and Gahlot, 2014).

$$\text{Fibre weight loss (\%)} = \frac{A - B}{A} \times 100$$

A- Initial weight of the fibre
B- Final weight of the fibre

Fibre fineness (tex) :

Fibre fineness directly determines the spinnability of yarn, any irregularity in the fibre affects the yarn strength. The fineness of the fibre also affects several mechanical properties and therefore, influences the behaviour of the fibre during processing and the properties of the resultant yarns and fabrics. Fineness of banana pseudostem was assessed using the gravimetric method (Booth, 1996).

Fineness of banana pseudostem was assessed using the gravimetric method. Constant length of 230 Number banana fibres (20 cm) were counted and then weighed in an electronic weighing balance. Fibre fineness was calculated using the following formula and the fineness expressed in tex. Three observations were made and the average fibre fineness was tabulated.

$$\text{Fibre fineness} = \frac{W}{L} \times 1000$$

where,
W is weight of the known length of fibre mass
L is the total length of the fibre (4.6 m)

Fibre strength (kgf) :

The fibre strength and elongation of the banana pseudostem fibres was analysed using Single yarn strength tester, the details of which are as follows:

Length of the fibre specimen : 20 mm
Replications (number of tests/sample): 5 replication
Equipment : Single yarn strength tester
Standards : ASTM 1294
Guage length (equipment) : 200 mm
Working principle : CRE
Number of observation : 50

Average strength of the fibres was expressed in terms of kgf.

Fibre elongation (%) :

Elongation of the banana pseudostem fibres was analysed using single yarn strength tester.

Length of the fibre specimen : 20 mm
Replication : 5 replication
Equipment : Single yarn strength tester
Standards : ASTM 1294
Guage length (equipment) : 200 mm
Working principle : CRE
Number of observation : 50

Mean elongation of the fibres was calculated and expressed in terms of percentage (%).

■ RESEARCH FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Mean ancillary characteristics of banana pseudostems :

Table 1 reveals the mean ancillary characteristics of banana stems. The height of Grand Naine (V_1) and Ney Poovan (V_2) trunks was 133 cm and 259 cm, respectively. V_2 recorded higher trunk weight (20 kg) than V_1 (12 kg). Total number of leaves in V_2 was 7-8 whereas V_1 had 4-5 leaves. Girth of the V_1 trunk measured 56 cm at the bottom, 49 cm in the middle and 36 cm at the top. Similarly, V_2 trunk recorded 47 cm, 34 cm and 31 cm circumference at the bottom, middle and

Table 1 : Mean ancillary characteristics of banana pseudostems

Sr. No.	Measurement		Mean	
			Grand Naine (V_1)	Ney Poovan (V_2)
1.	Plant height (cm)		133	259
2.	Plant weight (kg)		12	20
3.	No. of leaves per plant		4-5	7-8
4.	Pseudostem girth/circumference (cm)	Top (cm)	31	36
		Middle (cm)	34	49
		Bottom(cm)	47	56

top, respectively.

Plant ancillary characters of Ney Poovan (V_2) variety were higher than the Grand Naine (V_1) variety. The part of the plant that looks like a trunk is actually a false stem, called pseudostem. The pseudostem is formed by the tightly packed overlapping leaf sheaths. Even though the pseudostem is very fleshy and consists mostly of water, it is quite sturdy and can support a bunch that weighs 50 kg or more. The pseudostem continues to grow in height as the leaves emerge one after the other and reaches its maximum height when the real stem the floral stem which supports the inflorescence emerges at the top of the plant. Ney Poovan (V_2) has 'AB' genome group, *i.e*. cultivars that have two set of chromosomes, one donated by Musa acuminata and the other by Musa balbisiana in the ratio of 50:50. Cultivars with only A g-+enome are shorter in characters and and those with only B are taller. On the other hand V_1 (Grand Naine) is composed of AAA genome. The AAA genome group of edible triploid cultivars have three sets of chromosomes, all originally derived from Musa acuminata, which donated the so-called A genome. The AAA genome group of cultivars are the most widely grown group of edible bananas. However, the physiological properties are governed by these genomic configurations.

Impact of scouring on weight (g) of banana pseudostem fibres:

The weight of the fibre extracted from V_1 reduced from 300g to 297.6g on scouring with 1 per cent concentration, followed by 297.0g, 296.5g and 295.5g on scouring concentrations of 2, 3 and 4 per cent, respectively. Similarly, fibres extracted from V_2 reduced in weight from 300g (control) to 293.6g, 292.5g, 290.1g and 289.8g on scouring in 1, 2, 3 and 4 per cent NaOH concentrations, respectively (Table 2). Among varieties, significant weight loss was recorded with fibres of V_2 compared to fibres of V_1 pseudostems with all the concentrations of NaOH. Among the scouring treatments, results were highly significant on scouring concentrations of 1, 2, 3 and 4 per cent for fibres extracted from both varieties 1 and 2. Mean weight loss

Table 2 : Effect of scouring on weight (g) of banana pseudostem fibres

Scouring concentrations (%)		Grand Naine (V_1)	Ney Poovan (V_2)	Mean
Control		300.0	300.0	300.0
1.00		297.6**	293.6**	295.6
2.00		297.0**	292.5**	294.7
3.00		296.0**	290.1**	293.0
4.00		295.5**	289.8**	292.6
Mean		297.5	293.2	-
C.D. (P=0.01)	Varieties (V)		0.642	
	Scouring (S)		1.015	
	Varieties x Scouring (V x S)		1.435	
CV (%)			0.207	

** Highly significant @ C.D. (P=0.01)

Table 3 : Impact of scouring on strength (kgf) of banana pseudostem fibres

Scouring concentrations (%)		Grand Naine (V_1)	Ney Poovan (V_2)	Mean
Control		0.343	0.382	0.363
1.00		0.352**	0.407**	0.380
2.00		0.334**	0.363**	0.349
3.00		0.311**	0.340**	0.326
4.00		0.296**	0.315**	0.306
	Mean	0.327	0.362	-
C.D. (P=0.01)	Varieties (V)		0.006	
	Scouring (S)		0.009	
	Varieties x Scouring (V x S)		0.012	
CV (%)			1.947	

** Highly significant @ C.D. (P=0.01)

was 295.6g on scouring with 1 per cent concentration, followed by 294.7g, 293.0g and 292.6g on scouring with 2, 3 and 4 per cent concentrations, respectively. Irrespective of the scouring concentration, the mean weight loss of the fibres extracted from V_1 recorded 297.5g and fibres from V_2 recorded 293.2g on scouring (Fig. 1).

Higher weight loss was observed in the fibres extracted from V_2 was observed on scouring. Fibres extracted from V_1 pseudostems primarily had lower hemicellulosic content that may be one of the reasons for lesser weight loss of the fibres on scouring. Similar trend of results were also observed in a study on jute, flax and ramie fibres (Chattopadhyay *et al.*, 1999). Increase in the concentration of caustic soda, irrespective of the level of tension or extension, the weight loss increases for all the three fibres. It was maximum in case of jute and minimum in case of ramie. Relatively much less weight loss in case of ramie was attributed to its lower hemicellulose content and very compact fine structure with higher crystallinity and orientation.

Weight of the fibres reduced successively with increase in the scouring concentration. Minimum weight loss was observed with lower (1%) concentrations and maximum with higher concentrations (4%). It may be endorsed here that lower concentrations of NaOH may result in incomplete removal of the vegetative matter including non-cellulosic matter and hemicellulosic content; On the other hand, cleaning of the fibres may be efficient with higher concentrations of NaOH.

Impact of scouring on strength (kgf) of banana pseudostem fibres :

There is a highly significant increase in the strength of fibres extracted from V_2 (0.407 kgf) compared to the fibre extracted from V_1 (0.352 kgf). Further, the strength of the fibre from both V_1 (0.334 kgf) and V_2 (0.363 kgf) have decreased significantly over control (V_1: 0.343 kgf, V_2: 0.382 kgf). The decline in strength is continuing for the subsequent souring treatments. Across varieties, it is observed that the mean strength of banana pseudostem has increased (0.380 kgf) on scouring with 1 per cent

Table 4 : Impact of scouring on elongation (%) of banana pseudostem fibres

Scouring concentrations (%)		Grand Naine (V_1)	Ney Poovan (V_2)	Mean
Control		1.800	2.300	2.05
1.00		1.600**	2.100**	1.85
2.00		1.500**	2.000**	1.75
3.00		1.400**	1.900**	1.65
4.00		1.200**	1.800**	1.50
	Mean	1.500	2.020	-
C.D. (P=0.01)	Varieties (V)		0.121	
	Scouring (S)		0.191	
	Varieties x Scouring (V x S)		0.270	
CV (%)			8.984	

** Highly significant @ C.D. (P=0.01)

Table 5 : Impact of scouring on fineness (tex) of banana pseudostem fibres

Scouring concentrations (%)		Grand Naine (V_1)	Ney Poovan (V_2)	Mean
Control		152.1	166.6	159.3
1.00		137.6	159.3	148.5
2.00		130.3**	144.8**	137.6
3.00		123.1**	130.3**	126.7
4.00		115.8**	123.1**	119.5
	Mean	131.8	144.8	-
C.D. (P=0.01)	Varieties (V)		16.510	
	Scouring (S)		26.105	
	Varieties x Scouring (V x S)		36.918	
CV (%)			11.486	

** Highly significant @ C.D. (P=0.01)

concentration over control (0.363 kgf). On scouring with 2, 3 and 4 per cent concentration, the mean strength of the fibres recorded was 0.349 kgf, 0.326 kgf and 0.306 kgf, respectively. Among wet processing treatment (scouring), it is observed that 1 per cent concentration imparts strength to the pseudostem fibres that is statistically highly significant over control. Strength of the fibre decreases on scouring with higher concentrations of NaOH in the scouring liquor. The mean strength of the fibres from V_2 (0.362 kgf) was higher than the mean strength of fibres extracted from V_1 (0.327 kgf) (Table 3).

The strength of fibre extracted from V_2 was higher than the strength of fibre extracted from V_1. This is mainly because of the higher amount of hemicellulose and lignin content in the fibre extracted from V_2. Hemicelluloses are chain molecular substances having relatively short chain structure with Degree of Polymerization of 150. Hemicelluloses are present in the cell wall and consist of pentoses *viz.*, xylan and araban and hexosans *viz.*, galactan and rhamnan. They also contain substances with lower molecular weight *viz.*, glucan and uronic acid. Lignin is a complex amorphous polymer which functions as a structural supporting material in plants (Ray Maulik, 2003). Across varieties, there is a highly significant improvement in the strength of the pseudostem fibres on scouring with 1 per cent concentration. Scouring is a process of removal of unwanted vegetative matter and impurities from the fibre. Scoring prepares the textile substrate for further wet processing treatments. Many times bast fibres extracted mechanically are subjected to a process called degumming wherein the fibres are treated with acid/alkaline reagents for removal of impurities, cementing material or the pith. Degumming ramie fibre with 1 per cent NaOH concentration boiled for 4 hours has enhanced the strength (Pandey, 1998). Ray *et al*. (1973) while studying the influence of gum on the crystalline structure of ramie highlighted that on removal of gum, the crystallinity increases. Orientation of the fibre molecules is responsible for its physico-chemical properties. Crystalline fibres are stronger and durable than amorphous fibres. It is therefore imperative that the vegetative and pectinaceous matter adhered to the banana pseudostem fibre are removed on scouring to an optimum level that is responsible for the increased strength (kgf).

Scouring concentration of 2 per cent and above concentrations has further reduced the strength of the fibres significantly. Higher concentrations of alkalies cause weakening of inter-polymer structure of cellulosic fibres as a result fibres become weak and exhibit lower strength. Studies on alkali (caustic soda) treatment of bast fibres *viz.*, jute, ramie and flax have revealed that the fibres swell and a part of hemi cellulose dissolves that further is responsible for important changes in structural and physical properties (Chattopadhyay *et al*., 1999).

Impact of scouring on elongation (%) of banana pseudostem fibres :

Among the varieties it is evident that the fibres extracted from V_2 exhibited higher (2.300%) elongation percentage than the fibres extracted from V_1 (1.800%). Scouring with 1 per cent concentration reduced the elongation readings to 2.1 per cent and 1.6 per cent for fibres extracted from V_2 and V_1, respectively (Table 4). The difference in the fibre elongation values was found to be highly significant between varieties. Across varieties, scouring has reduced the elongation parameter. A steady but significant reduction in fibre elongation was observed on scouring with 2, 3 and 4 per cent concentration of the scouring liquor. Fibres of V_2 recorded 1.8 per cent and V_1 exhibited 1.5 per cent elongation on scouring with the highest concentration (4%).In general, mean elongation percentage of the pseudostem fibres reduced from 2.05 to 1.85 per cent on scouring with 1 per cent concentration of NaOH, followed by 1.75, 1.65 and 1.50 per cent on scouring with 2, 3 and 4 per cent concentration of the scouring

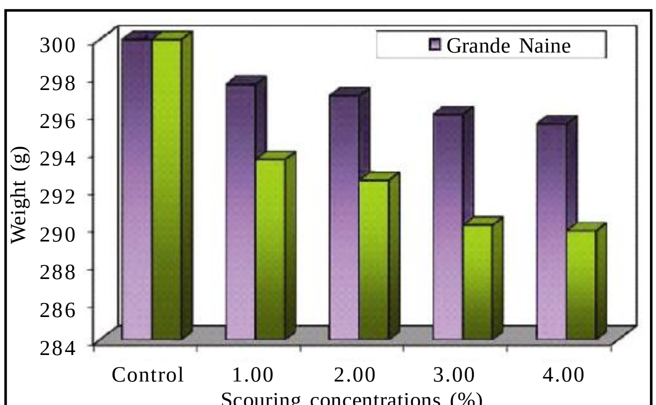

Fig. 1 : Impact of scouring on weight (g) of banana pseudostem fibres

solution. The elongation percentage of fibres extracted from V_2 was higher than the fibres extracted from V_1. Elongation of fibres is dependent on the fibre content and orientation. Crystalline structures are stronger and exhibit better elongation properties than the amorphous (Gohl and Vilensky, 1987).

Irrespective of the varieties, scouring gradually decreased the elongation properties of the banana pseudostem fibres. The reduction in the fibre elongation was gradual and significant. Reduction in the lignin and hemicellulose substances not only reduces the strength but due to the disturbance in the fibre orientation, there is a significant decrease in the fibre elongation parameter.

Impact of scouring on fineness (tex) of banana pseudostem fibres :

Among the varieties, fineness of fibre extracted from V_1 (152.1tex) were finer than the fibre extracted from V_2 (166.6tex). A higher and significant reduction in the fineness of fibre extracted from V_2 was observed on scouring with 2, 3 and 4 per cent than fibre extracted from V_1 over control. Across varieties, scouring reduced the fibre fineness that was non-significant with 1 per cent NaOH concentration. Fineness of the fibres reduced significantly on scouring with 2 (V_1:130.3tex; V_2:144.8tex), 3 (V_1: 123.1tex; V_2:130.3tex), and 4 (V_1:115.8tex; V_2:123.1tex) per cent concentrations of NaOH, respectively (Table 5). In general, the mean fineness of the pseudostem fibres was 159.3 tex that reduced to 148.5 tex on scouring with 1 per cent, 137.6 tex with 2 per cent, 126.7 with 3 per cent and 119.5 tex with 4 per cent, respectively.

The banana pseudostem fibres extracted from V_1 were finer than the fibres extracted from V_2. This is primarily due to the presence of higher proportions of α-cellulose and lignin contents. α-cellulose forms the main structural basis of vegetable fibres but is said to have intimate association with other cellulose constituents. α-cellulose occurs in the form of long chain polymer of β-D glucoside molecules which are joined to each other by β-1,4glucoside bonds *i.e.*, the glucose units being bonded through an oxygen bridge. Structural units of lignin are aromatic alcohols with a phenyl propane backbone. It is formed by the non-reversible removal of water from sugars to create aromatic structures. It maintains wall strength and permeability and helps with transportation of water (Ray Maulik, 2003 and Bungay, 2005).

Kundu *et al.* (2005) justifies that high α-cellulose, low lignin and pentosan content in khimp fibre indicate its suitability for use as a non-conventional raw material in pulp and paper industries and for making boards and composites. Further Asagekar and Joshi (2014) mention that due to high tex value, bagasse is more suitable in manufacturing of non-woven especially as reinforcement in composites for varied applications. On scouring treatment there is a significant impact of higher concentrations of NaOH in the scouring liquor. Removal of not only hemicellulose and lignin content, non-cellulosic substances reduces the diameter of the fibre making it finer (Kashayp *et al*., 2001). However an insignificant decrease in the fineness was found with 1 per cent scouring.

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Conclusion :

Ancillary parameters of the Ney Poovan pseudostem were higher than the Grand Naine pseudostem. Among the varieties fibre extracted from V_2 were stronger than the fibre extracted from V_1 pseudostem. In Scouring, 1 per cent NaOH concentration improved the strength of the fibres extracted from pseudostem of both the varieties. Whereas 2, 3 and 4 per cent NaOH concentration reduced the strength of the banana pseudostem fibres. However the 1 per cent NaOH treated fibre shows better strength these fibres were used to blending with other natural fibres like cotton to made fabrics and also could be suitable for use in textile, composites and value added utility articles as well as household products he fibre extracted from V_2 exhibited higher elongation percentage than the fibres obtained from $V_{1.}$ On scouring treatments, the elongation percentage decreased significantly with increase in NaOH concentrations. Among the varieties fibre extracted from V_1 was finer than the fibre extracted from V_2 pseudostem. After scouring, treatments fineness of the fibres extracted from pseudostem of both varieties increased significantly over control. However, maximum fineness was found in fibres treated with 4 per cent

NaOH concentrations. Improved the fibre fineness proved that it is satisfactory for textile processing; its superior moisture absorbing ability would contribute to the comfort of final products.

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