DAFFODIL INTERNATIONAL UNIVERSITY JOURNAL OF SCIENCE AND TECHNOLOGY, VOLUME 16, ISSUE 1, JANUARY 2021
ISSN 1818-5878 (Print) 2408-8498 (Online)

ASSESSMENT OF PHYSICO-MECHANICAL QUALITY PARAMETERS OF JUTE FIBRE GROWN IN DIFFERENT LOCATIONS OF BANGLADESH

Abul Khaiyer Mollah[1], *M. M. Alamgir Sayeed[2], M. Mahbubul Islam[1], Md. Mahmudul Habib[2] and M. Kamrujjaman[3]
[1]Planning, Training and Communication Wing, Bangladesh Jute Research Institute, Dhaka-1207, Bangladesh
[2]Textile Physics Division, Bangladesh Jute Research Institute, Dhaka-1207, Bangladesh
[3]Agriculture Wing, Bangladesh Jute Research Institute, Dhaka-1207, Bangladesh
Email: mmasayeed70@gmail.com

Abstract: This paper presents an experimental study on the physical and mechanical properties of jute fibres grown in seven different locations of Bangladesh. Two varieties, namely O-9897 and O-72 of Tossa jute and two varieties, namely CVL-1 and BJC-2197 of White jute fibre samples are collected from seven research stations of Bangladesh Jute Research Institute (BJRI), namely Faridpur, Manikganj, Rangpur, Kishoreganj, Pakhimara, Tarabo and Manirampur. A total of five physico-mechanical quality attributes, such as, bundle strength, fineness, linear density, whiteness and brightness are tested for this study. It is observed that fibre bundle strength of Tossa jute varieties is comparatively higher than that of White jute varieties. On the other hand, it is also revealed that linear densities of Tossa jute fibres are significantly higher than that of White jute fibres. However, between the Tossa jute varieties O-9897 and between the White jute varieties CVL-1 seemed to be better in terms of spinning quality of those jute fibres.

Keywords: *Jute; varieties; fibre quality; bundle strength; fineness; linear density; whiteness and brightness.*

1. INTRODUCTION

Jute is a ligno-cellulosic bast fibre due to its high content of lignin (12-13%) along with cellulose (61-71.5%) and hemicelluloses (13.6-20.4%). Bangladesh earns a huge amount of foreign currency by exporting raw jute and diversified jute products. Like other fibres, the producers and consumers judge raw jute fibre on the basis of its strength, fineness and colour for its decency in producing different types of yarns and its behaviour in the manufacturing process [1]. In our country, mainly two varieties of jute, namely *Corchorus olitorius* L. known as Tossa jute and *C. capsularis* L. known as White jute are grown abundantly. The character causes a lot of difference between two varieties of jute because Tossa jute mainly grows in high land areas and White jute grows in low land areas [2].

Quality of jute fibre depends on climates, soil and cultivating process. The soil, weather, cultivating process, water availability, retting system and drying system of all research stations of BJRI are not similar. At present white jute is not cultivated abundantly like Tossa jute due to various reasons and it is not always available in the market. Yet, it is a prominent variety that grows in some regions and has great demand after Tossa jute. Both the varieties i.e. tossa and white are classified into six grades by the graders according to the customers demand [3]. Appraisement of quality jute goods is an important cause for their commercial purposes. The accurate appraisement of fibre quality is thus important to avoid confusion in commercial and to manufacture right type of product of effective cost [4].

However, some physical and mechanical properties such as, bundle strength, fineness, brightness, whiteness and linear density has given importance to characterize jute fibres. Among these properties, bundle strength and fineness have given more importance over others. In this work, two tossa varieties, such as, 0-9897 and 0-72 and two white varieties, such as, CVL-1 and BJC-2197 are selected for their quality map. Bundle strength is the most important mechanical properties to produce durable jute product. Many research articles have demonstrated the effect of fibres dimensions on processing and on ultimate fabric and garments properties. As a consequence of this, the price of fibres, particularly in the natural fibres, is highly correlated with one or more of their dimensional properties [5]. The mechanical properties of natural fibres such as jute, kenaf, ramie etc. are directly correlated with the morphological structures of these natural fibres [6].

In a fibre, the ratio of length to width or cross-sectional areas is expressed as fineness. Fibre fineness is one of the main criteria of jute fibre to produce fine and regular yarns. Only fine fibre can

produce fine yarns. Earlier jute was used for producing conventional jute products such as sacking, Carpet Backing Cloth (CBC) and hessian cloth. At present, diversified use of jute fibre has increased remarkably. Thus, jute fibre is being used in manufacturing fine yarn for making different types of light weight fabrics for its diversified uses. Natural fibres such as jute, kenaf, flax, sisal etc. are also used as reinforcing materials for making light weight composite materials [7]–[13]. To produce fine products, fine yarn is needed and to produce strong yarn, strong fibre is needed; whereas weak fibre cannot produce a strong yarn. Individual fibres must have enough strength to sustain normal mechanical strain in the further processing [14].

The study aims to compare different physical and mechanical properties such as, fibre strength, fineness and colour of four jute varieties with varying jute fibre growing areas at different locations of Bangladesh.

2. MATERIALS AND METHODS

A. Materials

Jute fibres of four varieties released by BJRI (both Tossa and White) were collected from different Regional and Sub Stations namely, Faridpur, Manikganj, Rangpur, Kishoreganj, Manirampur, Tarabo and Pakhimara.

B. Methods

The different quality parameters of jute fibres, such as, bundle strength, fineness, linear density (tex), whiteness (%), and brightness (%)are determined to standardize the quality of jute fibre. Samples have been tested in standard atmospheric conditions (21±2)ºC and (65±5)% relative humidity. The details of test methods are described below.

- ***Bundle Strength test***

Bundle Strength of fibresis determined by Pressley fibre Strength Tester using zero-gauge length. The flat bundle of approx. 6.35 mm (1/4 inch) width is held by a pair of clamps [15]. All protruding ends are then sheared off evenly and tension is applied to separate the clamps and to break the fibres thereby. The broken bundle is then weighed by a precision balance. The result of fibre bundle strength is calculated using the following Equation.

$$Bundle\ Strength\ (gm/tex) = \frac{Breaking\ load\ (lb) \times 5.36}{Bundle\ weight\ (mg)} \quad (1)$$

- ***Fineness Test***

Fineness is determined by BJTRA (British Jute Trade Research Association) fineness testing apparatus which operates on airflow method. On this apparatus, air is sucked through a cylindrical bundle of fibres of 7.62 cm long having 3.3 cm diameters. The resistance to airflow is indicated in a flow meter, which is calibrated in terms of fibre diameter in micron(1 micron = 10^{-3} mm). On switching the machine the position of the float is read indicates the diameter of the fibre in micron [16].

- ***Linear Density***

Linear density in tex is determined by cut-middle method. For this measurement 50 to 60 reeds are randomly taken from each sample. Then the sample is stapled at 36 cm. From the middle portion of the reeds, one hundred filaments are taken to cut the jute fibres. These filaments are cut at 10 cm lengths and weighed in a precision balance to determine their linear density in tex [17].

- ***Whiteness(color) and Brightness(lustre)***

Colour and lustre of the fibre is determined by Photo Voltmeter (Leukometer) of sensitivity 4×10^{-9} a^0 using green and blue filter, respectively. The Photo- Volt meter is used in conjunction with a search unit containing several filter like amber, green and blue [15]. The measurement is done with a comparative standard of Magnesium oxide (MgO) block of 100% reflectance.

3. RESULTS AND DISCUSSION

The physical and mechanical properties of two tossa varieties based on seven fibre growing areas are given in Table I. Similarly, the physical and mechanical properties of two white varieties based on seven fibre growing areas are given in Table II. From Table I, it is observed that bundle strength of O-9897 fibre ranges from 53.12 to 60.09 gm/tex. Fineness value varies from 34.2 to 39.6 µm where average value has appeared to be 37.76µm. Brightness(%) and whiteness(%) of all samples are found from 19.7% to 25.3% and 33.35% to 36.85%, respectively. Bundle strength of O-72 variety shows in the range of 50.17to 56.01gm/tex. Fineness value of O-72 is found to be 31.6 to 38.5 µm and average value has found 36.26 µm (Table I). The highest brightness(%)has attained as 25.57% by the sample of Faridpur and the lowest value 18.86% has obtained by sample of Tarabo. Whiteness (%) of the jute fibre collected from Manikgonj are attained 36.85% as the highest value and the sample of Manirampur has possessed the lowest value of 31.8% (Table I).The results showed a good agreement with Mollah [18] and Molla *et al*. [19].
From Table II, it is revealed that bundle strength of variety CVL-1ranges from 48.40 to 55.64 gm/tex. The average fibre strength value has appeared to be 51.94 gm/tex which is very close to the bundle strength value of the sample collected from Faridpur, Manikganj and Rangpur station. Brightness (%) and whiteness (%) of seven samples

varies from 19.4% to 23.67% and 34.96% to 37.83%, respectively. The highest value of brightness (23.67%) has attained by the sample of Kishoreganj and the lowest value (19.4 %) has obtained by the sample of Tarabo Sub-Station (Table II). It is also observed that the average value of bundle strength for BJC-2197 has found to be 50.33 gm/tex, which is very close to six samples except Pakhimara Sub-Station.

TABLE I: LOCATION EFFECT ON BUNDLE STRENGTH, FINENESS, LINEAR DENSITY, BRIGHTNESS AND WHITENESS OF TOSSA JUTE FIBRES

Tossa jute varieties	Source location (Regional and Sub Research stations of BJRI)	Bundle Strength (gm/tex)	Fineness (µm)	Brightness % (Lustre)	Whiteness % (Colour)	Linear density (tex)
O-9897	Faridpur	60.09	39.60	25.12	33.90	3.24
	Manikganj	59.44	39.10	22.37	36.85	2.98
	Rangpur	58.16	36.90	23.21	34.65	2.75
	Kishoreganj	56.44	37.00	23.68	34.50	2.46
	Tarabo	56.44	37.90	19.70	33.35	2.77
	Manirampur	54.83	34.20	25.30	34.50	2.36
	Phakhimara	53.12	39.61	22.04	33.83	2.69
Average		**56.93**	**37.76**	**23.06**	**34.51**	**2.75**
SD		2.487	1.954	1.94	1.131	0.298
CV%		4.369	5.173	8.41	3.278	10.84
O-72	Faridpur	55.32	38.40	25.57	33.56	2.78
	Manikganj	56.01	38.50	23.27	36.85	2.81
	Rangpur	53.98	35.90	21.96	32.76	2.69
	Kishoreganj	53.17	36.50	23.12	34.36	2.41
	Tarabo	52.26	36.80	18.86	32.27	2.07
	Manirampur	50.17	31.60	22.30	31.80	2.44
	Phakhimara	51.19	36.10	22.71	33.34	2.24
Average		**53.17**	**36.26**	**22.54**	**33.56**	**2.49**
SD		2.122	0.451	2.0006	1.679	0.281
CV%		3.99	1.29	8.87	5.003	11.29

Fineness value shows in the range of 33.0 to 36.3 µm and average value has found 34.8 µm. The highest brightness value (23.92%) is attained by the sample of Tarabo and the lowest value (20.82 %) is obtained by the sample of Pakhimara Sub-Station. Whiteness (36.7%) of the Manirampur Sub-Station is the highest and Whiteness (%) value for jute sample collected from Kishoreganj has possessed the lowest one (33.6%) (Table II). The results showed also a agreement with Mollah[18], Mollah [18] and Molla *et al*. [19]. Molla *et al*. [1] reported that the white jutewas grown in low land areas with better retting facilities are of better quality in respect of fibre strength. Better fibre quality has been recorded at Shariatpur than that of Faridpur. Mollah [20] reported that finer fibre was obtained from jute fibres grown at Faridpur and Jamalpur.A comparison among four jute varieties (both tossa and white jute fibres) for different properties is shown in Table III. It is mentionable that these test results are the average values of seven jute growing areas (i.e., research stations of BJRI) of Bangladesh for four jute varieties. Based on the test results of Table III, bundle strength, linear density, fineness and whiteness results for four jute varieties are illustrated in Figures 1 to 4, respectively.

From Table III, it is observed that O-9897 fibre has possessed the highest numeric values for bundle strength and whiteness (%) with compared to that of the corresponding values of O-72 (Fig. 1 and 4). However, linear density and fineness values of O-72 are appeared to be better than that of O-9897(Table III, Fig. 2-3). Fineness of a fibre plays a vital role for producing uniform fine yarn with minimum yarn breakage. Bundle strength of a jute fibre can be helpful to produce stronger yarn which is required to make heavy load bearing jute products. Between White jute varieties, CVL-1 has found stronger and finer than that of BJC-2197 (Table III, Fig. 1-2). However, brightness and whiteness (%) values of CVL-1 has also been possessed slightly higher than that of BJC-2197 (Table III, Fig. 4). Brightness and whiteness (%) are the aesthetic properties which are given importance for producing nice looking product. So, consumers would be able to select right type of fibre according to their needs.

In general, it is observed that bundle strength of tossa jute fibres (both the varieties, i.e., O-9897 and O-72) are found to be better than that of white jute fibre varieties. However, linear density (tex) as well as fineness or fibre diameter (in micron) values of tossa jute varieties are also higher in comparison with that of white jute fibre varieties. On the other hand, whiteness value of white jute varieties (both the varieties, i.e., CVL 1 and BJC-2197) are higher than that of tossa jute varieties which is because of their inherent whitish colour of white jute fibres. Therefore, it may be concluded that tossa jute fibre is more suitable for producing jute products having

more strength and more durable whereas, white jute fibre is suitable for finer jute products where less strength and lower longevity is primary requirements.

TABLE II: LOCATION EFFECT ON BUNDLE STRENGTH, FINENESS, LINEAR DENSITY, BRIGHTNESS AND WHITENESS OF WHITE JUTE FIBRES

Tossa jute varieties	Source location (Regional and Sub Research stations of BJRI)	Bundle Strength (gm/tex)	Fineness (µm)	Brightness % (Lustre)	Whiteness % (Colour)	Linear density (tex)
CVL-1	Faridpur	52.64	35.00	23.35	35.97	2.32
	Manikganj	52.79	33.60	20.09	36.71	2.15
	Rangpur	51.78	35.30	22.91	35.80	2.36
	Kishoreganj	55.64	35.90	23.67	35.73	2.52
	Tarabo	50.22	33.80	19.40	35.92	2.36
	Manirampur	52.26	32.74	22.45	34.96	2.03
	Phakhimara	48.40	35.10	20.25	37.83	2.05
Average		**51.94**	**34.49**	**21.73**	**36.13**	**2.26**
SD		2.257	1.125	1.761	0.907	0.183
CV%		4.345	3.26	8.1	2.51	7.15
BJC-2197	Faridpur	52.26	35.10	23.68	35.29	2.53
	Manikganj	50.44	33.50	19.38	35.16	2.11
	Rangpur	51.56	36.30	22.03	35.10	2.08
	Kishoreganj	50.22	33.00	21.14	33.60	2.01
	Tarabo	50.12	35.60	23.92	34.30	2.71
	Manirampur	49.74	35.10	22.17	36.70	2.41
	Phakhimara	47.92	35.00	20.82	36.50	2.55
Average		**50.33**	**34.80**	**21.88**	**35.24**	**2.34**
SD		1.383	1.157	1.603	1.105	0.274
CV%		2.75	3.32	7.33	3.14	11.71

TABLE III: COMPARISON AMONG THE JUTE VARIETIES (VARIETAL EFFECT) FOR DIFFERENT PROPERTIES OF THE TOSSA AND WHITE JUTE FIBRES

Samples ID	Bundle strength (gm/tex)	Linear density (tex)	Fineness (micron)	Whiteness (%)
O-9897	56.93±2.49	2.75±0.29	37.76±1.95	34.51±1.13
O-72	53.17±2.12	2.49±0.28	36.26±0.45	33.56±1.67
CVL-1	51.94±2.26	2.26±0.18	34.49±1.12	36.13±0.90
BJC-2197	50.33±1.38	2.34±0.27	34.80±1.15	35.24±1.10

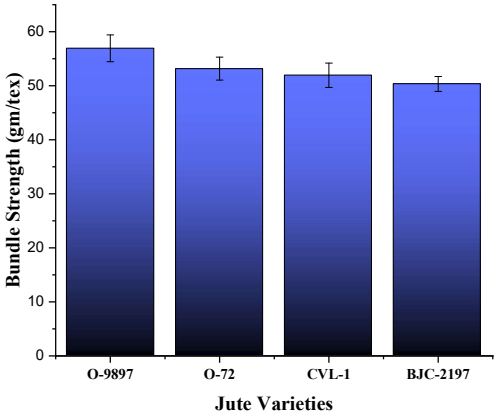

Figure 1: Bundle strength of jute varieties (both tossa and white jute)

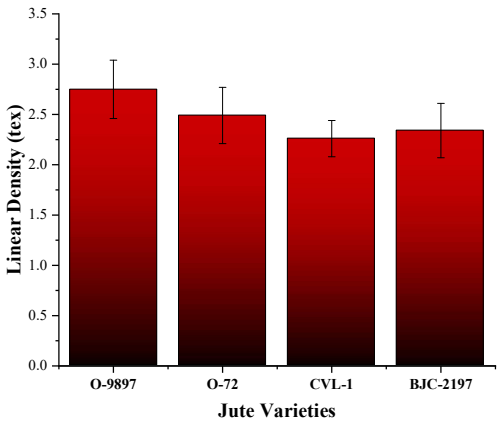

Figure 2: Linear density of jute varieties (both tossa and white jute)

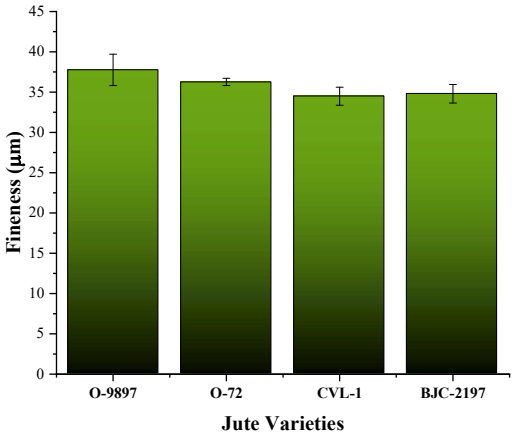

Figure 3: Fineness of jute varieties (both tossa and white jute)

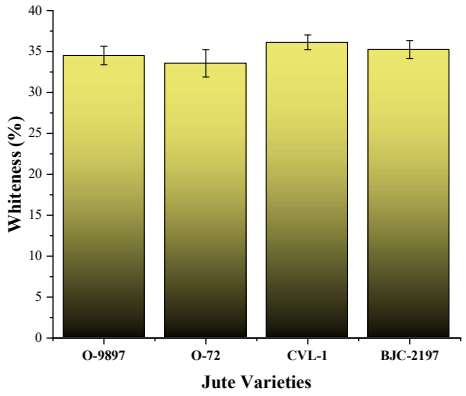

Figure 4: Whitenessof jute varieties (both tossa and white jute)

4. CONCLUSION

The fibre quality of Tossa jute varieties (O-9897 and O-72) and White varieties (CVL-1 and BJC-2197) are evaluated for jute fibres grown at different research stations of Bangladesh Jute Research Institute (BJRI). In case of tossa jute fibres, both are found almost same quality in respect of their obtained fibre characteristics. However, the jute fibre of O-9897 is found somewhat better than that of O-72 variety. Fineness and linear density values of O-72 variety are appeared to be better than that of O-9897. Similarly, fibre samples of two white jute varieties, CVL-1 and BJC-2197 shows almost similar values for three quality parameters except whiteness. However, it may be concluded that tossa jute fibres of O-9897 variety and white jute fibres of CVL-1 variety shows better properties for manufacturing better jute products based on their end use. This quality chart can play a vital role for the jute producers and consumers.

ACKNOWLEDGEMENT

The authors are thankful to the staff of Testing and Standardization Department, Textile Physics Division, BJRI for conducting the physical and mechanical properties of jute fibres of different varieties released by BJRI.

ORCID
M. M. Alamgir Sayeed http://orcid.org/0000-0001-7746-0329

REFERENCES

[1] A. K. Mollah, M.A.M., Shahidulla, M., Anwar, M.M., Sayeed, M.M.A. and Mollah, "A Comparative Study on Fibre strength with jute grown in diffferent areas of Bangladesh," *Bangladesh J. Jute Fibre Res.*, vol. 28, no. 1, pp. 57–64, 2008.

[2] M. Mahbubul Islam, "Varietal Advances of Jute, Kenaf and Mesta Crops in Bangladesh: A Review," *Int. J. Bioorganic Chem.*, vol. 4, no. 1, p. 24, 2019.

[3] G. M. Saha, N.G., Rahman, M., Samad, M.A., Aziz Mia, M.A., Islam, A., Taher Baksh and Talukder, "Importance of luster and strength of jute fibre in grading," *Bangladesh J. Jute Fibre Res.*, vol. 19, no. 1, pp. 59–64, 1994.

[4] M. Karim, K.M.A. and Kabir, "Quality assessment of raw jute in relation to its colour," *Bangladesh J. Jute Fibre Res.*, vol. 2, no. 1, pp. 14–18, 1977.

[5] S. L. Anderson, "THE MEASUREMENT OF FIBRE FINENESS AND LENGTH: THE PRESENT POSITION," *J. Text. Inst.*, vol. 67, no. 5, pp. 175–180, May 1976.

[6] M. E. Alves Fidelis, T. V. C. Pereira, O. da F. M. Gomes, F. de Andrade Silva, and R. D. Toledo Filho, "The effect of fiber morphology on the tensile strength of natural fibers," *J. Mater. Res. Technol.*, vol. 2, no. 2, pp. 149–157, 2013.

[7] P. Wambua, J. Ivens, and I. Verpoest, "Natural fibres: can they replace glass in fibre reinforced plastics?," *Compos. Sci. Technol.*, vol. 63, no. 9, pp. 1259–1264, 2003.

[8] N. Defoirdt *et al.*, "Assessment of the tensile properties of coir, bamboo and jute fibre," *Compos. Part A-applied Sci. Manuf.*, vol. 41, pp. 588–595, 2010.

[9] G. Rajesh and A. V. R. Prasad, "Effect of Fibre Loading and Successive Alkali Treatments on Tensile Properties of Short Jute Fibre Reinforced Polypropylene Composites," *Int. J. Adv. Mater. Manuf. Charact.*, vol. 3, no. 3, pp. 528–532, 2013.

[10] H. Bisaria, M. K. Gupta, P. Shandilya, and R. Srivastava, "Effect of Fibre Length on Mechanical Properties of Randomly Oriented Short Jute Fibre Reinforced Epoxy Composite," *Mater. Today Proc.*, vol. 2, pp. 1193–1199, 2015.

[11] M. M. A. Sayeed and A. Paharia, "Optimisation of

the surface treatment of jute fibres for natural fibre reinforced polymer composites using Weibull analysis," *J. Text. Inst.*, vol. 110, no. 11, pp. 1588–1595, Nov. 2019.

[12] Asumani, Oscar, and RatnamPaskaramoorthy. "Fatigue and impact strengths of kenaffibre reinforced polypropylene composites: effects of fibre treatments." *Adv. Compo. Mater.,* vol. 30, no. 2, pp. 1-13, 2020.

[13]Senthilkumar, K., Saba, N., Rajini, N., Chandrasekar, M., Jawaid, M., Siengchin, S., &Alotman, O. Y. "Mechanical properties evaluation of sisal fibre reinforced polymer composites: a review" *Construct. and Build. Mater.*, vol. 174, pp. 713-729, 2018.

[14] J. Wilson, "1 - Fibres, yarns and fabrics: fundamental principles for the textile designer," in *Woodhead Publishing Series in Textiles*, A. Briggs-Goode and K. B. T.-T. D. Townsend, Eds. Woodhead Publishing, 2011, pp. 3–30.

[15] J. E. Booth, *Principles of textile testing: an introduction to physical methods of testing textile fibres, yarns and fabrics [by] J. E. Booth*. London: Heywood Books, 1968.

OL FIBRE FINENESS," *J. Text. Inst. Proc.*, vol. 45, no. 7, pp. P312–P316, Jul. 1954.

[17] W. J. Lyons, *Impact Phenomena in Textiles (Research Monograph)*, 1st Edition. The MIT Press, 1963.

[18] M. A. . Mollah, M.A.M., Asaduzzaman, M. Shahidulla, M., Mollah, A.K. and Khan, "Quality assement of Tossa jute of Bangladesh in relation to fibre fineness," *J. Innov. Dev. Strateg.*, vol. 4, no. 1, pp. 22–26, 2010.

[19] A. K. and Z. Mollah, M.A.M., Shahidulla, M., Anwar, M.M., Sayeed, M.M.A., Mollah, "Quality assessment of tossa jute fibre grown in different districts of Bangladesh," *J. Primeasia Univ.*, vol. 1, no. 1, pp. 53–58, 2011.

[20] M. K. Mollah, M.A.M., Mollah, A.K., Khan, M.A.M., Shahinur, S. and Alam, "Fibre fineness of White jute of different districts of Bangladesh: An important Physico-Mechanical property for fine yarn manufacturing," *J. Innov. Dev. Strateg.*, vol. 9, no. 1, pp. 09–12, 2015.

