Extraction of fibre from paddy straw

Rajdeep Kaur*, Sandeep Bains** and Manisha Sethi***
Assistant Scientist*, Head cum Professor** and Research Fellow***
Department of Apparel and Textile Science
PAU, Ludhiana
(Email – **msrajdeepct@pau.edu**)

In present study, paddy straw was identified for fibre extraction. This fibre being a structural fibre is endogenous in nature, so it is weak and brittle as compared to bast fibres. The fibers were extracted manually by retting and treated with three concentrations of urea. The microscopic structural changes were examined by SEM under controlled conditions. When compared with control, it was observed that both surface area and pore size of treated straw increased partially due to solubilization of silica components. The untreated paddy straw exhibited a rigid and highly compact structure, whereas, treated sample showed opening of the holo-cellulose fibrils due to creation of pores of different sizes. Micro fibrils got separated from initial connected structure and were fully exposed, thus increasing the external surface area and porosity. Results showed that fibre weight decreased with the urea treatment. Chemical composition results exhibits that cellulose content increased with the increase in urea concentration on the fibre, while it decreased in case of hemi cellulose. There was a visible fall in lignin content. The content of fats and waxes was 1.0 for control condition, which increased to 3.5 when the straw was treated with both 4% and 6% urea concentration. With a worldwide annual availability of 580 million tons, rice straw is an annually renewable, abundant, and cheap source for natural fibers. Using paddy straw for high-value fibrous applications will help to add value to the rice crops, provide a sustainable resource for fibers, and also benefit the environment. Paddy straw an untouched structural minor fibre also has potential to be used in textile industry by blending with other waste fibres, making composites, biomass-based power plants; cardboard units paper industry.

Keywords: Extraction, Fibre, Paddy, Retting, Urea

Natural fibers are getting attention from researchers and academicians to utilize the polymer composites due to their eco-friendly nature and sustainability. So, the focus is on the development of biodegradable material, i.e., natural fiber in the composite fabrication which has vast advantages like being more innocuous, recyclable and cheap. Substantial amount of textiles is now used in homes to make life more comfortable. Textiles are also widely used in many industrial and technical textiles. In contrast to conventional materials, cellulose-based fibers are used in bio-composites, automobile industries, because of its advantages such as low cost, low density, acceptable specific strength and good thermal properties (Gupta 2014; Harish *et al*. 2009). Maturity of the plant and process implemented for its extraction determines its mechanical properties (Mohanty, Misra, and Drzal 2001).

Paddy is one of the oldest cultivated crop and ranks as the most widely grown food crop that serves as the staple food for more than 60% of Indian population. This crop leaves several million tons of straw annually. Paddy straw, which is a by-product of rice production, is natural and sustainable resource that could be used to produce fiber. It is available worldwide in large amounts. Commonly, paddy straw is used either as a livestock feed, burned at the field, or incorporated into the soil. Each of these paddy straw utilization methods presents challenges (Blank, S *et al* 1993). Although burning paddy straw on site is the cheapest method of its disposal, this method raises environmental concerns as burning paddy straw releases carbon dioxide. This is why some states have banned the burning of paddy fields and thus rice farmers face challenges in rice straw disposal. Using rice straw as a livestock feed is not a favourable option because of its poor quality. Incorporating rice straw in soil can be costly and can pose other challenges to rice farmers. Using rice straw to produce natural fibers for other applications can benefit both the rice industry as well as the farmers. Paddy straw an untouched structural minor fibre also has potential to be used in textile industry for making house hold and decorative articles. Apart from the use of paddy straw for fodder it can be alternatively used in blending with other waste fibres, making composites, household decorative articles, biomass-based power plants, cardboard units paper industry, etc. The selected paddy straw management techniques will help the farmers in increasing their socio-economic profile. Thus, the use of paddy straw in other practices will contribute to the management ways of paddy straw.

With a worldwide annual availability of 580 million tons, rice straw is an annually renewable, abundant, and cheap source for natural cellulose fibers. Using rice straw for high-value fibrous applications will help to add value to the rice crops, provide a sustainable resource for fibers, and also benefit the environment. In this investigation, extraction of fibre from paddy straw was done. The study also reports about the mechanical properties and morphology characterizations of the Paddy straw fibre and introduce them as novel natural fibre for various uses in textiles.

METHODOLOGY

Paddy straw was identified for fibre extraction. The straw was procured in the month of November from the fields of Punjab Agricultural University, Ludhiana, Punjab. Paddy stalks were taken out from the procured straw. The paddy stalks were separated out manually from the whole straw to remove the dust and unwanted waste.

Paddy straw was extracted by chemical retting using three concentrations of urea. Retting helps in better separation and extraction of fibre from non fibrous tissues and stem through dissolution and decomposition of cellulose, hemi-cellulose, pectin, gums and silica. Kozlowski *et al*, 2006, mentioned that addition of urea accelerates the process of retting of mesta for 40-50 hours, as compared to 70 to 100 hrs without using urea. Urea is an organic compound that is highly soluble in water and non-toxic. It is the common fertilizer used for most of the agricultural crops, since it aids the growth of bacteria in soil and water. Therefore, urea can be safely used for enhancing the retting process and provides a source of crude protein which straw is deficient in (Singh and Schiere, 1995).

A) **Mechanical retting/ extraction method**: The retting was done in the laboratory under controlled conditions at room temperature. It was done for 40 days. The water was changed weekly to avoid bacterial growth and secondly to avoid discolouration of paddy stalks.

B) **Scutching and cleaning of fibres:** The retted stalks were removed from water and washed thoroughly under tap water. The fibre was extracted manually.

RESULT AND DISCUSSION

Assessment of fibre parameters

The paddy fibre was analysed for chemical composition, which included, cellulose, hemi-cellulose, lignin, fat and waxes and ash. It can be elicited from the table 1, that the cellulose content increased, with the increase in urea concentration on the fibre, while it decreased in case of hemi cellulose. There was a visible fall in lignin content. The content of fats and waxes was 1.0 in control condition, which increased to 3.5 when the straw was treated with both 4% and 6% urea concentration. It has been reported by Nasrabadi B N *et al* 2014 that with treatment of NaOH, there is removal of amorphous regions (Lignin, hemicellulose, pectin, etc.) from the fibres during the chemical purification. Similar effect has also been observed after urea treatment on paddy fibre.

Table 1: Chemical composition of the extracted paddy fibres

Treatment	Composition				
	Cellulose	Hemi-cellulose	Lignin	Fat and waxes	Ash
Control	37	33	31.2	1.0	11.15
T1	45	28	16.8	3.3	11.00
T2	47	27	15.0	3.5	10.95
T3	47	26	15.0	3.5	10.85

(T1, T2 and T3 the three different concentrations of urea)

SEM Analysis

The change in surface structures of treated paddy fibre was observed by Scanning Electron Microscopy (SEM). SEM of untreated (control) and treated paddy fibre was done in Nano and Electron Microscopy Laboratory at Punjab Agricultural University, Ludhiana.

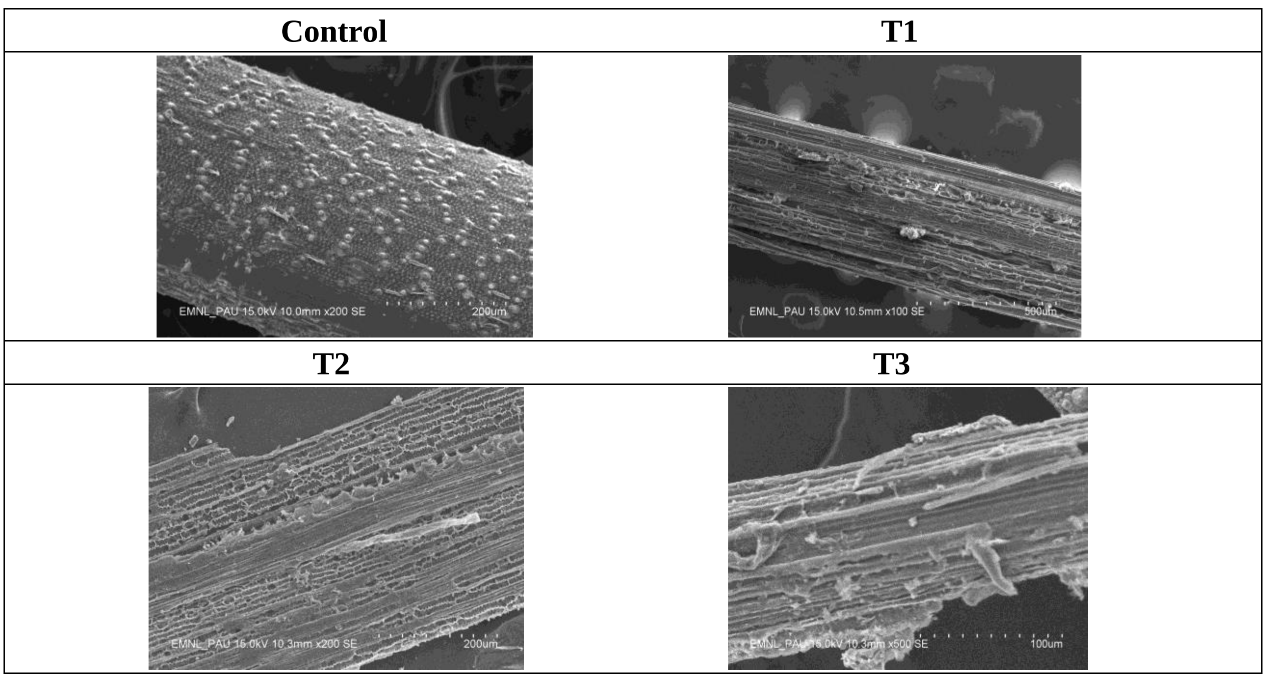

Plate 1: Scanning Electron Microscopy of paddy fibre

For SEM analysis, the paddy fibre was dried in oven at 60^0 C for 24 h. The samples were wedged with carbon glue for inspection, and were observed using SEM at 9-11 mm and 15 K magnification. The SEM analysis was conducted for control and all the three concentrations of urea. The present study reports the treatment of paddy fibre by using urea concentrations to observe the changes in chemical composition, change of surface structure and porosity of paddy fibre. The microscopic structural changes were examined by scanning electron microscopy under control conditions. Both surface area and pore size of treated fibre increased partially due to solubilization of silica components.

Because a large fraction of cellulose, hemicelluloses and lignin was removed by treatment with urea, it led to structural changes in the straw. SEM pictures of untreated and treated paddy fibre with urea justify the loss of chemical compounds. Plate 1 shows the longitudinal view of paddy fibre before and after urea treatment. The distinct changes in surface structure are visible in the basic tissue of paddy fibre. The untreated paddy fibre exhibited a rigid and highly compact structure, whereas, treated sample showed opening of the holo-cellulose fibrils due to creation of pores of different sizes. Micro-fibrils were separated from initial connected structure and are fully exposed, thus increasing the external surface area and porosity of paddy fibre. Similar results were also reported by Zhang and Cai (2008) who observed changes in histological structures of rice straw after 2% NaOH treatment. Xu *et al* (2007) reported the changed structure and surface area of the pretreated straw by SEM that is in the favour of enzymatic hydrolysis. Silica nodules were also observed in untreated straw (Plate 1). Kuhad and Johri (1992) too reported that the fermented straw showed strikingly prominent silica nodules attached to rib like structures.

CONCLUSION

In this research, paddy fibre has been exposed to urea treatment, which has increased the removal of amorphous regions of fibre. As a result, the soft and pliable fibre can be used for other potential, unexplored end uses. Lignocellulosic agricultural by-products are a copious and cheap source for cellulose fibers. Agro-based fibers have the composition, properties and structure that make them suitable for uses such as composite, textile, pulp and paper manufacture. Due to eco-friendly and sustainability nature, natural fiber products are preferred as compared to synthetic fibre products.

REFERENCES

1. Kuhad RC, Johri BN (1992) Fungal decomposition of paddy straw: light and scanning electron microscopic study. *Indian J Microbiol*. 32:255–258.
2. Blank, S.; Jetter, K.; Wick, C.; Williams, J. (1993) With a ban on burning, incorporating rice straw into soil may become disposal option for growers. *Calif. Agric*., 47, 8–12.

3. Mohanty, A. K., M. Misra, and L. T. Drzal. (2001)Surface modifications of natural fibers and performance of the resulting biocomposites: An overview. *Composite Interfaces* 8 (5):313–43
4. Harish, S., D. P. Michael, A. Bensely, D. M. Lal, and A. Rajadurai (2009) Mechanical property evaluation of natural fiber coir composite. *Materials Characterization* 60 (1):44-49.
5. Singh, K., Schiere, J.B. (1995) Handbook for Straw Feeding Systems and Applications with Emphasis on Indian Livestock Production. Dept. Animal Production Systems, Agricultural University Wageningen, The Netherlands.
6. Kozlowski, R., Batog, J., Konczewicz, W., Talarczyk, M.M., Muzyczek, M., Sedelnik, N. and Tanska, B (2006) Enzymes in bast fibrous plant processing. *Biotechnol Lett*., 28:761-765.
7. Xu Z, Wang Q, Jiang Z, Yang X, Ji Y (2007) Enzymatic hydrolysis of pretreated soybean straw. *Biomass Bioenergy*. 31:162–167.
8. Zhang Q, Cai W (2008). Enzymatic hydrolysis of alkali pretreated rice straw by *Trichoderma reesei* ZM4-F3. *Biomass Bio-energy*. 32: 1130–1135. doi: 10.1016/j.biombioe.
9. Nasrabadi B N, Behzad T and Bagheri R (2014) Extraction and characterization of rice straw cellulose nano fibers by an optimized chemo-mechanical method. *Journal of applied polymer science*.wileyonlinelibrary.com/app, Pp1-7
10. Thakur, V. K., M. K. Thakur, and R. K. Gupta (2014) Review: Raw natural fiber-based polymer composites. *International Journal of Polymer Analysis and Characterization* 19 (3):256–71.