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Conference Paper

Development of Sustainable Technology to Produce Jute-Ramie Blended Textile and Its Applications

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Ramie (*Boehmeria nivea*), commonly known as China grass, is the strongest and finest plant fibre which is considered one of the valuable textile entities. Despite its unique characteristics, ramie has received reasonably less importance specially in the Indian subcontinent due to unavailability of appropriate postharvesting and processing technologies. With increase in global environmental awareness, the alternative (to cotton) cellulosic natural fibre "ramie" is gaining importance in the international textile domain. Sustainable methods and technologies which could trigger the utilization of ramie fibre are in demand worldwide. This paper will describe the developments carried out in the areas of postharvesting and spinning process of ramie. An ecofriendly degumming technology of ramie fibre has been elaborated along with suitable fibre processing route of ramie-jute blends that will bring new avenue for manufacturing jute diversified market acceptable products.

1. Introduction

The raw ramie fibre is extracted by decortication of long fibre strands or ribbons, where gummy matter is encrusted around the ultimate fibre. Decorticated ramie fibre contains 25–30% of noncellulosic gummy matter (pectic colloidal substances, i.e., gum) [1] consisting of pectins, waxes, lignin, and hemicellulose. Postharvesting technology particularly "degumming" is the most crucial aspect for successful processing of ramie fibre due to presence of gum which needs to be removed to the highest possible extent (degumming) without compromising fibre properties and performance [2]. The existing degumming technologies [3] commonly practiced in the Indian subcontinent region encounter multifold limitations including biohazard and processing difficulties. As a sustainable alternative, a user friendly degumming technology has been developed recently exploring biotechnological (enzymatic) method. A cocktail of enzymes has been judiciously formulated with market available varieties, namely, hemicellulase, pectinase and pectate lyase, and so forth, and applied on freshly decorticated ramie to get a fibre that could be transformed into valuable blended textiles.

Degummed ramie fibre is suitable for textile applications since its properties have close coherence with the aesthetics of the apparel textiles [4]. However, available varieties of ramie fibre in India are difficult to process in both "long-staple" and "short-staple" spinning systems for producing finer yarns [5–7]; as a result ramie has been losing its worth in Indian textile scenario. A wide range of fibres have been tried for blending with ramie among them jute; a lingocellulosic plant fibre abundantly produced in the Indian subcontinent region, is an important one [8]. Both the fibres inherently have some similarities in their chemical constituents and physical properties [9]. These attributes are encouraging enough to get uniform fibre blend that might actuate the smooth fibre processing as well. In the current study, ramie fibre has been efficiently blended with Jute in different blend proportions (ramie : jute—100 : 0; and 50 : 50; 20 : 80) to produce jute-ramie blended fine yarns of count range from 75 tex to 45 tex, something difficult to produce with pure

jute fibre in commercial scale [10]. Innovative processing and spinning route (combination of semiworsted and jute spinning machines) have been explored to manufacture jute-ramie blended fine yarns without much alteration in existing industrial jute spinning setup.

The jute-ramie blended fabrics are superior in quality, having the potentiality to be utilized as value added home textiles.

2. Experimental Methods

2.1. Enzymatic Degumming of Ramie. To compensate the limitations of conventional "chemical degumming" [11] technology, which represents high energy consumption and heavy release of caustic residue in effluents, an enzymatic degumming route of ramie fibre has been explored. To avoid the processing difficulties, the common method of enzyme extraction from bacterial stains has been evaded. Purified grade of substrate specific enzymes has been mixed in a fitting ratio to develop a degumming formulation. The formulation has been tried on freshly decorticated ramie to get fibres that could be processed subsequently.

Ramie requires a multifunctional enzyme system to liquefy its complex gummy matters represented majorly by hemicellulose, pectin and lignin. The formulation comprising of synergistic mixture of organic enzymes has been used for the required degumming action. Major components of the enzyme formulation are hemicellulase (xylanase, arabinase) and pectinase (pectate lyase, polygalacturonase); those are supplied by Novozymes A/S, Denmark, in purified form. Activities of enzyme formulation on the substrate have been ensured by repeated enzyme assay. The enzyme formulation has shown optimum activity in 5.0 to 5.7 pH range; to achieve such pH profile Citrate Buffer (pH 3.0–6.2) has been selected as degumming bath media.

2.1.1. Degumming Process. The bundle of freshly decorticated raw ramie fibre having 70–75% moisture has been briefly opened up by manual hackling action with combs. After that prewashing treatment has been given to the decorticated fibre with ecoemulsifier to an extent of 0.1-0.2% on the weight of fibre. Citrate Buffer solution is prepared (pH—5.5–5.7) next to prewashing process for preparation of degumming bath (MLR-1 : 5). Subsequently, the enzyme formulation, as per optimized quantity, is added to the bath (1.0% enzyme on wt. of the fibre) along with gentle stirring action. Fibre bunch is then dipped into the degumming bath and kept in the incubation system for 24 Hrs.

2.1.2. Fibre Characterization. The efficiency of the degumming process is evaluated by the estimation of residual gum content (repeated acid and alkali extraction method) remaining in degummed fibre. Fibre tensile strength (IS 7032, Part-7) and fibre fineness (IS 7032, Part-8) are measured for both raw and degummed fibres for comparative analysis. Surface characteristics of the fibres have been observed under scanning electron microscopy (SEM).

Table 1: Characterization of degummed.

Enzyme activity (Units/mL)			
Pectinase	Jute hemicellulase	Endo, β-1-4-glucanase	Exo, β-1-4-glucanase
23000	560	360	20

Table 2: Characterization of degummed ramie fibres.

Test parameters	Raw ramie	Degummed ramie
Residual gum %	25.00	6.06
Fibre fineness (tex)	1.50	0.76
Single fibre tenacity (g/tex)	30.58	28.61
Bulk density (g/cc)	0.27	0.37

2.2. Customized Processing System for Ramie Blends. Ramie, being longer and finer natural fibre, is difficult to process and spin yarn utilizing commonly available spinning systems. Both short-staple spinning system, namely, cotton spinning and long-staple spinning process, namely, worsted spinning system have been explored for spinning of ramie yarns, although economic viability of such industrial process is difficult to attain. In search of a suitable alternative method to spin ramie blended yarns, a processing sequence has been customized which is basically a combination of jute and semiworsted spinning machinery.

Mainly four varieties of yarns, namely, 100% ramie, 50 : 50 jute-ramie, 80 : 20 jute-ramie blended, and 100% jute yarns have been developed under identical processing conditions.

2.2.1. Customized Spinning System. See Figure 2.

2.2.2. Characterization of Yarn. The quality characteristics of four varieties of ramie and jute-ramie blended yarns have been evaluated and compared with jute yarns. Tensile properties and yarn evenness properties have been evaluated in INSTRON (5500-R) and UT3 instruments.

3. Results and Conclusions

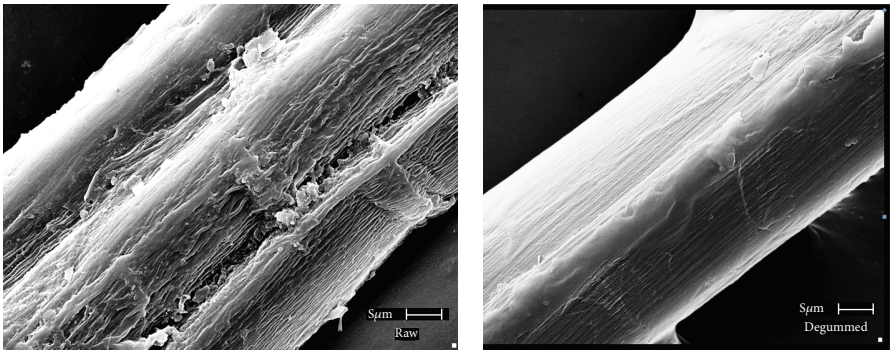
Before performing fibre degumming process, the activities of component enzymes in the formulation have been evaluated to ascertain the conjugal strength of the developed degumming formulation. It is observed (Table 1) that activity of pectinase is considerably high, and hemicellulase activity level is found to be within the desired mark.

The enzyme-based degumming formulation effectively acted on gummy substances and removed almost 75% of the inherent gum in ramie. The SEM of degummed fibre (see Figure 1 and Table 2) represents a regular and smooth surface as compared to raw fibre because of the removal of gummy matters from the fibre's outer periphery. As shown in Table 1 the fineness of ramie fibre has improved considerably without much compromise in tensile properties.

Quality parameters of developed yarns are compared with 100% ramie and 100% jute yarns, produced using identical process conditions. Gradual improvement in yarn quality

Table 3: Comparative analysis of yarn quality.

Yarn parameters	100% Ramie	50% Ramie 50% jute	20% Ramie 80% jute	100% Jute
Average yarn count (tex)	40.65	53.74	75.80	77.86
Wt. CV%	6.34	6.53	4.51	6.42
Yarn tenacity (g/tex)	13.81	9.27	7.63	7.48
Hairiness index	11.73	15.28	17.48	18.88



(a) (b)

Figure 1: SEM of raw and degummed ramie.

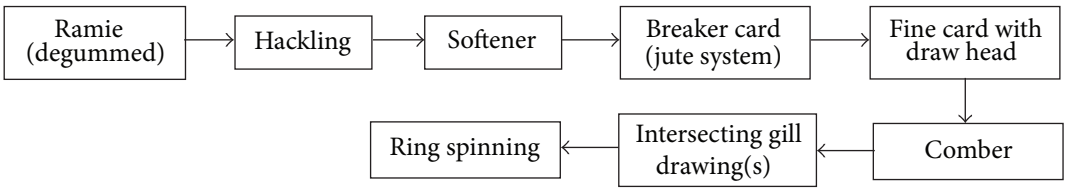


Figure 2

has been observed (Table 3) as the proportion of ramie is increased in the blends.

4. Conclusion

New sustainable approach for postharvesting processing and spinning of ramie fibre has been developed in this R&D study. The prescribed fibre degumming technology is biofriendly and the produced fibres possess adequate strength required for sustain subsequent fibre processing. The residual gum content and fineness confirm the suitability of degummed fibre in textile applications. The customized spinning line is effective for blending ramie with jute and other compatible fibres. The jute-ramie blended yarns are superior in quality and appearance and are quite suitable for development of home textiles that might add value to jute-based diversified product market.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper. Debkumar Biswas does not have a direct financial relation that might lead to a conflict of interests to any of the authors.

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