DEVELOPMENT OF TECHNOLOGY FOR MANUFACTURE OF RAMIE BASED PRODUCTS

FINAL PROJECT REPORT

Jute Technology Mission
(Mini Mission – IV, DDS 7.1/2)
Project No. 19

(Sponsored by the National Jute Board)
MINISTRY OF TEXTILES, GOVERNMENT OF INDIA





Implemented by:

Indian Jute Industries' Research Association
17, Taratala Road, Kolkata - 700 088

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Project Completion Report

SUBMITTED BY:

INDIAN JUTE INDUSTRIES' RESEARCH ASSOCIATION

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1.0 Executive Summary

Ramie (*Boehmeria nivea*), a bast fibre commonly known as China grass, is one of the oldest natural fibre having distinctive textile properties like high tenacity, enhanced strength on wetting, lusture, microbial resistivity and eco-friendliness. However, despite its valuable characteristics, ramie has received comparatively less importance in the world textile scenario. In India, ramie fibre still finds its usage at domestic level and could not capture the textile market in industrial scale due to unavailability of appropriate post harvesting and processing technologies. With the advent of the global environmental awareness among the people, the natural fibre ramie is finding its worth in diverse textile applications opening a great scope for our country to rejuvenate the ramie cultivation, production and related textile business. Since, North Eastern Region (NER) of India is blessed with the favourable environmental conditions for cultivation of ramie; the needs of R&D interventions for development of appropriate fibre processing technologies have been felt. The project has been focused to explore the possibilities of commercial level production of ramie based textiles as well as improvement of socio economic status of large farming community associated with ramie cultivation in NE Region.

The objectives of this R&D study are to develop suitable techno-economically viable eco route for ramie degumming and mechanical processing of ramie in blends with jute to produce fine yarns for subsequent production of jute-ramie blended Diversified Products for Home Textile applications; most of which have been addressed.

To asses the status of cultivation, production, industrial exploration and market potentiality of ramie and jute-ramie based products in India, a comprehensive market survey and field survey has been carried out. The survey report includes an overview of production of ramie fibre, the critical gaps that hinder popularization of this valuable fibre in India and its future scope in domestic textile market. The major lacunae that have been identified are; firstly absence of the appropriate fibre degumming technology and secondly the lack of appropriate technology for commercial exploitation of ramie fibre.

Degumming of ramie is a crucial issue that has been addressed first for satisfactory mechanical processing of ramie fibre in subsequent stages. In consequence, IJIRA has developed an enzyme based environment friendly degumming technology that is user friendly and practicable at farmers' field level. Synergistic action of mixture of enzymes viz. Hemi-cellulase, Pectinase & Pectate Lyase on freshly decorticated ramie substantially removes its non-fibrous gum content.

Optimization of the degumming process parameters (e.g. enzyme application %, incubation time, temperature etc.) have initially been carried out at laboratory scale within IJIRA and subsequently the technology has been examined and validated through field trials, carried out at NE Region in

collaboration with Ramie Research Station (RRS), Sorbhog, Assam, substation of CRIJAF (ICAR), Kolkata. Effects of degumming on various fibre properties (e.g. tensile strength, fibre fineness, rigidity, residual gum content etc.) have been examined during characterization of degummed fibre.

Ramie is considered as a difficult fibre to process in both 'Long Staple' and 'Short Staple' spinning systems to produce finer yarns. The situation is more challenging while blending with jute & ramie. In the course of R&D activities, appropriate processing technology for 100% ramie & jute-ramie blends (80:20 & 50:50) have been identified to spin fine yarns (<2lb/spy or 70 tex) using a combination of Semi-worsted and Jute spinning machines. Mechanical processing, spinning and fabric manufacturing trials have been fruitfully conducted in two mills (Unit-Wellington Jute Mill, Rishra & Anglo India Jute Mill, Jagatdal) of AI Champdany Industries Ltd. where different types of fabric samples have been developed from 100% ramie and jute-ramie blended yarns for their home textiles and other diversified applications.

Opportunity of ramie fibre in small scale industry/decentralized sector has also been examined. In collaboration with a small scale entrepreneur, innovative products especially home furnishing products have been developed by exploring conventional indigenous technology at domestic level. As a preliminary endeavor, an iconic profit model has been developed to show case the profit lying underneath.

In nut shell, under Jute Technology Mission project No. 19 (DDS 7.1/2) the critical technological gaps related to ramie fibre degumming process and spinning have been addressed. Jute over the years has emerged as a potential contender for being utilized in areas of value added home textiles. This study has enlightened the prospect of manufacturing jute-ramie blended value added home textile products and ensured the availability of technology for manufacturing the same. In conclusion, a vital step has been under taken towards popularizing ramie in India by encouraging technology development and promotion of products that will certainly help in improving the socio-economical conditions of the shrinking ramie farming community of NE Region.

2.0 Preamble

In India ramie is cultivated in small scale in Assam, North Eastern States and Northern part of West Bengal where it is used locally for making ropes, twines and fishing nets. Diverse uses of ramie fibre including value added applications e.g. home furnishings, home textiles, technical textiles, apparels etc. are globally established whereas it has not been commercially exploited in India. In addition, ramie grower mostly located in North Eastern states ultimately do not get proper remunerative price of their produce, hence facing financial crisis and gradually shifting towards cultivation of other crops. Industrial utilization of ramie fibre is limited owing to the difficulties associated with the availability of degumming and spinning technology.

On the other hand jute, another natural fibre that share many similarities with ramie, is well known for its use in gunny bags as well as abundantly produced in India. The valuable properties of ramie could be effectively amalgamated for betterment of diversified jute product quality and their market acceptance. It is commercially difficult to spin jute yarns to a finer count (less than 4.5 lb/spy) in the existing processing practice. The favourable properties of ramie need to be utilized for upgradation of jute yarn by blending ramie with jute. The appropriate technology for blending of ramie with jute on jute spinning system and semi worsted spinning system is required to develop for enhancing economic values and acceptability of jute and ramie based products. Since, there is no separate processing and spinning technology for ramie fibre, the needs have been felt for identification of suitable process route to make ramie and jute-ramie blended diversified products.

3.0 Objectives

a) To develop low cost eco-degumming process technology (enzymatic degumming) for ramie fibre

b) To develop technology for spinning of fine count jute-ramie blended yarns on suitable spinning system.

c) To develop fabrics for different end use application like home furnishings, home textiles etc.

4.0 Literature Review

4.1 Introduction

Ramie, commonly known as China grass, is obtained from the bark of plant *Boehmeria nivea*. It is the strongest natural fibre in the world as well as one of the oldest fibres which had ancient historical evidences. Existence of ramie is even observed in mummy cloths at Egypt during the pre-historical age. Ramie is native to South-Eastern countries of Asia and China being the major producer of this fibre with a production of 0.15 million metric tonnes followed by Brazil and Philippines. Major global importers of ramie fibre are Japan, Germany, France and USA. Ramie fibre accounts for 0.8% of the total natural fibre in volume and 0.5% in value [1]

In North Eastern (NE) region of India specially in Assam, ramie is grown abundantly due its congenital climatic condition and is popularly known as "rhea". About 19 species of ramie have been reported so far from India [2] most of which are distributed in North Eastern India including Meghalaya, Assam, Arunachal Pradesh, Manipur and Sikkim. Some species are also found in Western Ghats, northern parts of West Bengal and Uttaranchal region of India.

4.2 Cultivation of Ramie in India

Varieties of ramie species are grown sporadically as wild plant in different parts of India, but its cultivation is restricted particularly, in the North - Eastern states, and to some extent in Kangra valley and Nilgiri hills. Presently ramie is cultivated in Assam, Arunachal Pradesh and other North Eastern States due to favourable edapho-climatic conditions for its cultivation. Even though the favourable agro-climatic conditions (moist tropical and organic matter rich well drained deep soils) of North Eastern region is regarded till date as most suitable but cultivation of ramie may also be expanded to other parts in southern and western India. Ramie could be grown in the North Nilgiri Hill region in Southern Parts of India as well as in Konkan region in the West, if proper management practices are adopted with sufficient irrigation facilities. Its cultivation may also be tried in Andaman & Nicobar Islands [3].

Despite the fact that the crop has got immense potentiality in the trade but its growth and development, has not expanded in India to a desired level. The limitations are: large initial investment for land, lack of infrastructural facilities for extraction of fibre (decorticatoin) and degumming, lack of organized marketing system and lack of awareness about the potentials of ramie fibre in textile industry. The marketing and its use are totally dependent on degumming at planters' / farmers' level. There is a great scope in its use in the textile industry in our country, if degummed adequately [4].

4.3 Plant and Fibre

The ramie plant is a hardy perennial belonging to the Urticaceae or Nettle family, harvested 4-5 times in a year. The green plant is grown to full length within 45 days and harvesting is done within a stipulated time period (45-50 days) to avoid over maturity of the fibre. In a plantation it can effectively survive for 6-8 years after which its growth declines and re-plantation becomes necessary. Each time depending upon the congenital climatic conditions, the plant produces a number of straight slender stalks (of about 150 to 200 cm) with a base diameter of 10-20 mm from underground rhizomes.

The leaves are alternate, long petioled and appear on the upper part of the stalks. They are heart shaped, broadly ovate and abruptly acuminate having a width of nearly 50 to 130 mm. and length varying in between 100 to 150 mm. with finally serrated margins. Leaves contain nearly 20 to 24% protein. The leaves are hairy with felty hairs.

Unlike jute, ramie after harvesting is extracted by mechanical means which is called "decortications" [5]. It has been reported that initial success has been achieved in developing seedling varieties of ramie which will considerably reduce the cost of cultivation vis-à-vis cost of production of ramie based textiles [6].

Ramie fibre (upto 120 mm in length) originates from the phloem of the bast. Secondary thickening helps in the durability and stability needed to allow it to grow apically to that length. The inner structure of ramie fibre differs from that of other plant fibres in that the physical form of the cellulose is rigid and crystalline as like linen in a more porous sieve like form providing it with even better absorbency than other near cellulosic fibres. The unevenness of fibre has a strong resemblance to the thick and thin appearance of linen. These uneven strands of ramie make harvesting difficult. After being separated from the woody matter and soft tissues, fibres remain in ribbon like strips because they are held together by gums and pectins [4].

Pic.-1 Ramie Plant

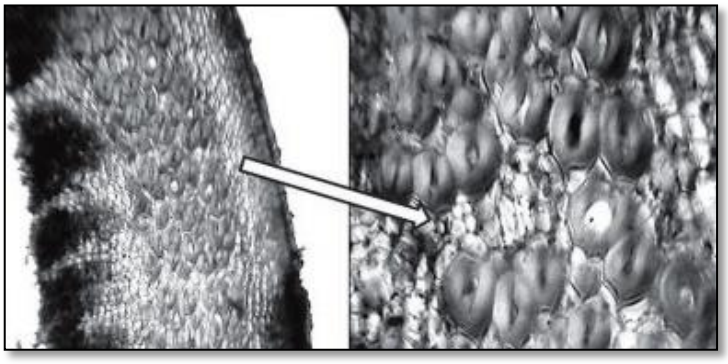
Pic.-2 Decortication

Pic.-3 Ramie fibre

4.4 Fibre Morphology and Properties

Ramie fibres are single cell systems, they are usually found as bundles of these single fibres, also called ultimates or ultimate fibres, and are cemented together within the plant stem. The fibres are located in the cortex layer of the stem just underneath the thin outer bark. The fibres are held together by natural cementing materials, such as resins and gums and the middle lamella. In bast fibres, the bast layer originates and develops from the terminal meristem close to the growing tip and is in its early development stage it is multinucleated and rich in protoplasm. It dissolves some of the middle lamella and develops simultaneously in length and diameter. This mechanism leads to pack the ultimate together tightly in polygonal form in cross section and oriented along longitudinal bundles with tapered ends. Due to its light packing, the middle lamella between the cells forms a thin uniform unbroken lamina (film) which covers each ultimate cell.

The microscopical observation of the topographical structure of the fibres reveals comparable structures with the other bust fibres. A comparison of various parameters of ramie and related natural fibres, such as jute, cotton fibres has been given in the Table-1. Ramie also has the highest value of length and breadth ratio. It is also reported that the diameter (thin) of ramie fibres is lower than those of other natural fibres except kapok [7].



Pic.-4 Cross sectional view of ramie fibre

The properly degummed fibres are single cell structures, length and breadth vary from 600-200 mm (average 120 mm) and 11-80 µm (average 50 µm) respectively. Depending on the variety of the species, agricultural practices, environmental conditions, soils and methods of decortications, the dimensions of the cells vary in considerable rate. As decorticated ramie is progressively degummed, (i) the tenacity of the fibre increases, (ii) the increase in the wet strength becomes higher (in the wet state, degumming ramie is about 30% stronger than what it is at 65% R. H.), (iv) the fibre becomes more extensible, (v) capacity for absorption of moisture decreases, (vi) the fibre dries out at a quicker rate, (vii) the fibre gradually separates into individual cells and (viii) the fibre to fibre friction becomes lower [8].

Table-1 Physical properties of some natural fibres [9]

Components	Properties	Jute	Ramie	Cotton
Ultimate Cell	Length (mm)	0.8-6.0	15-20	15-60
	Breadth x 10^{-3} mm	5-25	15-80	15-20
	Length/ Breadth value	110	3500	1300
Filament	Gravimetric fineness (tex)	2-5	0.4-0.8	0.1-0.3
	Tenacity (g/tex)	35-50	40-65	20-45
	Breaking extension (%)	1.0-2.0	3.0-4.0	6.5-7.5
	Torsional modulus (x 10^{10} dynes/cm^2)	0.25-1.3	0.7-1.3	0.8-1.2
	Flexural modulus (dynes/cm^2)	3.5-6.0	0.8-1.2	0.3-1.0
	Transverse swelling in water (%)	20-22	12-15	20-22
	Bundle tenacity (g/tex)	16-35	28-40	-
	True density (g/cm^3)	1.45	1.56	1.54
Moisture regain (%)	At 65% R.H.	12-13	6.5	7.0
	At 100% R.H.	36-37	17.5	24
Molecular chain	Degree of Crystallinity (X-ray)	High	Very high	Very high
	Angle of orientation (X-ray)	7^0-9^0	7^0-8^0	33^0-44^0

4.5 Chemical composition

Ramie fibre contains 86-90% cellulose along with other non-cellulosic constituents such as gums, waxes, fats, etc. Decorticated ramie is constituted of 95% Carbohydrates. The degummed ramie fibres are almost pure cellulose, viz. 96-97% α-cellulose, 3-4% β-cellulose and about 0.1-0.2% ash with very little or no trace of lignin.

The chemical properties are almost similar to those of other pure cellulosic fibres e.g. cotton, linen etc. Ramie is resistant to dilute alkaline solutions, cold dilute mineral acids do not affect the fibres but at higher temperature hydrolysis initiates. Cold concentrated mineral acids have a similar effect like mercerization. Organic solvent does not affect the quality of ramie fibre.

Table- 2 Chemical composition of ramie fibre

	Ramie	Cotton[a]	Jute[b]	Flax
Chemical composition of Fibre (%)				
α-Cellulose	86.9	88 – 96	61.0	80.0
β-Cellulose	5.0	-	-	-
Hemicellulose	3.9	-	15.9	4.4
Lignin	0.5	-	13.5	5.5

4.6 Fibre degumming

Raw ramie fibres, in their natural state, form the fibre bundles consisting of individual ultimate fibres that are cemented together by waxes and pectins which are called ramie gum in broad sense. The raw fibre is extracted by decortications of long fibre strands or ribbon where gum is incrusted around the ultimate fibre. Decorticated ramie fibre contains 19-30% of non-cellulosic gummy matter consisting of pectins, waxes, lignin and hemicelluloses [10].

As these bundles are too thick and too long to be used for processing purpose the fibres within the bundles need to be separated by removing the gum. This process is called degumming and produces textile grade fibres which can be spun into yams. Removal of gum from decorticated ramie is essential to unveil its unique properties and make it suitable for textile purpose. The fibre will be suitable for textile application only if freed from these substances to the greatest extent possible.

True degumming of ramie separates individual fibres and makes them soft, lustrous and almost white keeping intact their strength and other characteristics. Appropriate process of ramie degumming is yet to popularize in the market specially to Indian textile industry. Though few countries have developed the degumming & processing techniques of ramie but these have largely been trade secrets and most of them being covered under patents [11].

4.6.1 Traditional practice of ramie degumming

Over the years, various attempts have been made towards development of ramie degumming technology although a sustainable solution is yet to find out. Traditional methods which are commonly practiced are based on classical routes such as alkali hydrolysis of plant gum (chemical degumming) and biological decomposition of gummy matters by source specific microbes (microbial degumming), even though these methods are also associated with some major shortcomings e.g. environmental hazard etc.

Chemical degumming:

A standard method of chemical degumming process was developed at Jute Technological Research Laboratory (JTRL), now known as National Institute of Research on Jute & Allied Fibres (NIRJAFT), under ICAR. This method is based on caustic boiling of ramie.

The fibre sample is treated with 1% Sodium Hydroxide solution, for effective degumming, with a liquor ratio of 1:6 - 1:7 and some wetting agent (0.2% on the weight of alkali) at 96-98^{0}C for 2 hours, either in an open vat or in a digester under pressure. The residual gum content of the fibre

is reduced to below 5%. Addition of sodium sulphate to the extent of 0.5% in the degumming solution improves the tenacity of the fibre. The residual gum of the fibre was reduced to below 2% as reported, when the decorticated fibres are treated with1% sodium hydroxide solution at 120-125^{0}C for 2 hours. The repeating of the same treatment is reported to improve the feel of fibre and fibre separation [12, 13].

Since this method of degumming consumes large amount of boiling caustic solution, it also liberates heavy alkaline residues in the effluent which has been reported as bio-hazardous. In consequence, chemical degumming method has not been commercialized widely.

Pic.-5 Pictorial presentation of chemical degumming of raw ramie fibre

<u>Microbial degumming</u>:

Appreciable efforts by the scientists have given to develop an alternative environmental hazard free and cheaper method of microbial degumming. But so far no standard process has been evolved on a commercial scale. Central Research Institute for Jute & Allied Fibres (CRIJAF), under ICAR, has come up with a microbial degumming process which is under R&D trials. Microbial degumming has been reported using a strain of Bacillus substilis in sterilized water at 31-32^{0}C, wherein ramie ribbons were partially degummed and sterilized in 6-7 days without any degradation to the ramie fibre [14].

Degumming of ramie with substrate specific microbes has been tried in some R&D studies but no conclusive findings have been published and this process is yet to commercialize [15, 16].

<u>Breeding for reducing gum content in fibre: Traditional breeding</u>

Traditional breeding methods for reducing gum content in ramie have not been very successful so far for ramie. Being a facultative vegetatively propagated crop the crop has difficulty in synchronization of male and female flower induction and pollination. Seed set in ramie is problematic and environment dependant. Moreover, the genome structure of ramie is quite complex with twenty eight chromosomes (2n = 28), little understanding of species relationship and occurrence of polyploidy, which have limited advancement in traditional breeding in ramie [17].

4.6.2 Futuristic concept of ramie degumming

Possibilities for reducing Gum content through Genetic Engineering

For increasing acceptability of ramie as a fibre crop an innovative approach of developing genotypes with reduced gum content have been thought of that may diminish or eliminate the process of degumming. It has been reported that the same can be achieved by modification or silencing of endogenous genes involved in pectin biosynthesis. Recently, GalAT (α-1,4-galacturonosyltransferase), a key gene involved in pectin biosynthesis pathway have been cloned and isolated from ramie. Successful regulation of this key gene vis-à-vis identification of other genes involved in pectin biosynthesis is expected to open up a new era in ramie cultivation eliminating or reducing the current hazardous degumming process, which has presently crippled farmers and industry from using the finest and strongest plant vegetable fibre [2].

4.6.3 Scope of Enzyme application for Degumming of Ramie

As stated earlier, the microbial method of degumming is economical and simpler, but due to very slow process, it has not been successful so far for industrial application. In this context, few researchers have tried to augment the process speed by using site specific enzymes during degumming.

Different enzyme based products had been introduced in the market for rapid retting / degumming of natural fibres, among them products like Flaxzyme (for Flax fibre) and Ramizyme (for Ramie fibre degumming) from Novo Industry A/S, Denmark drew much attention [18]. In a R&D study in China, process of degumming of ramie using Ramizyme has been reported to give better results |as compared to conventional degumming [19]. Similar study has been carried out with Jute and allied natural fibres by IJIRA, Kolkata with commercial Pectinolytic enzyme preparations e.g. Flaxzyme [20].

The processes of enzyme based degumming which have been reported mostly by Chinese scientists are either covered under patent or restricted as trade secret. No such technology has been reported to be commercialized as industrial process in India. Although in the present global context, enzyme based bio-hazard free degumming technology for ramie fibre could be a sustainable alternative to the conventional technologies.

4.7 Mechanical Processing of Ramie and its blends – status in India

For processing of ramie fibre in India, attempts have been made to use modifications and combination of existing spinning machines viz. in cotton, wool and jute spinning system, rather than to embark on the development of new machinery for ramie fibre. As the production of the

fibre has not been very promising, the development in the area of fibre processing was also restricted.

Ramie has the required characteristics for producing high value textile products along or in blends with other textile fibres if properly degummed. Ramie could be efficiently blended with cotton in cotton spinning system, although it requires stringent control in gum removal. Unfortunately, due to lack of efficient post harvesting processing technology Indian ramie rarely mixed with cotton in cotton spinning machinery. In a recent study carried out at CIRCOT, Mumbai chemically degummed ramie has been mixed up with cotton in Pilot Scale to produce value added products [21]. Jute, lingo cellulosic fibre, share many similar characteristics with ramie. In earlier days of of research on ramie, a handful of studies were carried out to find out the possibilities of blending jute and ramie in conventional jute spinning systems. Few of them have represented encouraging results, although those were not continued further.

Processing of Jute-Ramie blends

It has been reported [22] that blending ramie (in raw stage and partially degummed stage) with jute could be spun satisfactorily for producing the blended yarns, although the developments could not be translated into commercial success. The studies [23] have highlighted majorly the mechanical processing aspects and spinning suitability of jute-ramie blends in conventional jute spinning system whereas the details of physical properties, yarn evenness studies and the aesthetics of the products have not been elaborated. In the earlier studies [24] the Roving frames (F.L.C.B frame; 9" x 4½") were exclusively used after three passage of gill drawing followed by Rove Spinning system (F.L.C.B AD Rove Spinning frame; 3½" pitch). The partially degummed ramie (containing 6-8 % residual gum) fibre when cut into 8 inch (20 cm) staple length exhibits better performance during the processing in jute/flax spinning system as reported in the literature [25].

4.8 Potential applications of Ramie blended products

Ramie products are attractive because of the lusture and extensive colour saturation. It can be observed that ramie products do not soil readily; it is durable and easy to wash. The moisture absorption is good which adds value to its aesthetic appeal. Some of the potential areas of application [26] are mentioned below:

- Ramie is exclusively used to make industrial products such as industrial sewing thread, packing materials, fishing nets, filter cloths' Sewing threads, Parachute fabrics, Woven fire hoses, Narrow weaving Canvas, and Filter cloth etc

- Good results have been obtained with table cloths, towels, glass cloths, aprons and coarse shirting often blended with wool. Suiting materials of ramie with wool, rayon staple or terylene may be used for summer, topical and work clothing.
- It is also made into fabrics for household furnishings (upholstery, canvas), Home fashion curtains, draperies, bedspreads, table linens, sheets, dish towels.
- Apparel dresses, suits, skirts, jackets, pants, blouses, shirts, children wear, mixed with cotton in knitted sweaters.
- Short waste fibres are used for the production of high quality papers, such as bank notes & cigarette papers.
- As ramie takes up phosphorous, it is potentially useful for cleaning up the Everglades. This region suffers from a nutrient overload from the sugar industry.

5.0 Need Assessment Market Survey & Field Survey

5.1 Summery Report

The technology of ramie fibre processing and manufacturing of jute-ramie blended products is not established in our country. The need assessment cum market survey have thrown some light on actual status of production / supply of raw ramie, quantity of jute-ramie based textiles produced, technologies that are currently practiced in industry as well as in small scale sector for producing ramie based products, awareness among the industry and finally the future prospect of jute-ramie blended products for holding the domestic market of home textiles. Considering the importance a reputed agency, M/s Roots & Yards, Kolkata, having the past experience of similar market survey and promotional activities related to natural fibres has been entrusted to conduct the survey.

Need assessment of the market for JDP has been studied considering related factors and actual. The data of ramie production have been collected starting from the North East Region of India viz. Assam, Arunachal Pradesh and Nagaland to the Terai region of West Bengal along with few places in Maharashtra for example Pune and Nagpur. The information is based on the collection of data from the Directorates and Universities of agriculture, Government and non-Government institutes and agencies. Interactions have been made with textile entrepreneurs, export houses and merchandising organizations to have their plan and proposals for the extension of business concerning ramie based textiles in a holistic fashion.

The ramie in the field, post harvesting treatment, de-gumming of the fibre, spinning of the fibre into yarns and diversified products having blends with Jute have been worked out accompanying with authentic data. The market for the JDP has been surveyed in the domestic market and industry. The incremented demand of the natural fibre has inspired the survey work at each stage.

The chief findings of the survey are summarized below:

- Major constrains in the ramie cultivation and processing are inaccessibility of easy and economic degumming technology to the ramie growers, non availability of appropriate ramie fibre processing and spinning technology as well as the poor promotion and marketing strategy for this valuable natural fibre. The situation has been aggravated due to high initial investment required for farming of ramie crop.
- North Eastern States like Assam, Arunachal Pradesh and Nagaland have sporadic farming practice at the promotion and business level. The enthusiastic individuals have tried in a considerable large scale and expanded their fibre production with assurance from the textile mills although consistent supply was not ensured.

- With arrival of new technologies, the Agriculture Ministry and other agencies are now showing interest for the extension of ramie cultivation specially in the NE states.
- Objectionable chemical based pesticides and insecticides are largely used in farming of Cotton which is now gradually being restricted by the world textile consumers and buyers. Thus an inherent demand has been created for other natural fibres those are being cultivated without imposing any chemical repellents. Since ramie has inherent antimicrobial characteristics, it may capitalize the favourable situation in the context of its exploitation globally in the home textile market.
- Jute and Ramie both are bast fibre and share few similar textile properties including colour of raw fibres. Jute being a cheaper complementary variety can suitably blended with ramie in different proportions for making considerably value addition and cost competitive home textiles products. The jute-ramie blended items would be innovative in real sense and as per the market survey they have the potentiality to hit the domestic as well as overseas market.

5.2 Detailed report on Need Assessment Survey of the market for JDP

5.2.1 Introduction

Like linen and cotton, ramie has the textile characteristics that contemplate its superiority in terms of its application and acceptability. But in the Indian perspective ramie has very little importance as the textile fibres. The current R&D study is meant for the technology development for manufacturing jute-ramie based products which is considered to be a new avenue for popularization of ramie in domestic market. The revamping of one of the finest textile fibres i.e. ramie impart new height to the Indian textile market.

Since jute has a limited use in the value added textile products, blending with ramie should be a new line to the textile players and users. Recently jute has been explored in the home furnishing applications and therefore fine count (4 to 8 lb/spy.) of jute-ramie blended yarn should attract the textile manufacturers. The beautiful textile properties of ramie, if blended with jute, can give series of home furnishing fabrics, upholstery, table linen, curtains, pillow covers etc. that definitely draw the attention of the consumers. The ramie-jute blend can give excellent image to the importers in the USA, European Union and Australian market who are looking for more natural and vegetable fibres in their livelihood articles including textiles.

Due to extensive use of pesticides and insecticides, cotton is being rejected by the people of USA, Australia and European countries like Sweden, Irelands, Denmark etc. Especially, for the Home textiles, people want to add more natural (preferably vegetable) eco friendly fabrics and accessories to breath well after a day's work. Therefore jute-ramie based fabrics have promising future if properly managed and exploited with commercial components.

5.2.2 Objective of the survey

a. To know the present status of ramie farms in the ramie growing states of India particularly in the North Eastern States.
b. To find the present fibre production of ramie farms both in the public stations and at the private initiatives.
c. To find the problems of production of fibre.
d. To know availability of decorticated ramie fibre with Government, Non Government Organizations (NGO), Co-operatives and private entrepreneurs.
e. To know the common practice of the degumming of the decorticated fibre at the producers' level and its scope of implementation at the farm level
f. To survey the availability of spinning technique of ramie at the research level in the universities and the research institutes.
g. To identify the Jute-Ramie blended diversified consumer acceptable products for textile usage.
h. To look into the cost benefit ratio for manufacturing of product.
i. To map the possibility of the fibre production and involvement of the Government and Private sectors in the production flow.

5.2.3 Present scenario of Ramie in India

Present scenario i.e. production of raw ramie fibre, import of ramie in different forms (e.g. degummed fibre, yarns etc.), plans of the State Governments of concerned ramie producing states on extension of cultivation; initiatives of the private players and NGOs, Agriculture Universities and Research Institutes have been observed and studied. The status of cost effective and field level applicable degumming technology has been reviewed. The efforts have been put to identify the textile applications of jute-ramie diversified products.

A. Area wise production of ramie fibre in global context

Table-3 Production of ramie in global context

Year	WORLD			ASIA		
	Area (ha)	Production (tonnes)	Yield (t/ha)	Area (ha)	Production (tonnes)	Yield (t/ha)
1990	94021	105892	1.13	86882	95709	1.12
2000	98895	164916	1.67	98430	163966	1.67
2001	117149	201041	1.72	116750	200144	1.74
2002	128730	243069	1.88	128250	241691	1.89
2003	131589	249581	1.89	131050	248200	1.89
2004	104589	259396	2.48	104050	258200	2.48
2005	135639	281458	2.08	135100	280300	2.08
2006	109547	226561	2.07	109100	225300	2.07
2007	98894	166372	1.68	98500	165300	1.68

Source: FAO Statistics (2009)

Area wise production of Ramie in India has been drawn by CRIJAF in a bulletin published in 2009 is shown in the following table.

Table-4 Production of ramie in major states in India

States	Area (ha)			Production (tones)			Yield (t/ha)		
	2004 - 05	2005 - 06	2006 - 07	2004 - 05	2005 - 06	2006 - 07	2004 - 05	2005 - 06	2006 - 07
Arunachal Pradesh	100	-	-	24	-	-	0.24	-	-
Assam	185	89	97	47	128.9	147.1	0.25	1.45	1.52
Meghalaya	25	-	-	5	-	-	0.20	-	-
Nagaland	10	-	-	3	-	-	0.30	-	-
All India	320	89	97	79	128.9	147.1	0.25	-	-

Source: Directorate of Jute Development, Govt. of India

So, it is observed in the above table that there has been a decreasing trend in the growth in ramie production in India mainly due to lack of govt. initiatives. Now considering the growing value of natural fibres an extension plan has been taken by the Govt. agencies across the India to grow ramie in the states as they have found it remunerative in the domestic market. There is a growing demand of Ramie all over the world because of its excellent natural property. Hence the Indian growers are showing interest to produce ramie fiber in a large scale.

Endeavour Biotech in Pimpli, Maharashtra has covered 10 hectares of land under ramie production as trial basis. The farm has planned to produce more than 10 MT of (decorticated ramie fiber each year). In Pimpri, Maharashtra ramie farm has been initiated for raw ramie production which produces approximately 10 MT per year in their ramie field spread over 8 hectares.

AI Champdany Industries have also entered in the ramie farming business through contact farming in Murshidabad, West Bengal. The initial experimental farm land was more than 10 hectares, thus producing 10 MT raw ramie fibre per year.

These endeavours are definitely a healthy for the growth at research level although much more efforts are required to attract a textile entrepreneur for establishment of ramie based market in commercial scale. Where there is a growing demand all over the world for ramie, hemp, flax and jute kind of bast fibers, India is not qualifying amongst other Asian countries like China and Philippines, with supply of good quantity fiber for textile applications.

B. Import of ramie fiber and yarns

Demand in the international market for degummed, spinnable ramie fibre can be visualized from the following table.

Table-5 Demand of spinnable quality of ramie fibre in the international market

Country	Import *(MT)/year*
Japan	20,000
South Korea	2,800
USA	27,000
France	13,000
Italy	11,000
Belgium	300
Spain	400

Source: Wikipedia: Natural Fibre: Ramie, its market and potential, August 2008

In Indian perspective, ramie yarns are imported from China, Philippines and other countries as the technology for industrial processing and spinning of true ramie is not available. After making fabrics and further embellishments ramie fabrics are re-exported to the European and American countries. Ramie yarns are imported principally from China by a few textile Mills like Pasupati Textiles, Pardesh Export Agency and others. As the production level is very low Indian growers cannot supply bulk quantity fiber to the industries. However this is expected that in a year or two the supply of fiber will increase in India.

C. Availability of Rhizomes and Seedlings for Ramie cultivation

The Ramie Research Station, Sorbhog, (under CRIJAF, ICAR) is the only institute which provides the Rhizomes for Ramie cultivation throughout the country and meets the demand for Rhizomes. Presently the institute is having a land of 15 ha for Ramie cultivation and other Research and Development activities. According to RRS, Sorbhog authority there are several requisitions for Rhizomes from different State Agriculture Departments, Research Institutes and private enterprises for expansion of ramie cultivation, the institute is not able to satisfy all of them due to having shortage of adequate cultivation land. The institute is planning to increase the area of cultivation sharply under the promotional activities of Ramie cultivation and an extension programme has been in action at Lakhimpur Dist. of Assam.

Few high yield newer varieties of Ramie have been developed by RRS, Sorbhog in the last couple of years. The latest development is R-6720 which has shown very promising features and might provide a yield of almost 20 qt. per Ha. The said variety is still being used for R&D activities. The trials of new varieties having six times harvesting capacity per year and further R&D works are going on under the supervision of the scientists of RRS, Sorbhog, Assam

Additionally, the “Seedling” variety of Ramie has been developed and is under extensive trial at identified experimental/ promotional land. This is also reported that, this development would be a breakthrough in Ramie cultivation, as using seed for Ramie cultivation would reduce the cost of cultivation drastically; it is expected to be reduced by 50% by using such seedling variety.

Interestingly, 10 gm of seed is equivalent to 10 qt. of Rhizomes which perhaps would provide solution to the scarcity of Rhizomes too.

5.2.4 Ramie diversified products

High quality ramie-cotton blended product has got tremendous potential in apparel sector. Some of the diversified apparel products can be stated as examples:

- 100% ramie knitted apparel. Perfect hygiene and comfort properties make them especially attractive for hot and humid climates. Ramie socks and jerseys are used as sportswear because of its excellent properties.
- Ramie has a unique property of anti-bed sore; therefore it has an application for bed sheeting and home furnishing textiles. It could be used as hospital apparels too.
- Ramie fabrics are hygienic and having anti bacterial properties thus used as sport shoes, and sport jerseys.
- It could be fantastically used as blend with jute for home furnishing fabrics and other life style products.
- Ramie fabric is durable and long lasting, so preferred by people.
- India and other tropical countries would always prefer fabrics of ramie which will sooth their body even in hot and humid climate.

Ramie is the purest of all cellulose fibres, practically having very low lignin content. It can meet the demand for pure cellulose, to make durable fabrics in the synthetic fibre industry. High order of silky luster and its great affinity for dye stuff are its plus points. Consequently, the fabrics woven out of ramie are also of superior quality. One most important quality of the fibre is its 34% increase in strength when wet which makes it suitable for making hose pipes, towels, glass cloth, table cloths, aprons, curtains, carpet backing, sail cloth, canvas, nets and webbings, cordage and ropes.

Ramie is preferable for shirting and suiting when blended with cotton, synthetic fibres etc. Fabrics made of ramie are very stiff because of its rigidity and low extensibility. Fabrics made entirely of Ramie look good and durable and in no way inferior to linen. Unlike linen its durability in washing is practically unlimited and it can thus be a good substitute for flax which is not grown in India. Blending of Ramie with wool in the ratio of 50:50 results in a material with shrinkage of 10% only compared to 25% for pure wool. 55% Ramie with 45% Cotton is a perfect blend proved to be best in blend with Cotton.

Acceptability is high for applications in the table cloths, towels, glass cloths, aprons and coarse shirting materials when the ramie is mixed with regenerated cellulosic fibre. Suiting materials of ramie with wool, rayon staple or terylene may be used for summer, tropical and work

clothing. Ramie cloths may be treated for crease resistance in a similar way as other cellulose fibres.

Ramie may further be used for curtains and awnings, sail cloth, canvas, tent duck, hose pipe, filter and press cloth, nets and webbings, sewing thread, cordage and ropes. Ramie can easily be blended with almost all the fibres like cotton, flax, silk, wool, munga, endi and polyester fibres successfully. This widens its range of utilisation in the textile industries to a great extent. For example, ramie can be blended in various proportions like 30:70, 33:67, 35:65 and 40:60, with polyesters. The fibre of ramie can also blend nicely with wool and a 50:50 mixture with wool is reported to be stronger than even the carpets. The experiments conducted at the Handloom Research and Design Centre, Guwahati (Assam) also indicate that ramie can be efficiently blended with munga and endi. *(Source: Ramie: Dr. D. P. Singh)*

Some of the textile industries viz. Jagi road Spun Silk Mill, Assam Polyester Ltd, Assam Syntax Ltd, Jayashree Textiles Ltd. has demonstrated the use of de-gummed fibre in blend with polyester, cotton and silk.

The design centre of Khadi and Village Industries Commission (KVIC), Wardha has devised a Charkha (Ambar Charkha) available in various spindles with a processing technique for spinning ramie in various counts.

Roots and Yards tried ramie spinning in traditional home spinning (Khadi) system in Murshidabad, West Bengal. The entrepreneur tried spinning directly from the fibres after required hackling in the conventional system. It also tried to make sliver in the cotton spinning system and made yarns from the Ambar Charkha (a Cotton spinning machine developed by Wadha KVIC with 6-16 spindles) of various counts. The ramie yarns have been used in weft to obtain fabrics of various counts and textures. In the warp cotton, flax and silk were used. Roots & Yards made home furnishing fabrics for a niche export market with immense reputation.

Table-6 Few products that have been tried with ramie and other natural fibres

Warp Yarn	**Weft Yarn**	**EPI**	**PPI**	**GSM**	**Use**
Cotton 20's	Ramie (6 lbs)	42	46	200	Drapery
Cotton 40's	Ramie (4 lbs)	36	42	210	Drapery
Flax 1/20 lea	Ramie (6 lbs)	42	44	195	Bed Sheet
Flax 1/10 lea	Ramie(8 lbs)	40	42	320	Cushion
Matka-worstso	Ramie (4 lbs)	50	52	285	Apparel
Ramie (6 lbs)	Ramie (8 lbs)	48	50	400	Bed Linen

Ramie-Jute blend at the fibre level may give extremely value added products (various counts of single and two ply yarns). Ramie jute blended yarns would give wide range of home textiles and draperies. Jute-Ramie blended yarns in 4-8lb count could be used in home line products with different GSM. Less than 3lb ramie yarn would be used in all ramie textile products at the hands of designers and export production houses.

Few entrepreneurs have tried Jute and ramie yarns in various kinds of carpets of different categories. The carpet categories could be made out of jute ramie blended yarns are drawn in the following table.

Table-7 Potential carpet qualities could be tried with Jute ramie blended yarns

Carpet type	**Style**	**Size** (cm^2)	**Quality**
Dari	Panja Dari	120 x 180	10 x 42
Dari	Panja Dari	250 x 300	8 x 22
Indo Tibetan	Tufted	250 x 350	10 x 42
Shaggy	Tufted	260 x 370	9 x 25
Persian Knotted	Cut Pile	400 x 600	8 x 22
Abusan	Cut & Knotted	500 x 700	10 x 42
Indo Tibetan	Loop Pilled	250 x 350	10 x 42
Indo Tibetan	Cut Pilled	250 x 350	10 x 42

Jute Ramie carpets will have the following properties:

- Carpets shall be much lustrous than that of wool
- Shredding shall be much less than that of all jute carpets
- The strength of the blended yarns will be much higher, thus carpets will be more durable.
- Ramie blended carpets will be bacteria free and will be preferred by the customers of all over the world.
- Ramie is a very dye friendly fibre thus jute ramie blended yarns can easily be dyed with reactive or direct dyes.

5.2.5 Need Assessment of the market for Jute-Ramie based Diversified products

In the Premiere Vision 2007, it was observed that European big textile buyers are looking for new natural especially vegetable textiles. USA buyers started rejecting conventional cotton as they have found it causes enormous skin disease and it surely makes harms to the environment at a large scale. As a result, a general preference has been build up for organically cultivated natural fibres in their textile image. The big players in global textile and fashion trade like Georgio Armany, Givonchy, Sonia Rykiel, Zara Home, L'Accessorio, Faliero Sartie, Barbara Bui, Dries Van Noten are putting natural textiles in their collection. Indian stalwarts like Rohit Bal, Sabyasachi Mukherjee, Sharbari Dutta are also giving emphasis on natural textiles.

Indian exporters like JJ Exports, A P Fashions, Padesh Export Agencies, Ventures are importing ramie yarns of different counts from China. They are developing their fabrics and garment collection for European, Australian and USA market. The Ramie blend with cotton (preferably organic) has become a tested fashion image fabric. The exporters prefer ramie, flax and organic cotton with the changing pattern of textile and fashion across the globe.

Martin Graham, the Chairman of Pardesh Export Agency, in Noida, UP was insisting to produce Ramie and organic cotton with infinity quantity. The Pardesh Export Agency is one of the big importers of Ramie yarns from China. They do develop fabrics from several producers across India.

Ramie could be blended very well with Cotton, Wool, Silks and Cellulosic Viscose. Other than those blend ramie could be very well blended with Jute. Jute will get more luster, strength, fineness and value when it will be blended with Ramie. Jute-Ramie blend in different ratio should be tried in the home textile trade. Zara Home and Jacques Bellandi of Italy had done lot of home textiles with Jute cotton blend. Jute Ramie blend is a new approach to the home textiles. So it must attract the home line people around all over the world. Carpets made from Jute must give better luster and strength when their will be a ramie blend.

It was seen that companies like Jamui Handlooms Stores in Bhagalpur, Bihar, India (one of the biggest production houses of Hand and Powerloom Fabrics in Bhagalpur) is importing Ramie yarns from China and Philippines and make apparel fabrics for the Indian exporters. From these stories, it is understood, that, there is an incremental demand of Ramie fabrics all over the globe that signifies Ramie is going to supplement the textile need in Indian Textile Industry.

Biswas Handlooms, Champa, in Chhattisgarh is also manufacturing ramie apparel fabrics and supplying to the exporters based in Delhi, Kolkata, Bangalore and Mumbai.

Jute-Ramie blended yarns (4-8 lb) having blend of different ratio could be tried in home textiles. Beautiful drapery, Mats, curtains made from Jute ramie blend will attract the natural fabric lovers. Those fabrics have to go to the Heim Tex or Ma Maison kind of textile fairs for the exposures.

Ramie as individual fabric or as blend is in a great demand in the textile market at present. There is a need of the fabric to supplement the textile practice all over the world. With the demand of such fabric there has to be several entrepreneurial activities at all stages from field to the market. Thus, it requires expansion and promotion from the Government and entrepreneurial levels to produce this excellent textile fibres and yarns and fabrics and fashions

at a large scale. Because there is a potential market and there is an incremental demand of natural fabrics from all corners of the globe.

Cost benefit analysis of jute-ramie blended end products

Jute-Ramie blended products shall be of much higher price for sure than all jute products. This comparison may seem to be very fictitious as the products of all jute and ramie-jute shall be totally different from one another. The cost shall vary with percentage of use of ramie in the blend and the count of yarn to be used in the products. The more the ratio of ramie the higher the cost shall be is a simplest equation.

However, after interaction with foreign buyers it was felt that there is an open market for new diversified products, and price hardly matters in new innovative products and designs. The end products should be of international quality and standard and for that product the manufacturers and growers would earn profit at large.

Cost benefit ratio can be analytically discussed in the following table taking a drapery as a union fabric of different yarns in the warp and in the weft as well. Ends of the yarns will vary between 32 and 54, picks from 44 to 58 per inch.

Table-8 Cost benefit ratio for some home décor products made out of natural fibre blends

Product	Warp Yarn	Weft Yarn	GSM	Width (cm)	(COP in Rs)
Drapery	Ramie 1/6	Ramie 1/8 lbs	340	120 cm	200.00
	Ramie 2/8 lbs	Ramie 1/4's	430	120 cm	110.00
	Cotton 1/10's	Jute 1/6 lb	380	120 cm	115.00
	Cotton 2/17's	Ramie 1/81b	350	120 cm	140.00
	Matka 1/10 D	Ramie 1/81b	270	120 cm	240.00
	Worsted 2/10 D	Ramie 1/61b	270	120 cm	190.00

(The cost benefit analysis drawn by Roots & Yards, November 2008)

5.2.6 Constraints of present degumming technology and probable solutions

A major problem in promoting ramie cultivation is the lack of an appropriate technology for de-gumming. There is no standard method of degumming available in the market. Cultivators of ramie specially in the NE Region could not able to degum the ramie field itself and compelled to supply un-degummed fibre is to the industry, hence could not get desired price remuneration. The industry as well follows the crude chemical methods of degumming hence it makes the process tedious. Countries like China have developed fruitful degumming technologies for ramie but these are remained largely as commercial trade secret.

The chemical method of de-gumming is basically a caustic boil method which requires high concentration of caustic and much energy inputs resulting in environmental pollution as the hot degumming liquor is thrown away as waste. A method of chemical de-gumming has been standardized at NIRJAFT although the process is not popularized among the farmers to incorporate the practice to be performed in the field level.

Microbial techniques of degumming have been tried with limited success so far eventually in the laboratory scale. The technology was meant to be performed at field level as like retting of jute etc. but the knowledge and expertise required to carry out the same is probably absent in among the farmers of the NE Region.

Therefore, a demand has been created for developing energy conducive, bio-friendly degumming process of ramie that can be performed in the farmers level which might be adding the value, consequently the farmers could get the desired price.

5.2.7 Prospects of Ramie in India

As an under exploited fibre crop ramie has got promising economic value in North East India especially in Assam. There lies a good prospect for this potential crop in the region because of the suitable agro climatic conditions prevailing in this area.

Polyester is generally blended with cotton and viscose fibres. Both cotton and viscose fibres are not available in the region of North East India. Instead the region can substitute ramie for cotton or viscose if large scale plantation of the crop is undertaken. Extension of ramie cultivation can also reduce the country's dependence on imported long staple fibres and there is a good possibility of ramie to take the place of the substitute for flax which is presently imported.

The National Commission of Agriculture has also recommended the expansion of ramie cultivation in the states of Assam and other neighbouring states in North East Region. Ramie cultivation in these regions will always be paying so long the textile industries maintain the demand. Terelyne-Ramie and Polyester-Ramie garments may become universal choice, once its superiority over cotton or polyester cotton fabrics is demonstrated. Recently, a programme for the production of 'low priced fabric' has been formulated by the Department of Textiles, Government of India. On 28th August, 1985, Govt. of India has also announced substantial duty reliefs for polyester fibre, polyester-cotton blended yarn and polyester-viscose blended yarn for increasing the consumption of blended fabrics in its new textile policy. The government is now deliberately encouraging the use of man-made fibre to reduce the dependence of the textile industry on cotton, the supply of which was generally fluctuating according to weather and several other factors. Government is thinking to even export cotton or its yarn if it is' found

surplus. This leaves a good scope for developing ramie more rapidly in our country and now every effort should be made to bring this crop in the fore front.

It has come to our knowledge that Roots & Yards, an innovative entrepreneur has developed a de- gumming method at their own unit in Murshidabad and successfully demonstrated degumming technology at the farmers' field which seems to be very cost effective and absolutely harmless to the environment. The fibre the company produced after de-gumming are liked by the textile entrepreneurs because those have least amount of gum content and are spinnable in a standard spinning unit. Roots & Yards also produces khadi yarns and hand loom fabrics of hand spun ramie yarns.

After having discussed with the directorates of agriculture and individual growers in the north east it is felt that the latest technology of de-gumming would motivate them to restart the ramie farm in a large scale if there is proper agreement between farmers or growers and the textile entrepreneurs.

6.0 Methodology followed for R&D Activities

- Selection of market available enzymes/chemical formulations suitable for removing the gummy matters from decorticated ramie (the highest possible extent) at the ambient temperature and conditions
- Development of appropriate degumming formulation by cocktailing one or more enzymes together to encounter different constituents of gum in ramie fibre
- Laboratory scale establishment of degumming technology
- Pilot Plant study for optimization of degumming process parameters like enzyme application %, incubation time, temperature etc. and evaluation of physical properties of degummed fibre
- Lab to bulk conversion of technology through field trial with optimized degumming formulation in NE Region and assessment of field level efficacy of the developed process technology
- Development / identification of appropriate process route for satisfactory processing and spinning of 100% ramie fibre and jute-ramie blends. Spinning of fine yarn from 100% ramie and jute-ramie blends that are suitable for jute diversified product manufacturing
- Development of value added fabrics/ products from jute-ramie blended fine yarns
- Development of traditional house hold products by exploring indigenously available technology with ramie and jute-ramie blends at cottage level to promote ramie fibre based products to small scale entrepreneurs

7.0 Detailed Report on Research and Development Activities

7.1 Laboratory scale development of eco-degumming technology for decorticated Ramie fibre

Decorticated ramie is obtained as bundles of individual fibres cemented together by natural gums. Decorticated ramie fibre contains considerable amount (about 20 to 30%) of non-cellulosic gummy matter mostly consisting of hemi-cellulose and other non-fibrous entities like pectin, waxes and lignin. The ramie fibre bundles are converted to spinnable individual fibre if freed from such gummy substances to the greatest possible extent. The prime focus of the degumming has been removal of these non-cellulosic components by bio-chemical means without affecting the mainstay structural constituents and their functionalities.

Enzymatic route has been opted in this study considering its eco-friendliness and process suitability. The chemical composition of gum in the ramie is an important factor for selection of enzyme mixture appropriate for degumming of ramie fibre.

7.1.1 Study on the Ramie 'gum'

Ramie is one the purest cellulosic fibres having 85-87% hollo-cellulose. As reported [4] the ramie fibre contains 73% - 75% alpha-cellulose and the rest is represented by hemi-cellulose along with pectin, lignin and waxes. The chemical composition of ramie is represented in the table (9) below:

Table- 9: Chemical composition of ramie fibre

	Constituents	Percentage on dry weight basis
Ramie Gum	Hemi-cellulose	13.0-14.5
	Pectin	4.0-5.4
	Lignin	0.6-1.2
	Lipid-wax	0.3-0.5
	Water soluble subs.	6.0-7.6
	∝- Cellulose	73.0-74.0

It is apparent from the above table that hemi-cellulose and pectin hold the major part of the ramie gum. A suitable enzyme system that can act on the respective hemi-cellulose and pectin would be appropriate for the development of enzymatic degumming process. Accordingly an enzyme system has been formulated based on the laboratory trials with the commercially available substrate specific enzymes for degumming of ramie fibre.

7.1.2 Selection of enzyme formulation:

As represented, ramie gum is a multi-component system with hemi cellulose, pectin & lignin. The hemi-cellulose contributes almost 13-14% to the dry weight of the ramie fibre. The other components e.g. pectin, lignin etc. differs in their chemical nature indicating that a single enzyme could not be able to produce the desired efficiency in enzymatic degumming process. Accordingly, a formulation has been developed comprising of synergistic mixture of organic enzymes compatible with each other as well as effective against the targeted components which are critical to remove during degumming process.

The enzyme formulation prescribed for ramie degumming is represented in the below table along with commercial sources of the components.

Table-10 Components of enzyme formulation

Components of Enzyme mix	**Commercial Source**
Hemi-cellulase • Xylanase • Arabinase	Novozymes, Denmark
Pectinase • Pectate Lyase • Poly Galactouranase	Novozymes South Asia Pvt. Ltd

Estimation of Enzyme Activity of Ramie degumming formulation

Assay of enzyme profile in ramie degumming formulation has been carried out at the laboratory. Hemi-cellulase has been assayed with citrate buffer (pH-5.0) under an incubation temperature at 45^0C for 30 min. followed by estimation of reducing sugar. Pectin liquefying activity has been measured by the viscometric method and activity of cellulase in the enzyme cocktail used has also assayed. Activity profile of enzymes present in degumming formulation used is depicted below

Table-11 Enzyme activity of degumming formulation

Enzyme activity (Units/ml)			
Pectinase	Jute Hemi-cellulase	Endo, β-1-4-Glucanase	Exo, β-1-4-Glucanase
23000	560	360	20

In the enzymatic degumming formulation of ramie fibre, multiple enzymes are present. It has been observed that activity of pectinase is considerably high where as Hemi-cellulase activity is moderate

and Cellulase activity is lowest. This further indicates minimum possibility of disorder in the mainstay cellulosic structure of ramie during degumming process.

7.1.3 Selection of suitable buffer medium

Enzymes are sensitive to the pH and temperature of reaction media for their optimum activity. Major enzymes used for the eco-degumming process are acidic in nature and have shown best activity in the pH range of 5.0 to 5.7. To achieve the constant equilibrium of the said pH profile Citrate Buffer (pH 3.0-6.2) has been selected.

In the laboratory trials while carrying out degumming of ramie fibre it has been observed that Citrate Buffer further stimulates the enzymatic degumming process. Sodium citrate in the presence of citric acid chelates the complex metal ions and accelerates the degumming process. Additionally, the use of citrate buffer has also been found to improve the visual appearance of the degummed ramie fibre.

7.1.4 Enzymatic Degumming Process developed at laboratory scale

a) Hackling/ tearing of the ramie bundle (1st Step): The bundle of raw ramie (50-100 gm) having 70-75% moisture has been briefly opened up by manual tearing or hackling with metal combs. This gentle mechanical hackling action releases the hardy portion where bundles of individual fibres are adhered together with gum. The hackling also helps the degumming solution to penetrate well into the fibre bundle.

b) Wetting of the fibre bundles (2nd Step): The dry ramie fibre is difficult to degum as the wet gummy matters are encrusted on the fibre after drying. Hence, pre-washing treatment has been given to the decorticated fibre with eco-emulsifier to an extent of 0.1-0.2% on the weight of fibre. Ramie bundles have been thoroughly impregnated in the bath containing eco-emulsifier and kept at immersed condition for 2-3 hours at 60^0C temperature. Then washed carefully to bring out the remnants of bark, leaves, dirt and water soluble non-fibrous matters.

c) Preparation of buffer media (3rd Step): The synergistic activity of enzyme formulation recommended for degumming is best obtained in the Citrate buffer solution (0.1 M, pH-5.5-5.7). Sodium Citrate dihydrate and Citric Acid have been used in combination into the degumming bath water.

d) Preparation of degumming bath (4th Step): The beakers and other accessories have been washed thoroughly with hot water to eliminate the chances of protease contamination, if any, in the

degumming bath. Material: Liquor Ration (MLR) in the degumming bath has been kept 1:5 to 1:10, pH of which is maintained at 5.0-5.7 by using buffer solution. Temperature of the degumming bath is maintained at 37^0-40^0C.

e) Enzymatic degumming of ramie (5^{th} Step): Subsequent to the bath preparation the dozing of enzyme formulation has been followed by adjusting enzyme in different proportions (on wt. of the fibre). The specified amount of pre-washed fibre (50-100 g) then dipped into the degumming bath and kept in the incubation system at 35^0-40^0C for the specified duration as per the experiment as designed.

f) Washing of degummed fibre (6^{th} Step): The degummed ramie samples then washed thoroughly with hot and cold water respectively. The rigorous washing is essential to avoid the sticking of the gum onto the surface of fibre. The washing cycles have been repeated for twice or thrice during laboratory scale trials.

g) Mild alkaline washing of fibre (7^{th} Step): After degumming of fibre a mild alkaline pre-bleaching treatment (optional) is given for increase the aesthetic and appearance of the degummed ramie fibre. The fibre bundles are boiled in water containing sodium sulphite (0.5% w/v) and sodium hydroxide (0.1% w/v) for 15-20 minutes. After boiling the ramie fibre samples have been neutralized with mild acid followed by washing with water.

Process Flow Chart for Lab Scale Degumming of Ramie Fibre

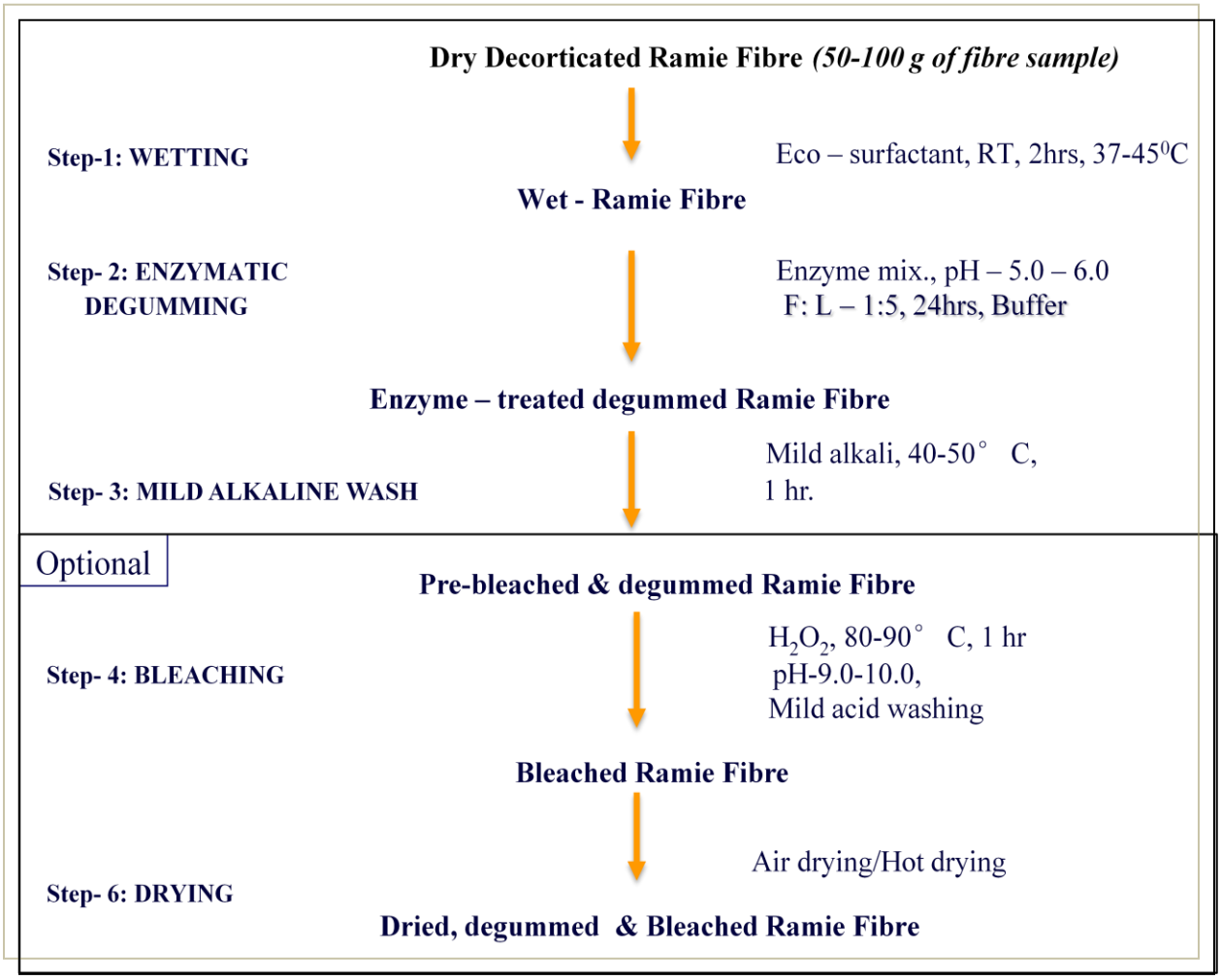


Fig.-1 Process Flow Chart for laboratory scale degumming of ramie Fibre

Pic.-6 Raw ramie fibre and lab scale degummed & bleached ramie

7.1.5 Characterization methods followed:

The efficiency of the degumming process is mainly evaluated by the estimation of residual gum content remaining in the degummed fibre. The standardized method of NIRJAFT, Kolkata has been followed for evaluation of residual gum content. After degumming fibres fineness and tensile properties have also been evaluated.

i) Determination of Bundle Strength:

The bundle strength of the degummed ramie has been carried out according to the standard method at the GOODBAND (SCOTT) machine. 15 cm long fibre bundles weighing between 0.2g and 0.3g have been tested.

ii) Determination of Fibre Fineness of degummed ramie fibre:

Both (i) gravimetric method and (ii) Vibroskope method have been followed for estimation of fibre fineness (linear weight) of the degummed ramie fibre. Initially the single fibres have been separated carefully from the flock of the degummed ramie.

In gravimetric method, 50 pieces of 5 cm long single ramie fibre was taken as one sample and weighed. Hence, it is the weight of 50x5 cm = 2.5 metre of single ramie fibre; subsequently the fineness was measured according to the following formula -

$$\text{Fineness (Denier):} \quad \frac{\text{Wt. of 2.5 m single ramie fibre}}{2.5} \times 9{,}000$$

In Vibroskope, the single fibre of degummed ramie has been mounted in the probe with estimated initial load. The fineness is provided by the instrument immediately in terms of Denier. 50 such readings have been taken for each experiment.

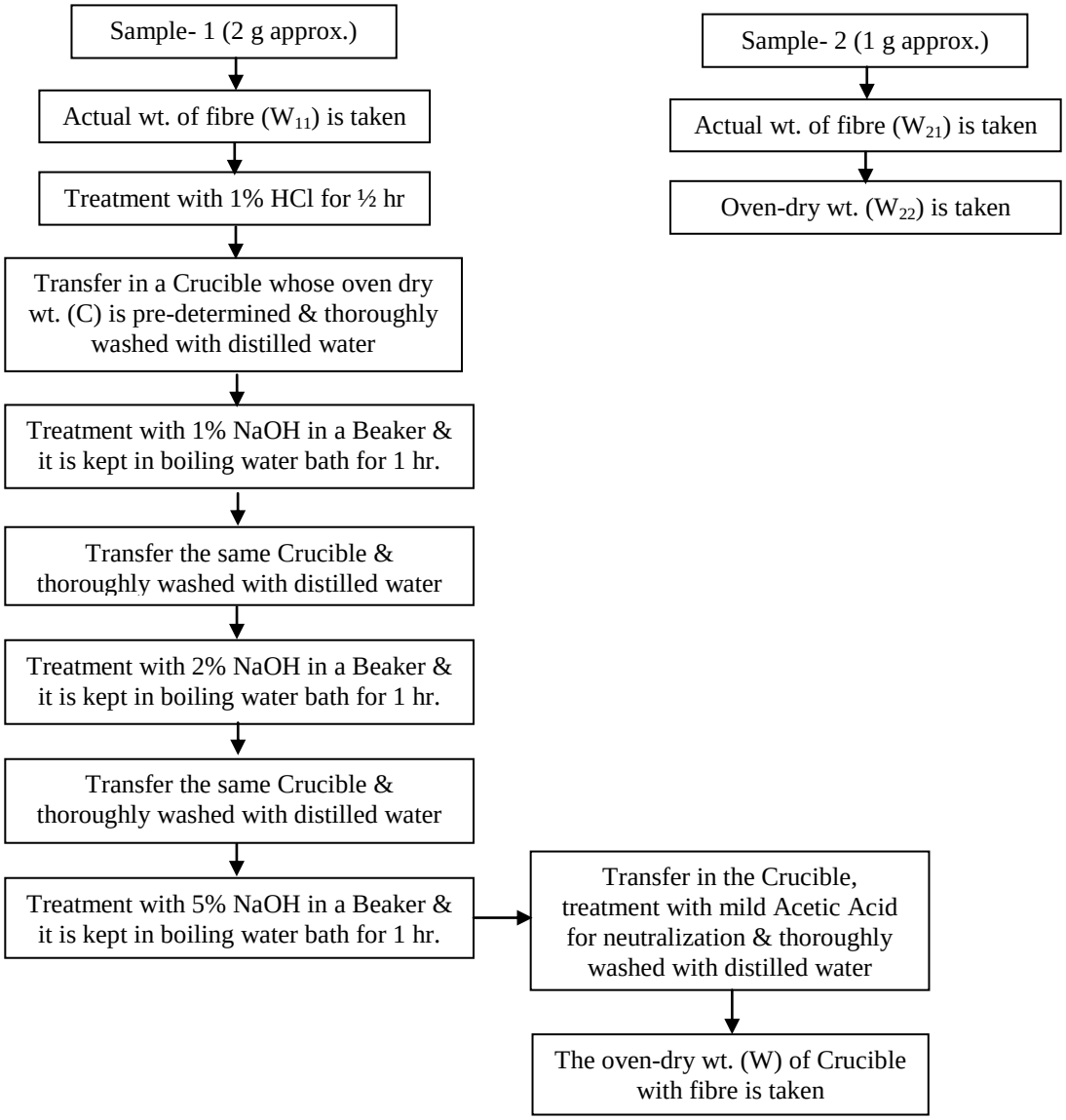
iii) Characterization by Scanning Electron Microscopy (SEM):

Subjective assessment of the efficiency of degumming process has been evaluated through the Scanning Electron Microscopic pictures. Scanning Electron Microscope, model S430 from LEO, UK, of Central Glass & Ceramic Research Institute (CGCRI), Kolkata has been utilized for micro-structural analysis.

The samples are stubbed and coated with silver carefully to prevent charging in the electron beam. SEM pictures at same range of magnifications are taken for comparison between un-degummed and degummed ramie for analysis of adherence of the gum at the fibre surface.

iv) Estimation of Residual Gum Content in ramie fibre

Initially two samples of fibre are taken and cut thoroughly into very small pieces. These samples are subjected to the subsequent treatments as indicated below:



Moisture present per gm of fibre: **$M = [W_{21} - W_{21}] / W_{21}$**

Dry wt. of totally degummed fibre (Sample-1): **$F_D = W - C$**

Dry wt. of original fibre (Sample-1): **$F = W_{21} (1-W)$**

Residual Gum Content: **$RG\% = [(F - F_D) / F] \times 100$**

7.1.6 Laboratory scale optimization of the eco-degumming process

Various physico-chemical process parameters e.g. enzyme concentration (%), incubation time, pH, temperature etc. have been optimized through extensive laboratory experiments. Characterizations of degummed fibre have also been carried out to observe both fibre properties of degummed ramie fibre and associated cost of the degumming process.

To establish an optimized degumming process, four parameters have been taken in account.

i) Enzyme concentration (o. w. f.)
ii) Incubation time
iii) Incubation temp
iv) pH of the bath

ECO-DEGUMMING PROCESS OPTIMIZATION: RESULTS AND ANALYSIS

A. Optimization of enzyme concentration for degumming

Table-12 Optimization of enzyme concentration for degumming

Enzyme (%) (w.r.t. fibre weight)	No. of observations	Initial wt. of ramie fibre (gm.)	Wt. of ramie fibre (after degumming & bleaching) (gm.)	Avg. Wt. loss (%)	Residual Gum Content (%)
0.5	1.	20.63	18.04	14.30	**7.64**
	2.	20.48	17.22		
	3.	20.23	17.31		
1.0	1.	20.67	17.43	15.25	**5.66**
	2.	20.7	17.25		
	3.	20.6	16.82		
1.5	1.	20.16	16.58	16.41	**5.56**
	2.	20.47	17.27		
	3.	20.47	17.22		
2.0	1.	20.03	16.45	16.54	**5.36**
	2.	20.54	17.20		
	3.	20.00	16.90		
2.5	1.	20.66	17.48	16.74	**5.32**
	2.	20.12	17.15		
	3.	20.25	16.86		

•pH of the solution: 5.7 •Incubation temp.: 35^0C - 37^0C, •Incubation time: 24 hours

B. Optimization of Incubation Time

Table- 13 Optimization of Incubation Time

Incubation period of enzyme treatment (hr)	No. of observations	Initial wt. of ramie fibre (gm.)	Wt. of ramie fibre (after degumming) (gm.)	Avg. wt. reduction (%)	Residual Gum Content degumming & bleaching (%)
4	1.	10.04	8.63	14.18	7.80
	2.	10.03	8.59		
	3.	10.01	8.60		
8	1.	10.00	8.63	14.79	7.20
	2.	10.06	8.51		
	3.	10.02	8.55		
12	1.	10.03	8.56	15.05	6.95
	2.	10.05	8.51		
	3.	10.02	8.49		
16	1.	10.04	8.47	15.33	6.66
	2.	10.07	8.55		
	3.	10.03	8.48		
20	1.	10.01	8.39	16.12	5.88
	2.	10.09	8.48		
	3.	10.01	8.42		
24	1.	10.00	8.34	16.53	5.37
	2.	10.06	8.40		
	3.	10.05	8.37		
30	1.	10.00	8.32	16.91	5.32
	2.	10.06	8.31		
	3.	10.09	8.41		

•pH of the solution: 5.7 •Incubation temp.: 37^{0}C •% application of enzyme: 1%

C. Optimization of Temperature of degumming process

Table- 14 Optimization of Temperature of degumming process

Incubation temperature (°C)	No. of observations	Initial wt. of ramie fibre (gm.)	Final wt. of ramie fibre (after degumming) (gm.)	Avg. wt. reduction (%)	Residual Gum Content (%)
Room temperature (28-30°C)	1.	10.03	8.95	10.65	11.43
	2.	10.03	8.96		
	3.	10.06	9.00		
37°C	1.	10.05	8.71	14.02	8.18
	2.	10.05	8.47		
	3.	10.05	8.75		
55°C	1.	10.00	8.10	15.52	6.07
	2.	10.00	8.32		
	3.	10.00	8.69		

•pH of the solution: 5.7 •Incubation time: 24hr •% application of enzyme: 1%

D. Optimization of pH of the degumming process

Enzyme formulation used for eco-degumming of ramie fibre is acidic in nature and it has shown optimum activity in the pH range of 5.0 to 5.7.

Analysis of test results

In the enzymatic degumming process, residual gum content of the degummed ramie fibre largely depends on the concentration of enzyme used. The experimental results indicate that efficiency of degumming (with decrease in residual gum content) improves with gradual increase in enzyme application upto 2.5% (w/w), however, degumming process is leveled of beyond 1% (w/w).

Hence, considering the cost competitiveness of enzyme degumming technology, 1% enzyme application (o. w. f) has been considered as optimum (Fig.-2).

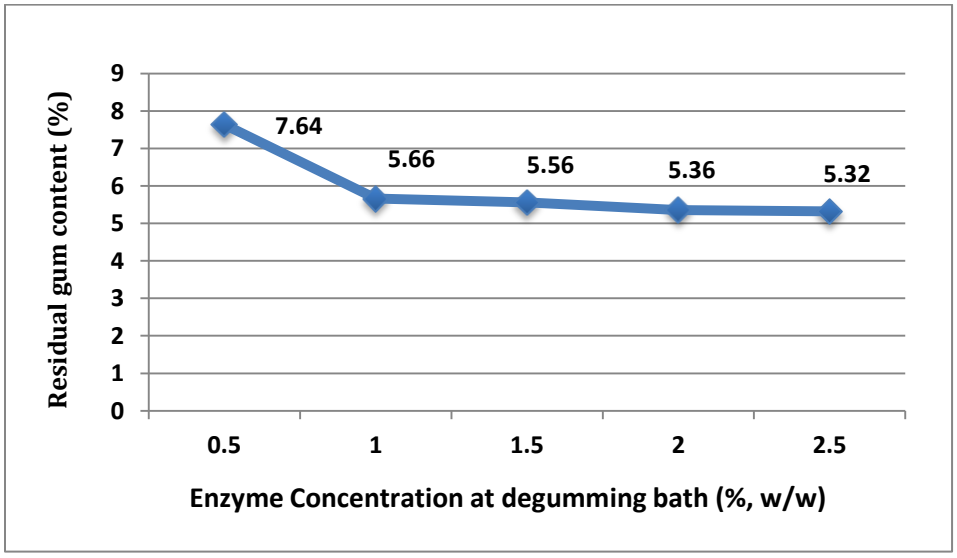


Fig.-2 Optimization of enzyme application on ramie fibre degumming

Incubation time for enzymatic reaction is a prime factor for getting efficient enzyme based degumming action. It has been observed that at 24 hrs of incubation time, enzymes mixture used attained maximum degumming efficiency (Fig.-3)

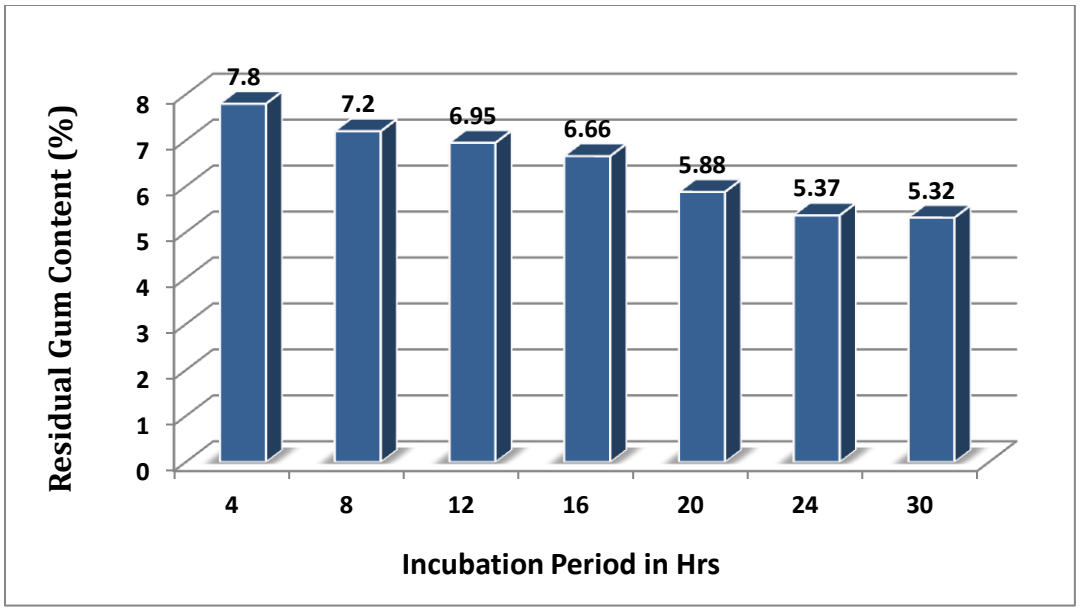


Fig.-3 Effect of incubation period on ramie fibre degumming

The experimental results as shown in Fig.-4 suggest that enzyme formulation used for degumming process in ambient temperature (37^0C to 40^0C), but at higher temperature (50^0C-60^0C) its degumming efficiency is enhanced. At elevated temperature there is a possibility of enzyme de-naturation during prolonged incubation. Therefore temperature of enzymatic degumming is maintained at 37^0C to 40^0C in order to obtain uniform and smooth degumming of ramie fibre.

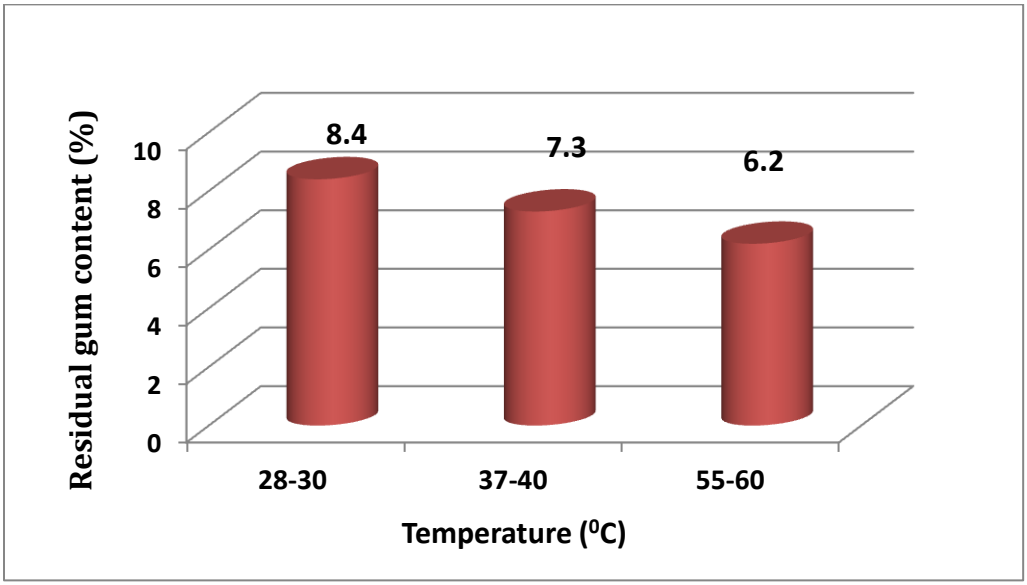


Fig.-4 Effect of temperature on ramie fibre degumming

Optimal process parameters of eco-degumming technology developed for ramie fibre:

- Fibre: Liquor for degumming: 1:5
- pH of the solution: 5.5-5.7
- Enzyme application: 1.0%
- Incubation temperature: 37^0C-42^0C
- Incubation period with enzyme: 24 hours

Pic.-7 Physical demonstration of Eco-degumming process of ramie fibre at IJIRA

7.2 Pilot Plant trials with optimized Eco-degumming formulation and process

Multiple mini pilot scale trials (with each of 10 kgs of ramie fibre batch) with optimized enzyme based degumming process parameters have been carried out at IJIRA Pilot Plant and have been shown in Pic.-7. The eco-degummed ramie fibres have been characterized subsequently to observe the change in physical properties after enzyme degumming action.

Pic.-8 Pilot scale trial of Eco-degumming process at IJIRA Pilot Plant

Characterization of degummed Ramie fibre:

The characterizations e.g. Bundle Strength, fibre fineness of the degummed ramie fibres have been carried out with varying enzyme application (%), incubation time and temperature.

It has been observed that with increase in enzyme concentration, there is a decrease in bundle strength of the ramie fibre. At 1% (w/w) enzyme application, reduction in fibre strength is 8.2% which is not, however, critical and further correlates the findings of optimization of enzyme concentration. As the drop in bundle strength is not much significant, it is expected that loss in strength will have no negative input in subsequent yarn/fabric performance.

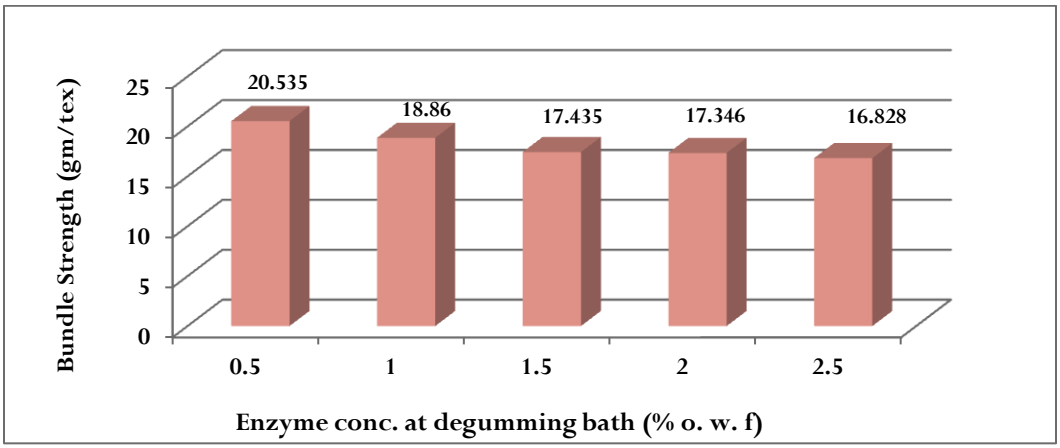


Fig.-5 Effect of enzyme conc. on Strength of degummed ramie fibre

A similar trend has been observed in fineness analysis (Fig.-6). Improvement in fibre fineness has been observed with the increase in enzyme application, quantifying removal of non-fibrous gummy material due to enzyme action during degumming process. Eco-degummed finer ramie fibre is a better substrate for subsequent spinning of finer count yarn.

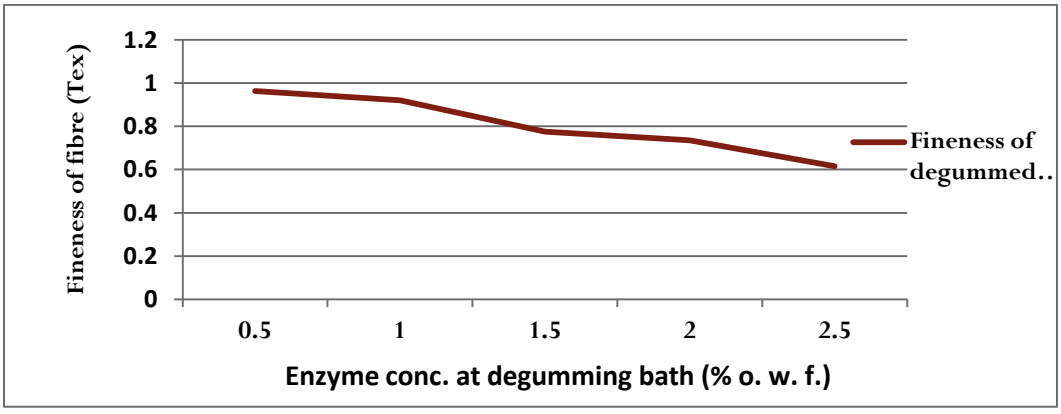
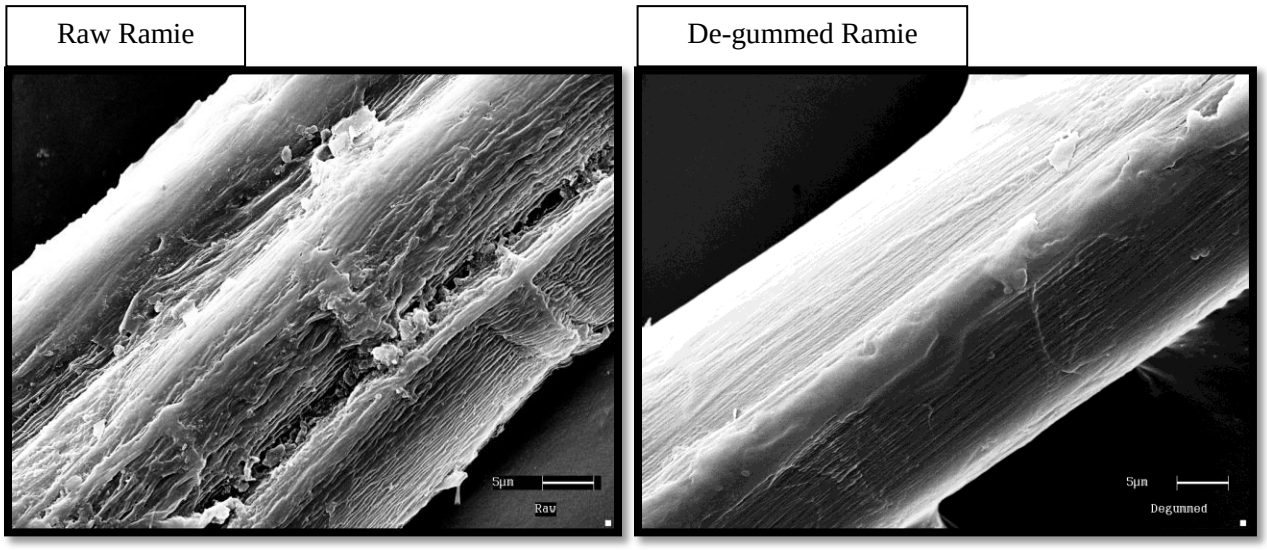


Fig.-6 Effect of enzyme conc. on Fineness of degummed fibre

Subjective assessment of the enzymatic degummed ramie fibre and effectiveness of degumming process has been carried out through the Scanning Electron Microscopic study (Pic.-9).



Pic.-9 Characterization of degumming Ramie fibre - SEM Pictures

Remarks:

Degumming' is the most crucial aspect for successful processing of ramie fibre as it contains 25-30% pectic colloidal substances (gum) which needs to be removed in highest possible extent (degumming) without compromising fibre properties and performance. As a sustainable alternative to the existing degumming technologies commonly practiced in the Indi,a a user friendly degumming technology has been developed in laboratory scale exploring bio-technological (enzymatic) route. A cocktail of enzymes has been judiciously formulated with market available varieties viz. Hemi-cellulase, Pectinase etc. and applied on decorticated ramie to get individual degummed fibres.

The newly developed degumming process has been optimized taking into consideration the cost of the process and performance of the degummed fibre. Different characterization techniques have been used for evaluation of degumming efficiency and respective fibre properties. The enzyme based degumming process developed for ramie fibre can be used effectively at ambient condition and hence would be farmers friendly.

7.3 Field trial of Eco-degumming process technology at North Eastern Region

A technology validation cum field trial of eco-degumming technology developed by IJIRA has been carried out using optimized degumming formulation at the ramie cultivation field in NE Region. The field trial was conducted in collaboration with CRIJAF (ICAR), Barrackpore, Kolkata and Ramie Research Station (RRS), Sorbhog, Assam at RRS, Sorbhog, Barpeta Dist., Assam.

In the field trial, the efficacy of the developed technology under actual field application has been examined. The potentiality of the process for lab to bulk conversion has also evaluated. One tonne of freshly decorticated ramie has taken under the trial. The characterization of the fibres obtained during the field trial has been carried out and compared against the pilot trial sample subjected to the identical degumming process. The degummed fibres have been brought to AI Champdany Industries Ltd. (Unit- Wellington Jute Mill, Rishra) for industrial processing of fibre.

7.3.1 Summary report of Field trial

I. **Reference**: Collaborative filed trial of eco-degumming technology developed by IJIRA under Jute Technology Mission project no.-19 (MM-IV, DDS-2/7.1) carried out in collaboration with CRIJAF (ICAR), Barrackpore, Kolkata and Ramie Research Station (RRS), Sorbhog, Assam.

II. **Trial duration:** 5th December'2011 to 30th December'2011

III. **Trial venue:** Ramie Research Station (RRS), Sorbhog, Barpeta Dist., Assam and its associated ramie cultivation field

IV. **Details of the Trial:**

Material details:

a. Ramie:

The trial was carried out on one tone of fresh decorticated fibre which was procured from RRS, Sorbhog, Assam. The ramie was harvested during the month of November'2011 and first week of December'2011. The whole lot was consisted of few qualities among them R-1411 was the major.

b. **Chemicals:**

a) Enzyme solution; b) Citrate buffer media; c) Fibre lubricant; d) pH stabilizing chemical

c. Electrical heating arrangement:

Electrical heating arrangement was arranged to maintain a temperature around 35^0C to 40^0C of the degumming bath as due to winter season the surrounding temperature was at lower side.

Process details:

a. **Preparation of degumming tank:** The cement tank (10'X10'X10') was washed thoroughly and then coated with synthetic paint to prevent any shorts of contamination that can hinder the enzyme action.
b. **Hand tearing of the ramie bundle:** The bundle of raw ramie is briefly opened up by manual tearing of the bunch of fibres. This gentle tearing action helped the degumming solution to penetrate well into the fibre bundle.
c. **Wetting of the fibre bundles:** The opened up fibre bunches are immersed into the water at the degumming tank and impregnated thoroughly. Ramie bundles are kept at immersed condition for 2-3 hours then washed well to bring out the remnants of bark and leaves.

		
Preparation of Degumming Tank	Supply of bulk quantity of ramie	Impregnation of ramie into the degumming tank

Pic.-10 Pictures of the field trial

d. Degumming of ramie:

- Fibre to Liquor Ratio (F: L) of the degumming bath was 1:5.
- 100 Kg fibre was processed per batch
- Sodium Citrate and Citric Acid in combination were used to prepare the Citrate media
- The degumming bath temperature was kept to 35^0C to 40^0C.
- 0.5% dozing of enzyme was done on the weight of the fibre
- The wet fibre bundles are immersed into the degumming bath and 24 hours of incubation time was given
- The degummed fibres are washed thoroughly with fresh water
- As per requirement, degummed fibre was treated with fibre lubricating solution

e. Drying of degummed ramie fibre:

After degumming process the wet fibre are dried by exposing them in sunlight and open air. The bamboo posts were set up for the said purpose. Before taking them in sunlight the fibre bundles are opened up completely along with gentle manual tearing.

	
Ramie fibre after degumming & washing	Drying of ramie at open air/sunlight

Pic.-11 Pictures of the field trial

	
Demonstration of process to the review team	Visit of officials to RRS, Sorbhog

Pic.-12 Visit of members of Project Management Committee during field trial

7. Observations:

The bulk scale degumming of one tonne of ramie was successfully carried at the cultivation field of ramie in NE Region. The prototype set up for bulk scale degumming was established due to the trial. Since the trial was carried out in the mid season of winter, the surrounding temperature was very low specially during the night. As the enzyme action is dependent upon the bath temperature and the trial was carried out in the field itself, even though the heating system was arranged the degumming efficiency of few batches might be lower due to lower surrounding temperature. From one tonne of raw ramie 840 Kgs of degummed ramie was obtained that directly implies 16% loss of weight owing to degumming action.

7.3.2 Detailed Report on Residual Gum Content after Degumming at field trial

The residual gum content in the eco-degummed ramie fibre obtained during the bulk scale degumming trials has been represented below:

Table-15 Residual gum content of eco-degummed ramie fibre, degummed at field level

Lot No.	Sample No.	Process Parameters	Residual Gum Content of decorticated ramie (%)	Residual Gum Content of Degummed fibre (%)
I.	1	• F/L : 1:5 • pH: 5.5-5.7 • Application: 1.0% • Incubation Temp.: ***Normal*** • Incubation period: 24 hrs	23.6	10.55
	2		24.4	12.64
	3		23.9	11.33
II.	1		24.3	14.26
	2		24.9	14.65
	3		25.5	15.49
III.	1		24.6	15.17
	2		24.7	15.96
	3		24.2	15.43
IV.	1		24.1	12.02
	2		23.8	10.25
	3		24.0	11.54
V.	1		27.8	16.75
	2		28.3	16.81
	3		27.4	16.38
Average			**25.0**	**13.95**

The results represented in Table-15 indicates that the average residual gum content of the degummed ramie fibre obtained after field trial is considerably higher as compared to laboratory scale degummed fibre. Although the average gum content of the raw material is similar in both the cases.

Though the process parameters for both laboratory scale and field level degumming trials were identical the ambient condition differs in case of field trial. The optimum temperature suitable for degumming is in the range of 37^0C to 55^0C which was efficiently maintained during laboratory scale degumming experiments. Since the field trial of eco-degumming process has been conducted in the open ramie cultivation land at RRS, Sorbhog during winter season the optimized incubation

temperature could not be maintained to the desired level. The efficacy of the eco-degumming formulation is found to be dependent on the degumming process condition. Hence, the desired scale of degumming has not been achieved during field trial.

To obtain the desired efficiency in the bulk scale degumming with eco-degumming technology, it has been advised to establish a centralized degumming system (a simple fermentation plant) preferably in the ramie growing areas at NE Region for upholding the optimized degumming parameters during eco-degumming of ramie.

7.3.3 Characterization of degummed fibres from Field Trial

The products of field trial i.e. eco-degummed ramie fibres were characterized at IJIRA Testing laboratory. Both the physical and chemical characterizations of fibre were carried out.

Table-16 Comparative test results of raw and degummed ramie fibre obtained from Field Trial

Sr. No.	Test Parameters	Raw Ramie	Degummed Ramie
1	Moisture Regain (%)	11.5	9.5
2	Real Density (g/cc)	1.2	1.5
3	Bulk Density (g/cc)	0.27	0.37
4	Fibre Fineness (Denier) Avg. of 20 tests	13.54	10.12
5	Bundle Tenacity (g/tex) Avg. of 30 tests	23.01	18.60
6	Single Fibre Tenacity (g/tex) Avg. of 50 tests	30.58	28.61

7.3.4 Tentative Cost of Degumming

For commercial scale degumming of ramie following IJIRA developed enzymatic method, no additional infrastructure/ capital investment is needed. The cost of degumming has been calculated based on actual expanses during bulk scale degumming performed in the farmers' field at NE Region. Costing is, therefore, estimated on the basis of actual cost of ramie fibre (provided by RRS, Sorbhog), enzymes and other chemicals considering their commercial price.

Cost of Enzymatic Degumming / MT of Ramie Fibre

Cost of Raw Ramie	: 60,000/-	
Cost of Chemicals	: 6100/-	Cost of enzyme degumming Rs. 14,755/-
Cost of Enzyme	: 7,155/-	
Processing charges	: 1,500/-	
Loss in wt. during degumming	: 140 Kg.	
Remaining fibre weight	: 860 Kg.	
Actual cost of fibre (per Kg)	**: Rs. 86.92 (Rs. 74,755 / 860 Kg)**	
Cost of Degumming (per Kg)	**: Rs. 17.16 (Rs. 14,755 / 860 Kg)**	

7.4 Processing Jute & Ramie fibre in blends at conventional "Jute Spinning System"

Ramie being longer and finer natural fibre poses a big challenge to process and spin ramie fibre satisfactorily utilizing available spinning systems in our country. While blending with other natural fibres like jute, the judicious selection of process sequence and machinery helps in controlling the yarn quality and characteristics [27].

In the ongoing study, the experimental trials have been carried out to process and spin fine quality of yarns with 100% ramie and jute-ramie blends in conventional jute spinning system for exploring the suitability of the process.

7.4.1 Pilot Plant trials for spinning of Ramie & Jute-Ramie blends in Jute Spinning System

With degummed ramie fibre (degummed with IJIRA developed enzymatic degumming process) and jute (Semi-Northern TD-4, Semi-Northern TD-5, Daisee TD-4) mini-pilot scale trials (in batch of 10 kgs) have been carried out at IJIRA Pilot Plant to spin fine yarns in conventional jute spinning system. Fibre properties (Table- 17) of input fibres have been characterized prior to processing. Yarns of 100% ramie, 50:50 jute-ramie blends and 100% jute yarns have been produced under identical processing set up. Subsequently the properties of the yarns have been compared. To incorporate ramie in jute processing system some minor process modifications have also been worked out.

Properties of fibres used for Pilot trial

The properties of the feed materials i.e. the degummed ramie and jute have been assessed prior to the trial. The properties are represented in the following tables.

Table-17 Properties of degummed and bleached ramie fibre

Properties	**Degummed & Bleached ramie**	**Raw jute (100% SN TD4)**
Avg. fibre fineness (tex)	0.92	2.19
Bundle Tenacity (gm/ tex) Avg. of 30 tests	18.82	17.60
Single fibre strength (gm/ tex) Avg. of 50 tests	32.40	27.59
Residual Gum Content (%)	5.88	-

Details of the machinery used for Pilot Plant trial

- **Softener** : Indigenous type having 8 pair of fluted rollers
- **Breaker Card** : J. F. Card; 2½ circular
- **Finisher Card** : J. F. Card; 2½ circular
- **Drawing** : Screw Gill drawing frames (1st, 2nd & Finisher Drawing frame of Lagan)
- **Spinning** : Mackie's 4¼" Apron Draft (AD) spinning frame

Modifications in the Conventional Jute Processing System

Degummed ramie fibre being softer and finer demand special care to accommodate it in jute spinning system, as a result few minor modifications have been carried out in the conventional processing practice which is normally being performed for making jute yarn for conventional hessian cloth.

Pic.-13 Hacking of fibre

- ***'Hackling' of ramie fibres prior to softening stage:*** The fibres obtained after degumming process exhibited residual gum content in the range of 5 to 8%. Thus, few portion of the fibres found to be stuck together. In order to eliminate those agglomerated fibres a gentle kneading or hackling action was introduced prior to softening of ramie.

- ***Stapling of long fibre to the shorter "Staple Length":*** During several experimental trials it has been observed in the carding stage frequent fibre lapping occurred when full length ramie strands (3'-4') were feed directly to the Breaker Card. Different staple length like 12", 8" etc. have been tried where 8" (20cm) staple length worked efficiently. To keep the process identical, the raw jute has also been cut in the said staple length during processing.

- ***Reduction in emulsion application % for processing of ramie:*** The moisture absorption and retention capacity of ramie has been found to be higher than jute. In the experimental trials, it has been observed that application of 25% or more emulsion creates difficulties during the carding. Frequent lapping, lump formation have been experienced during the trials. Ramie fibre softening with 12-15% emulsion helps in trouble free subsequent processing. While blending with jute, slightly higher moisture application improves the drawing and spinning performance.

- ***Four stages Drawing process:*** While drawing of ramie sliver in conventional jute processing system it has been found that penetration of the gill pins into the fibre fleece is not fully effective due to more compactness of the sliver. Hence, the number of drawing stages has been increased to assist in gradual attenuation of fibre and better management of floating fibres.

These process modifications have been carried out to stabilize the process for producing 100% ramie and 50:50 jute-ramie blended yarns during the spinning trials at IJIRA Pilot Plant.

Process Flow Chart for Pilot Plant Trial on spinning of Ramie & Jute-Ramie blended yarns

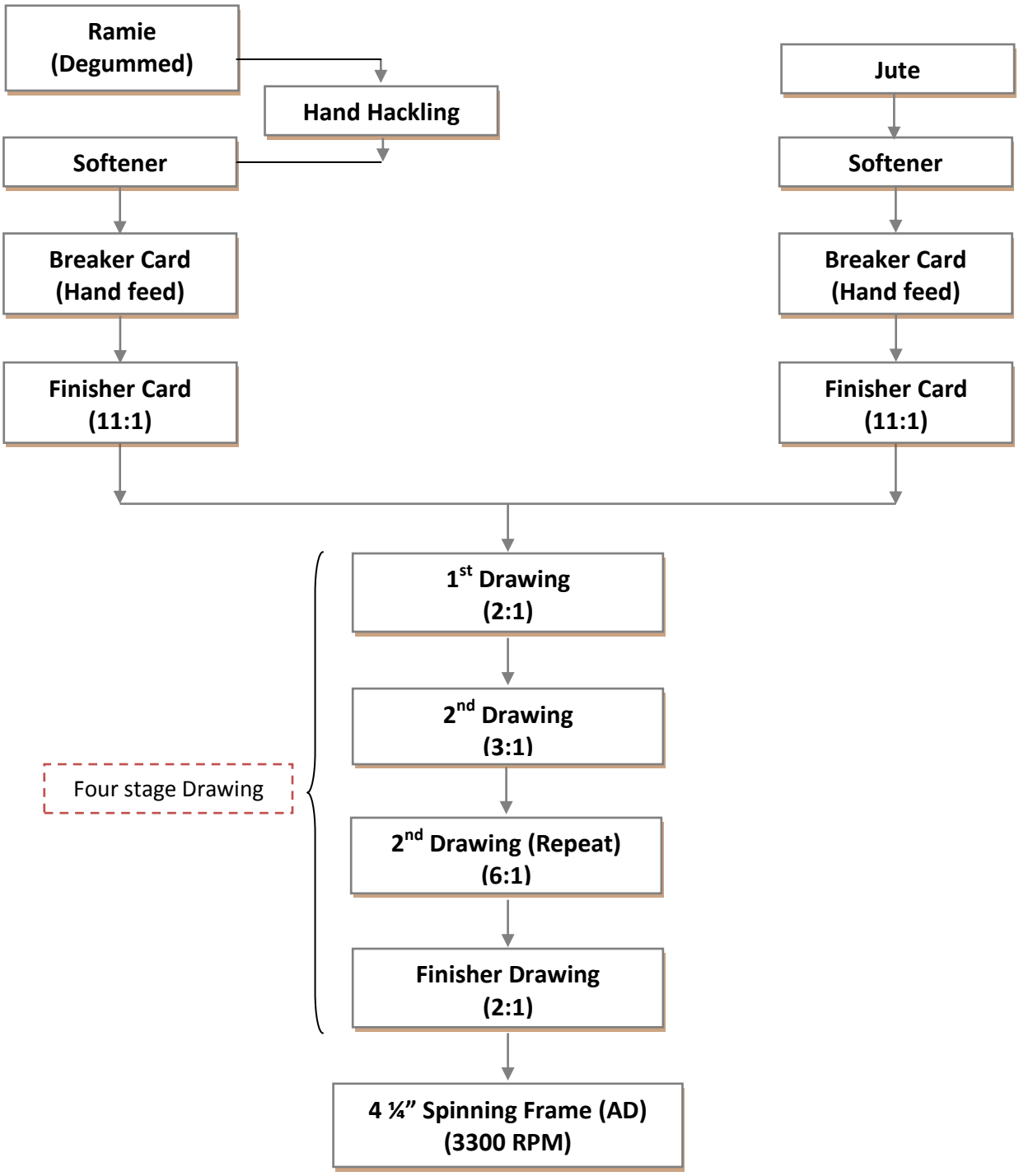


Fig.-7 Process Flow Chart on spinning of Ramie & jute-ramie blended yarns

Process parameters of the Pilot Scale trial at IJIRA Pilot Plant

Table-18 Process parameters for spinning of 100 % ramie yarn (count 6.5 lb/spy)

Processing Stage	**Process Details**			
	Avg. Sliver Wt. @16% MR	MR%	Draft	Doubling
SOFTENER	• Emulsion application=15 % • Piling duration=72 hrs			
BREAKER CARD	19	18	14	-
FINISHER CARD	13.57	17	14	10:1
1ST DRAWING	7.55	15	3.5	2:1
2ND DRAWING	3.87	15	6.0	3:1
2nd DRAWING (Repeat)	3.87	14	6.0	6:1
FINISHER DRAWING	117.55 (lb/spy)	14	9.5	2:1

Table-19 Process parameters for spinning of jute- ramie blended yarn (count 6.5 lb/spy)

Processing Stage	**Process Details**			
	Avg. Sliver Wt. @16% MR	MR%	Draft	Doubling
FOR RAMIE				
SOFTENER	Emulsion application=15 % Piling duration=72 hrs			
BREAKER CARD	19	18	14	-
FINISHER CARD	13.57	17	14	10:1
FOR JUTE				
SOFTENER	Emulsion application=30 % Piling duration=24 hrs			
BREAKER CARD	20.5	28	14	-
FINISHER CARD	16.10	24	14	11:1
BLENDING OF JUTE:RAMIE = 1:1				
1ST DRAWING	8.48	19	3.5	2:1
2ND DRAWING	4.23	18	6.0	3:1
2nd DRAWING (Repeat)	4.23	16	6.0	6:1
FINISHER DRAWING	128.52 (lb/spy)	15	9.5	2:1

- Draft @ Spinning frame (AD): 18

7.4.2 Characterization of yarns developed in Pilot Plant trial

Table-20 Comparative analysis of yarn tensile properties

Type	Count in lbs @ 16%MR	Quality Ratio	Strength CV%
100% Ramie	6.5	86.56	27.35
50:50- J: R	7.0	82.71	21.99
100% Jute	7.2	94.56	14.95

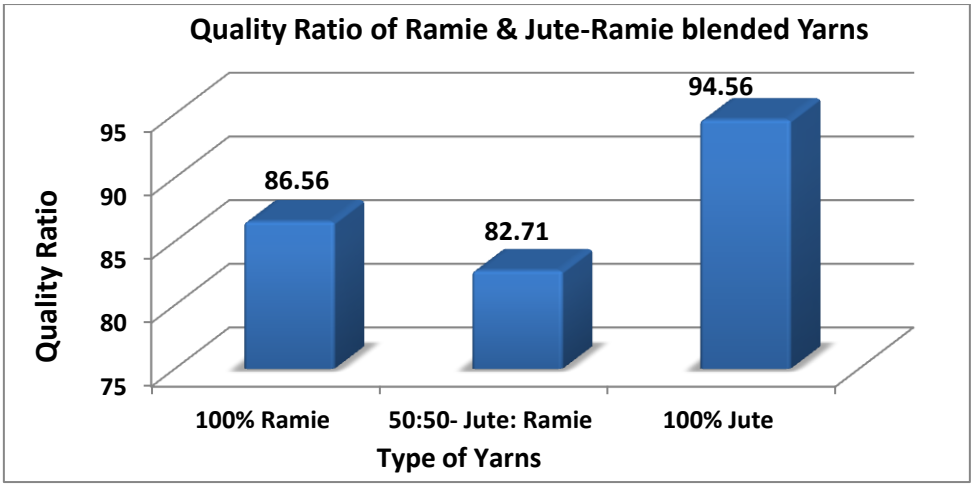
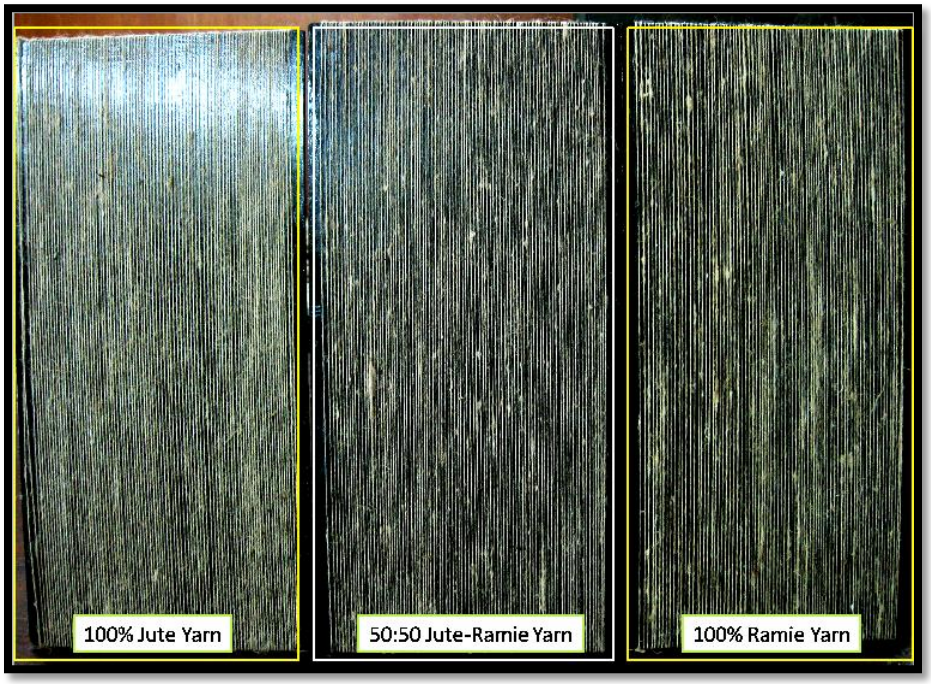


Fig.-8 Comparative analysis of tensile properties of yarns

Visual Assessment of yarn evenness by Black Board Estimation



Pic.-14 Black Board Estimation of three types of yarns

Test Parameters

- Board length : 45.60 cm
- Board Thickness : 2.49 cm
- No. of wrap : 87
- Test length : 87.25 yds

Table-21 Comparative analysis of yarn Appearance

Sl. No.	Type	Slub count/100 yds (@+50% of yarn Dia.)	Count of Neps/ 100yds (@+400% of yarn Dia.)	Subjective Appearance
1	100% Ramie	27.98	17.0	Poor
2	50:50- Jute: Ramie	14.04	11.0	Poor
3	100% Jute	3.44	3.0	Good

Remarks:

- From the above mentioned yarn parameters it has been observed that though the processing of the jute/ramie blends has been run moderately on the jute processing system, but it demands more fibre control in the drafting system.

- It is apparent that the QR% of 100% ramie yarn is almost 12% less than 100% jute yarn where as the Bundle Tenacity is higher for ramie. It is needless to mention that fibre with higher strength would give stronger yarn whereas here it is reflecting the opposite phenomenon. Hence processing systems with finer pin density needs to be explored for better filamentation of ramie for getting better utilization of the individual fibre strength in the final yarn.

Pic.-15 J-R blended yarn produced in Jute Spg. System

7.5 Development of appropriate route for manufacturing of fine Ramie and Jute-Ramie blended yarns exploring "Modern Spinning System"

Ramie being longer and finer natural fibre, poses a great challenge to process and spin ramie yarn satisfactorily utilizing commonly available spinning systems. Both short staple spinning system viz. cotton spinning and long staple spinning process viz. worsted spinning system have been explored for spinning of 100% ramie/ ramie in blends with other natural fibres. Particularly Semi-Worsted spinning system having Combing and Intersecting Gill Drawing stages have found to be suitable for processing of ramie fibre [28].

The advantage of semi-worsted system against the contemporary other spinning processes is its capability to accommodate longer as well as finer fibres which are prone to form neps. In the entire processing sequence due care has been taken to avoid formation of neps as well as removal of them prior to spinning. However, the semi-worsted system is not widely available in India.

In search of a suitable and economically viable alternative route for processing and spinning of 100% ramie and jute ramie blends, an appropriate processing sequence have been identified which is basically a combination of Jute spinning system and Semi-worsted spinning system. The machinery facilities have been found under the mills of AI Champdany Industries Ltd., one of the leading industries in the jute sector. The industrial trials for manufacturing of fine quality yarns from ramie and jute-ramie blends have been carried out in two identified jute mills having the desired process set up.

7.5.1 Industrial trials for spinning of Ramie & Jute-Ramie blends at participating mills

With degummed ramie (processed with IJIRA developed enzymatic degumming process during the field trial at NE Region subsequently brought from Sorbhog, Assam) and jute (Northern TD-4) the industrial trials have been carried out initially at Wellington Jute Mill, Rishra, followed by trial at Anglo India Jute Mill, Jagatdal. Both the mills have the machinery set up as identified by IJIRA. Fibre properties (Table- 22) of both ramie and jute have been assessed prior to their uses.

Mainly four qualities of yarns namely 100% ramie, 50:50 jute-ramie, 80:20 jute-ramie blended and 100% jute yarns have developed under identical processing conditions. Subsequently the properties of the ramie and jute-ramie blended yarns have been compared with jute yarns in terms of tensile properties, evenness and aesthetic appeal. Further experimental trials have been undertaken for

producing yarn with lowest possible count from ramie fibre and jute-ramie blends by using ring spinning machines.

By using the fine yarns of different qualities viz. ramie, 50:50 jute-ramie blends, 80:20 jute-ramie blends and 100% jute yarn varieties of fabrics have been developed on high speed automatic looms for value added home furnishing applications.

7.5.1.1 Details of the Industrial Trials

a) Properties of fibres used in Industrial Trial

The properties of the feed fibres as represented below have been assessed prior to process

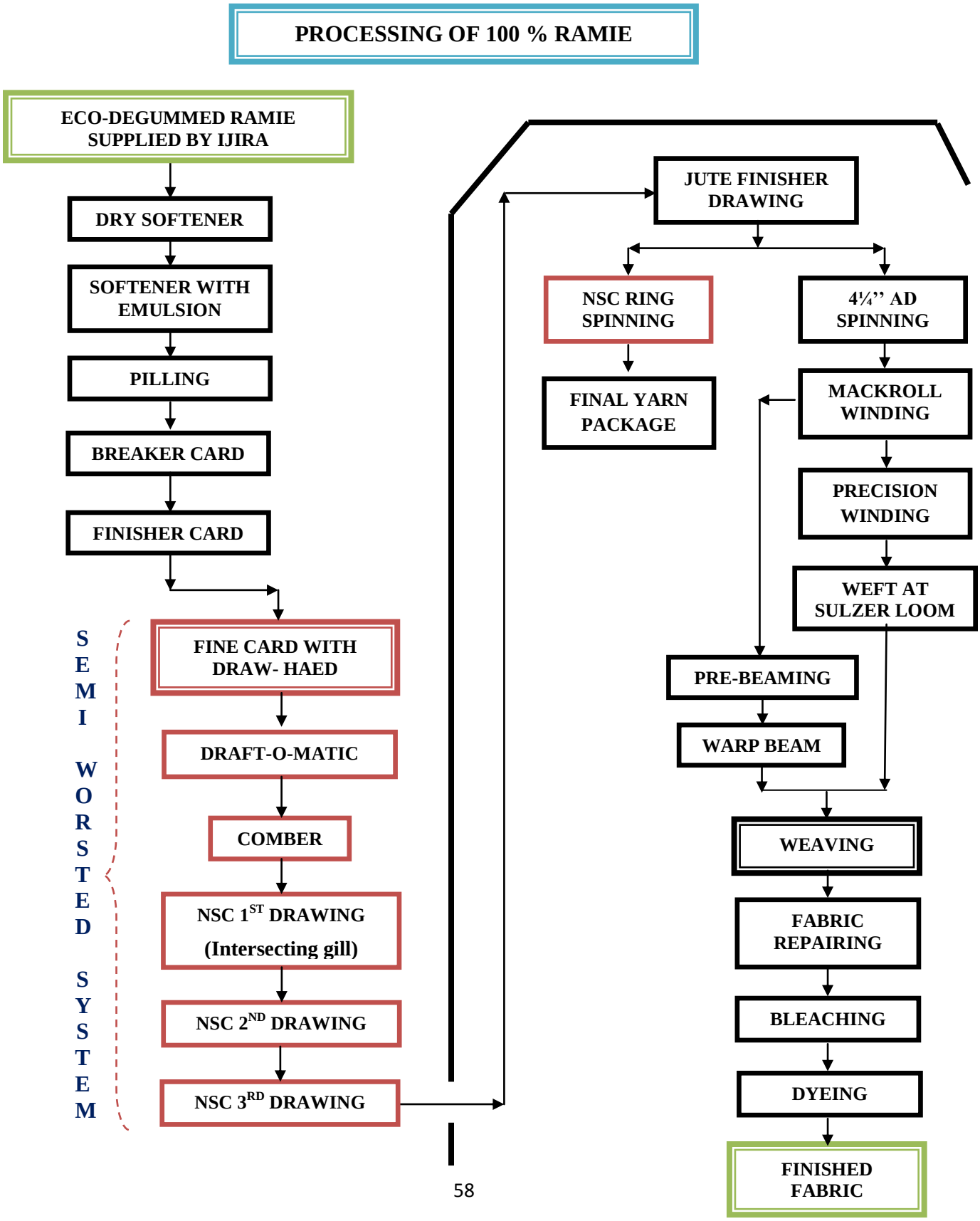
Table-22 Properties of degummed ramie fibre

Sr. No.	Test Parameters	Degummed Ramie
1	Moisture Regain (%)	9.5
2	Density (g/cc)	1.5
3	Fibre Fineness (Denier) Avg. of 20 tests	10.12
4	Bundle Tenacity (g/tex) Avg. of 30 tests	18.60

Table-23 Properties of raw jute fibre (provided by the mill)

Properties	Jute fibre used in the trial
	N-TD4
Bundle Tenacity (gm/tex) at 16% MR (Avg. of 30 tests)	16.40
CV%	13.64
Avg. fibre Fineness (Denier)	18.72

Process Flow Chart for Industrial Trial on spinning of Ramie & jute-ramie blended yarns (Wellington Jute Mill)



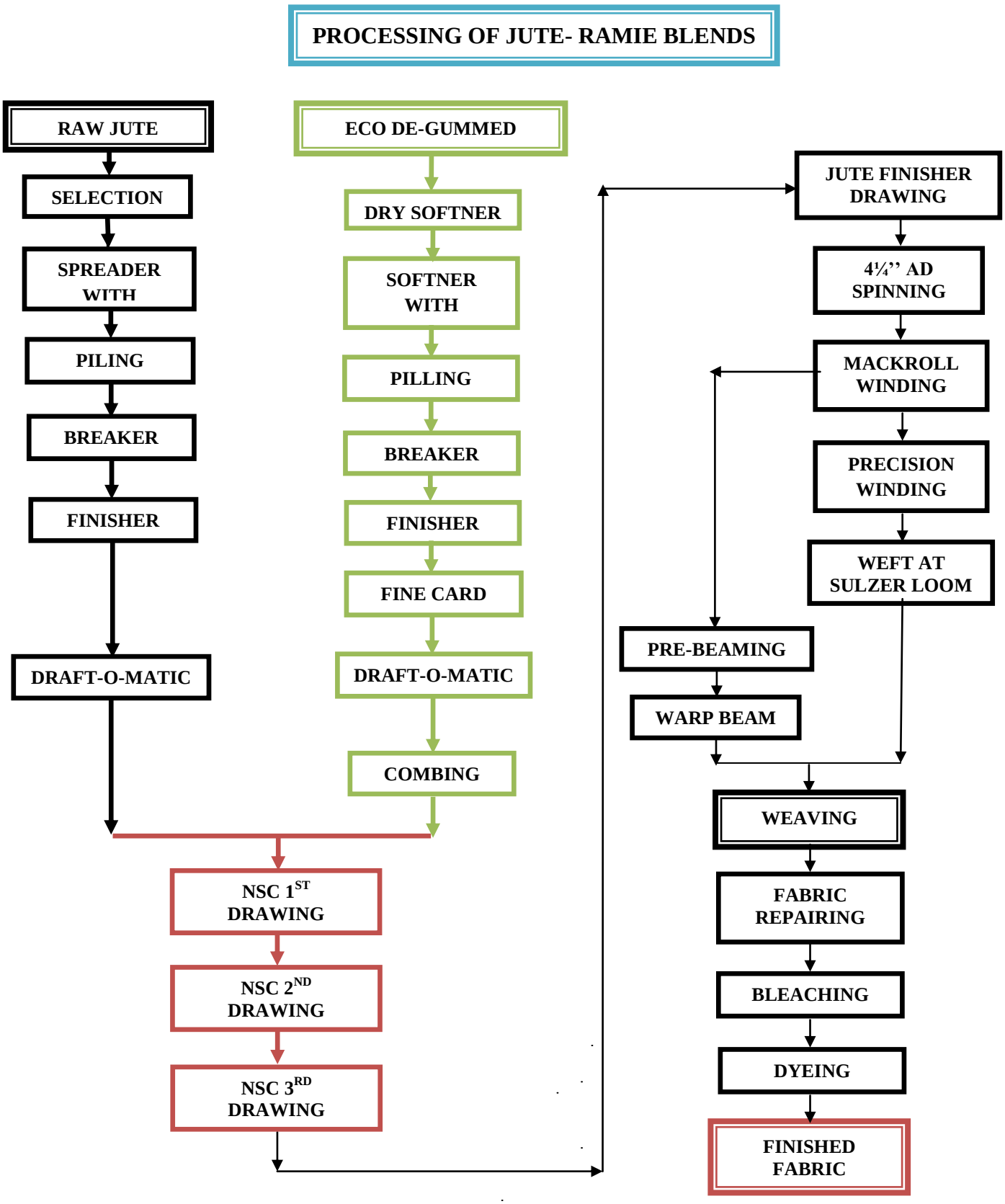


Fig.-9 Process Flow Chart for Industrial Trial on spinning of Ramie & jute-ramie blended yarns

b) Machine & process parameters for spinning of Ramie & jute-ramie blended yarns followed in Industrial Trial (at Wellington Jute Mill)

Table-24 Machine & Process Parameters for 100% Ramie yarn (of 4.5 lb/ spy)

PROCESSING STAGE	Machine Type	Process Details				
		Avg. Sliver Wt. (lb/100yds) @14% MR	MR%	CV%	Draft	Doubling
1. DRY SOFTENER	24 pair of rollers	-	-	-	-	-
2. WET SOFTENER	24 pair of rollers	• ***Emulsion application=34 %*** • ***Piling duration=72 hrs***				
3. BREAKER CARD	Mackie's 2 ½ pair	20	36	6.20	14	-
4. FINISHER CARD	Mackie's 4 ½ pair Full Circular	14.95	32	5.73	14	10:1
5. FINE CARD WITH DRAW HEAD	Mackie's 7 ½ pair Double Doffer	6.51	27	3.90	20	9:1
6. DRAFT-O-MATIC	Mackie	7.04	24	4.66	6.2	8:1
7. COMBER	NSC PB22	1.80	14	2.29	-	5:1
8. NSC 1ST DRAWING	NSC GN4	2.64	12	2.03	5.2	6:1
9. NSC 2ND DRAWING	NSC GN4	2.69	11	1.62	5.2	6:1
10. NSC 3RD DRAWING	NSC GN4	2.70	11	1.92	5.2	6:1
11. FINISHER DRAWING	Mackie	83.24 (lb/spy)	9	2.11	9.0	2:1

Table-25 Machine & Process Parameters for 100% Jute (To be used in Jute-Ramie Blends)

PROCESSING STAGE	Machine Type	Process Details				
		Avg. Sliver Wt. (lb/100yds)	MR%	CV%	Draft	Doubling
1. Raw Jute	-	Avg. morah wt. = 1.14 Kg	11.3	12.54	-	-
2. SPREADER	***Emulsion app.=22.4% Piling time – 24 Hr.***	77.81	31.5	12.85	-	-
3. BREAKER CARD	Mackie's 2 ½ pair	17.63	26.4	3.61	14	-
4. FINISHER CARD	Mackie's 4 ½ pair Full Circular	12.18	23.6	2.48	16	11:1
5. MONO HEAD	Mackie's	6.59	22.0	1.19	3.5	2.1
6. DRAFT-O-MATIC	Mackie	7.23	21.0	1.51	6.2	6.1

Table-26 Machine & Process Parameters for 80:20 Jute - Ramie Blend processing (4.5 lb/spy yarn)

- *Count of combed sliver 100% Ramie- 1.8lb/100 yds :1*
- *Count of D-O-M sliver of 100% Jute- 7.2lb/100 yds :1*

PROCESSING STAGE	**Machine Type**	**Process Details**				
		Avg. Sliver Wt. (lb/100yds)	MR%	CV%	Draft	Doubling
NSC 1ST DRAWING	NSC GN4	2.66	17.5	1.06	7.2	1:1
NSC 2ND DRAWING	NSC GN4	2.69	17.0	1.62	7.8	8:1
NSC 3RD DRAWING	NSC GN4	2.70	17.0	1.92	8.7	8:1
FINISHER DRAWING	Mackie	84.26 (lb/spy)	17.0	1.67	9.0	2:1

Table-27 Machine & Process Parameters for 50:50 Jute - Ramie Blend processing (4.5 lb/spy yarn)

- *Count of combed sliver 100% Ramie- 1.8lb/100 yds :4*
- *Count of D-O-M sliver of 100% Jute- 7.2lb/100 yds :1*

PROCESSING STAGE	**Machine Type**	**Process Details**				
		Avg. Sliver Wt. (lb/100yds)	MR%	CV%	Draft	Doubling
NSC 1ST DRAWING	NSC GN4	5.09	20.0	0.55	5.3	4:1
NSC 2ND DRAWING	NSC GN4	2.68	19.5	1.68	5.5	4:1
NSC 3RD DRAWING	NSC GN4	2.69	19.0	1.62	5.8	6:1
FINISHER DRAWING	Mackie	85.25 (lb/spy)	19.0	2.75	9.0	2:1

Table-28 Machine & Process Parameters for 100% Jute yarn (of 4.5 lb/spy)

PROCESSING STAGE	**Machine Type**	**Process Details**				
		Avg. Sliver Wt. (lb/100yds)	MR%	CV%	Draft	Doubling
Raw Jute	-	Avg. morah wt. = 1.14 Kg	11.3	12.54	-	-
SPREADER	Emulsion app.=22.4%	77.81	31.1	12.85	-	-
BREAKER CARD	Mackie's 2 ½ pair	17.63	26.4	3.61	14.0	-
FINISHER CARD	Mackie's 4 ½ pair Full Circular	11.25	23.6	2.10	16.0	11:1
MONO HEAD	Mackie's	5.45	22.0	2.52	4.0	2.1
DRAFT-O-MATIC	Mackie	5.33	21.0	2.02	6.2	6.1
FINISHER DRAWING	Mackie	85.04 (lb/spy)	20.0	4.25	9.0	1:1

c) Spinning of Yarns:

The four types of ramie and jute-ramie blended yarns have been spun in the identical spinning conditions. A single spinning frame (4¼" AD) engaged to spin simultaneously all four types of yarns where 25 spindles for each quality have been allocated.

Spinning parameters:

- Machine: 100 spindle 4 ¼" Apron Draft Frame (Lagan)
- Machine RPM= 3300
- Machine set draft: 18.75
- Machine Set Twist: 6.5

The spinning performance has been found to be good for 100% ramie yarn and the performance of the jute-ramie blends was comparatively better than 100% jute yarn. Though spinning performance has been found satisfactory and the overall yarn Breakage Rate was 82 breaks/ 100 spindles/ hour. Doff weight could not be measured as the number of spindles dedicated to a single quality are too less.

d) Characterization of yarn and comparative analysis:

The fibre, sliver and yarn qualities have been measured at IJIRA Lab. The stage wise results are given below.

Stage wise Fibre Fineness study for 100% Ramie Fibre (by Vibroskope)

Table-29 Fibre Fineness of ramie at different stage of processing

Sl. No.	Processing stage	Fibre fineness (Denier)	Corresponding value in Tex
1	Breaker Card	8.88	0.98
2	Finisher Card	6.86	0.76
3	Draw Head	6.72	0.74
4	Draft-o-Matic	6.08	0.67
5	Comber	8.54	0.95

It is apparent from the above table that fibre fineness has been remained largely same during processing. At initial stage of Carding, a sharp fall in fibre fineness could be seen due to splitting of fibres which are partially degummed. In subsequent stages, fibre fineness has remained unaltered.

Stage wise Fibre Length study for 100% Ramie Fibre

Table-30 Fibre Length of ramie at different stage of processing after filamentation

Long Fibre Length (mm) (Minimum fibre length attained by specified % of fibres)	**Breaker Card**	**Finisher Card**	**Fine Card + Draw Head**	**Draft-o-Matic**	**Comber**
95%	11.4	11.2	11.0	9.7	13.7
75%	54.2	29.8	21.9	26.8	34
50%	107.2	69.5	43.1	57.4	65.7
25%	166.2	116.7	84.6	90.5	104.8
10%	211.2	182.6	132.7	129.6	137.2
5%	232.2	208.1	178	149.8	156.2
3%	256.0	234.9	201.4	163.5	170.1
1%	258.2	254.3	220.0	178.1	185.7

During processing of ramie fibre through the prescribed process route, the fibre length has been decreased at the subsequent carding stages as shown in the Table-30. The average fibre length improves considerably at the combing stage due to removal of short fibres from the fibre fleece.

Comparative data of fibre fineness and fibre length at corresponding stages of processing is given in below Table.

Table-31 Representative results of fibre Length and Finenss of ramie at different stage of processing

Parameter	**Breaker Card**	**Finisher Card**	**Fine Card +Draw Head**	**Draft-o-Matic**	**Comber**
Average Fibre fineness (Denier)	8.88	6.72	6.86	6.08	8.54
Mean fibre Length (mm)	113.8	83.9	59.9	64.3	72.2

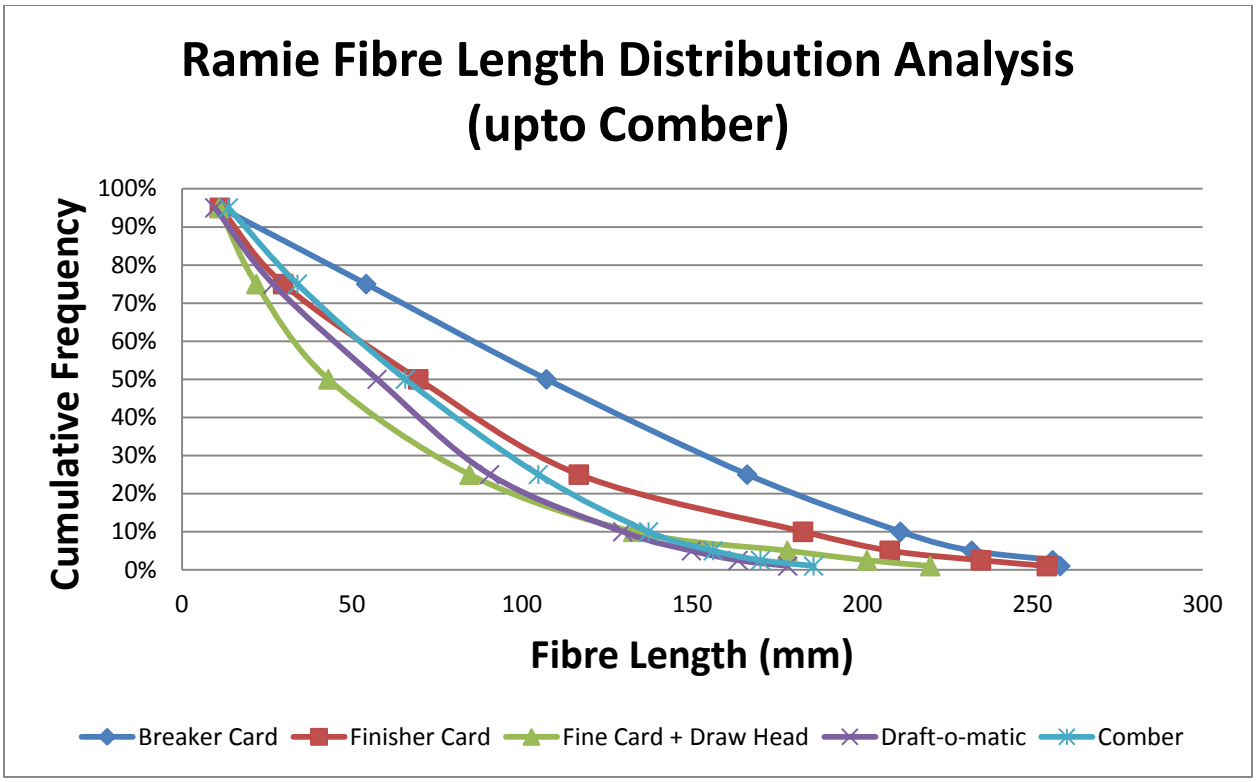


Fig.10 Fibre Length Distribution of Ramie at different stages of processing

The above table (Table-31) is indicating that the mean fibre length has been decreased in subsequent carding stages of mechanical processing upto combing process. During the carding stages the decline in the mean fibre length is sharp. It might happen due to prolonged carding action (Three stages of carding).

Interestingly, in subsequent stages e.g. Draw Head & Combing there is an improvement in average fibre length owing to removal of short fibres in combing process.

Comparative analysis of yarn quality vs. physical properties

Table-32 Comparative yarn quality and physical properties

Type of yarn	Grist (@14%MR)	Count CV%	Avg. Breaking Strength(lb)	Strength C.V (%)	Quality Ratio	TPI
100% Jute	4.22	2.11	2.65	29.22	**65.59**	6.17
80:20 J-R blended	4.23	3.38	3.47	20.08	**82.03**	6.64
50:50 J-R blended	4.65	0.48	4.33	15.17	**94.54**	6.66
100% Ramie	4.53	2.90	5.42	15.77	**117.06**	6.58

The improvement of properties of jute yarns/products has been the prime focus of this R&D study. The result of Table-32 is actually establishing that blending of ramie considerably enhanced the tensile properties of blended yarns as compared to pure jute yarn processed in identical condition. A gradual increment has been observed as the ratio of ramie in the blends has been increased. Hence, the similar properties of the blended yarns would be translated in the fabric/products also.

Comparative analysis of Yarn Evenness

Table-33 Comparative results of yarn irregularity evaluation

Test Speed: 200m/min; *Test Duration: 2.5min*

Sl. No.	**Average Yarn Parameters**	**100% Ramie**	**50% Ramie 50% Jute**	**20% Ramie 80% Jute**	**100% Jute**
1.	Yarn Count (tex)	160	158	150	139
2.	CVm%	33.87	30.21	29.06	32.61
3.	CVm% (1m)	14.35	12.91	12.69	14.93
4.	CVm% (3m)	10.66	8.9	8.88	10.89
5.	CVm% (10m)	8.06	6.29	5.81	8.01
6.	Thin Place/km (-50%)	2695	2106	2341	2218
7.	Thick Place/km (+50%)	1640	1681	1588	1326
8.	Thick Place/km (+100%)	326	194	87	187
9.	Neps/km (+200%)	2303	1373	1131	1261
10.	Hairiness	11.73	15.28	17.48	18.88

The yarn evenness results (Table-33) indicate that among the four varieties of yarn 100% ramie yarn have higher thick and thin places. On the other hand, 100% ramie yarn also represents minimum hairiness which is a considerable positive sign as it directly correlates the appearance of developed yarn. However, the yarn imperfections could be minimized through appropriate process control during the mechanical processing of ramie fibres.

Trial for manufacturing of fine Ramie & Jute-Ramie blended yarns (At Anglo India Jute Mill)

The positive results of the experimental trials at Wellington Jute Mill, Rishra have inspired to carry out trial for producing yarns with minimum possible count from ramie and jute-ramie blends by using ring spinning machine with same slivers processed at Wellington Jute Mill.

Anglo India Jute Mill, Jagatdal have been selected for conducting the said experimental trial as the mill has facility of upgraded Ring spinning machines.

a) Spinning of Yarns:

Four types of ramie and jute-ramie blended fine yarns (count <2.0 lb/spy) are spun in the NSC Ring Spinning Frame from the slivers processed at Wellington Jute Mill. The fine yarns were produced successfully at the ring spinning system suitably adjusting the speed of the machine. Process parameters and yarn properties are given in the Table-34

Table-34 Spinning parameters and yarn properties

Type of yarn	Machine Specification	Speed (RPM)	Draft	Avg. Grist (@14% MR)	Avg. T.P.I
100% Jute	NSC Ring Frame Mod. No.- CF 32D Ring dia.- 3" Lift- 14" Traveler No.- 150	3700	2.5x9.1=27.75	2.2	8.6
80:20 J-R blended		3700	2.5x9.1=27.75	2.3	8.6
50:50 J-R blended		5000	3.8x9.1=34.58	1.6	13.2
100% Ramie		5000	3.8x9.1=34.58	1.2	13.2

b) Comparative analysis of yarn quality vs. physical properties

Table-35 Physical properties yarns developed in the Trial (Anglo India Jute Mill)

Yarn Parameters	Quality of Yarn			
	100% Ramie	50:50 Jute-Ramie	80:20 Jute-Ramie	100% Jute
Avg. count (lb/spy) @14% MR	1.18	1.56	2.26	2.20
Wt. CV%	6.34	6.53	4.51	6.42
Avg. Br. St. (lb)	1.24	0.89	1.59	1.28
Strength CV%	21.15	36.35	27.05	34.34
Quality Ratio	**105.08**	**70.57**	**58.09**	**56.92**

REMARKS:

Available varieties of ramie fibre (both un-degummed and degummed) are difficult to process in available spinning systems for producing finer yarns. In this experimental study ramie fibre has been efficiently blended with Jute in different blend proportions (Ramie: Jute – 100:0; 50:50; 20:80) to produce Jute-Ramie blended fine yarns of count upto < 2lb/spy, something difficult to produce with pure jute fibre in commercial scale. Innovative processing and spinning route (combination of Semi-worsted and Jute spinning machines) has been identified to manufacture Jute-Ramie blended fine yarns having some alteration in existing industrial jute spinning setup.

7.5.1 Industrial trials for manufacture fabrics from Ramie & Jute-Ramie blends yarns

Three qualities of fabrics of have been produced from the four types of yarns namely 100% Ramie, 50:50 Jute-Ramie blends and 100% Jute yarn developed during the spinning trials. The fabrics having construction (67x67, 220 GSM) have been developed to replace the existing market available similar type jute cloths of construction 67x67, 220 GSM.

The details of the fabric properties have been shown below:

Table-36 Properties of fabrics developed in industrial trials

Sl. No	Warp yarn quality	Weft yarn quality	Effective Blend Ratio (J:R)	Ends/dm	Picks/dm	GSM
1.	100% Ramie	100% Jute	50:50 J-R	66	66	226.7
2.	-do-	100% Ramie	100% Ramie	68	67.5	223.5
3.	100% Jute	100% Jute	100% Jute	66	65	225.2

7.6 Commercialization of the developed Technologies

Under this R&D project ramie fibre degumming, processing, spinning and fabric manufacturing with degummed ramie & jute have carried out successfully using IJIRA developed technologies. Technology validation cum field trial of IJIRA developed degumming technology has been performed at farmers' field in NE Region. The industrial trials of the processing technologies have been conducted at two different units of AI Champdany Industries Ltd. (Unit- Wellington Jute Mill, Rishra & Anglo India Jute Mill, Jagatdal) where fine quality of ramie yarns (<2lb/spy) and jute-ramie blended yarns have been

spun efficiently. Different types of fabrics from jute-ramie/ ramie-cotton blends have been developed. Subsequently bleaching and dyeing of samples carried out to flourish their appearance. The quality of yarns and developed fabrics may be suitably utilized as value added home textiles.

The IJIRA developed technologies have been validated both in laboratories and in mill shop floor. Although the techno-commercial feasibility of the process needs to be ascertain in bulk scale production system. Hence, some more cumulative efforts both from R&D institutes, Agriculture/farming communities and Govt. agencies are required for in-field implementation of the proposed technologies by Public Private Partnership mode.

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भारतीय मानक ब्यूरो IS / ISO9001
BUREAU OF INDIAN STANDARDS QMS

Ref No.: WQ / IJIRA / 15 / 12 Date: 26.08.2012

To
The Director,
IJIRA
17, Taratala Road.
Kolkata - 700088

Sub.: Development of Technology for Manufacture Ramie Based Product Under JTM-19.

With reference to the above, we like to inform you that an industrial trial of the abovementioned project has been carried out at our mills for producing different types of Jute/Ramie blended yarn, grey, bleached & dyed fabric from 28.03.2012 to 11.06.2012 under the guidance of your scientist Mr. A. K. Nandi, and Mr. D. K. Biswas,. The enzyme de-gummed ramie fiber was supplied by IJIRA which had been processed in our units to develop different types of jute blended yarn and fabrics. The bleaching and dying process also performed to produce home textiles for different use.

The further study may be explored for its techno economical feasibility.

Thanking you,

Yours Faithfully

(P. Chatterjee)
President

Pic. - 16 Letter of acknowledgement from the participating industry

Snap shots of industrial trials on processing Jute-Ramie blends

Hackling of ramie

Carding at Fine Card

Combing process

Spinning at Ring Spg. frame

Ramie blended yarns

Fabric manufacturing at loom

Different Jute-Ramie based yarns & fabrics

Review of Project activities

Pic.-17 Snap shots of industrial trials carried out at participating mills

8.0 Product development at Decentralized Sector in collaboration with SMEs

One of the critical gaps for popularizing Ramie fibre in India is improper marketing strategy. Eventually, there is no available profit model of cultivation and production of Ramie fibre to the farmers. After development of the sustainable technologies for ramie processing, IJIRA has taken initiatives within the scope of the project to build up a model supply chain for manufacturing Jute-Ramie based products at cottage level in collaboration with an identified small scale entrepreneur. Innovative products especially home decor & home furnishings have been developed by exploring conventional indigenous technologies at the domestic level. The profit model is an iconic example to the ramie dwellers for visualizing the profit lying underneath.

New products have been developed with eco-degummed Ramie fibre & Jute by exploring indigenously available technologies with a SME, Roots & Yards who have their set up in various places in rural Malda and Murshidabad. Products including varieties of hand-spun export quality yarns, Indo-Tibetan carpets, home decorative have been designed and developed.

8.1 Product Development at Cottage level

The hand spun yarns have been developed utilizing the primitive art of spinning which is commonly called as Khadi. Resource of rural artisans in the village level was provided by Roots & Yards. Blended yarns like 80% Ramie-20% Cotton; 40% Ramie-40% Jute-40% Cotton have been also developed by hand spinning technology.

Pic.-18 Hand spinning of yarn

Hand spun ramie yarns have been suitably used in manufacturing of the Indo-Tibetan carpets. Indo Tibetan carpet is a modern concept of doing handloom carpets in fashionable bend. The following products have been developed at cottage level.

Pic.-19 Hand spun Ramie yarns

- Hand spun ramie yarns in natural shade of different counts
- Hand spun ramie bleached yarns of various counts
- Indo Tibetan Carpet of cut pile in natural colour with bleached geometric pattern
- Indo Tibetan carpet of loop cut style in natural shade
- Geometric pattern modern design of Indo Tibetan carpets.
- Jute ramie blended braided carpet
- Ramie, cotton and jute based discharged printed and surface embellished bed linen
- Ramie, flax and cotton blended printed and surface embellished table linen

8.2 Market response for the new products

Hand spun jute yarns were introduced in the hand-made carpet industry in 6/7 years back. Apart from jute, demand of other natural fibers in carpets is also increasing rapidly. The exporters are looking for hemp, banana and other vegetable fibres to come to carpet/home furnishing industry as new products. The inclination towards vegetable fibres is vividly seen in the foreign market due to the global consciousness of health and nature. In countries like Australia and UK rug users are giving preferences to vegetable fibres rather than wool. Handloom carpets look very crafty and that make them feel to be very close to the nature and man.

Pic.-20 Making of carpet at Malda

Chemicals are used for the finishing of woollen carpets to minimize shredding. On the other hand jute hand spun carpets leave more shreds than wool or viscose. When it comes with ramie hand spun yarns, customers get a perfect solution. The tensile strength is much higher than wool, cotton and silk as well as shredding of ramie fibres in carpets are found to be much less, hence widely accepted by the customers at the first look. In the DOMOTEX HANNOVER 2011, one of the worlds' reputed trade shows on home furnishings, samples of ramie carpets/home decor products were introduced from India. Very optimistic reports and feedback have been received from the buyers' end.

Pic.-21 Decorative carpets with ramie

Pic.-22 Decorative carpets with jute-ramie blends

9.0 Conclusion with future scope of work

Under Jute Technology Mission project (MM-IV, DDS 7.1/2; Serial No.-19) the critical technological issues related to eco-friendly degumming of ramie and their subsequent mechanical processing and spinning into quality yarns and products have been addressed.

A farmer's friendly enzyme based degumming technology for ramie fibre has been developed, and standardized. Optimization of the enzymatic degumming process has been carried out both at laboratory and also in farmer's field through multiple field trials.

Appropriate process technology for mechanical processing of ramie fibre into fine yarns have been identified by multiple industrial trials at participating jute mills.

Marketable jute-ramie based products have been developed and test marketing of them has also been carried out. There is increasing demand for ramie based products in India. North Eastern states of India have been identified to have good potential for promotion and extension of ramie based textiles. In nutshell it can be concluded that

- An **appropriate low cost post harvesting eco-degumming technology for ramie** fibre has been developed keeping in mind its future implications to ramie growers
- **A new avenue has been explored for the JDPs** by developing jute-ramie based value added products along with its prospective technology.
- **Popularizing ramie in NE Region has been initiated** to ensure economic growth of ramie grower.

Scope of Extension of R&D Work

- Building up of Eco-degumming setup at NER in PPP model
- Extensive promotion of jute-ramie based JDPs which are superior in functionalities and appearance.
- Development of defined Supply Chain of ramie fibre for Decentralized sector
- Possibility of import substitution of ramie in Indian scenario.

References

1. *Fibre Policy Report*, 2010, Ministry of Textiles, Govt. of India
2. P. Satya et al., *Possibilities for Reducing Gum Content in Ramie by Genetic Modification of Pectin Biosynthesis Pathway*, Indian Journal of Experimental Biology, 2010, 3(3), p. 261-264.
3. S. Mitra et al., *Ramie: A Promising Fibre for Diversified Uses*, CRIJAF (ICAR), Barrackpore, Bulletin no. 24/2009
4. M.N. Saha, M. Samaddar, D. Ghorai, *Ramie: Cultivation & Diversified uses*, CRIJAF (ICAR), Barrackpore, Bulletin no. 8/2006
5. *Need assessment survey of market for Jute-Ramie blended JDPs*, Indian Jute Industries' Research Association, 2009
6. D. P. Singh, *Ramie (Book)*, 1997. CRIJAF, Barrackpore, Kolkata
7. S. N. Pandey, *Ramie fibre: part II. Physical fibre properties. A critical appreciation of recent developments*, Textile Progress, December 2007, Vol. 19. No. 4, p. 189-268
8. A. C. Chakravarty, S. K. Sen and P. C. Das Gupta, *Studies on Ramie Fibre: Part I The effect of gum content on the Physical Properties of Ramie Fibre,* Journal of Textile Association, 1972, 33, p. 73
9. G. Basu and A.N. Roy, *Blending of Jute with Different Natural Fibres*, Journal of Natural Fibres, 2007, Vol. 4(4), p. 13-29
10. S. N. Pandey, *Ramie fibre: part I. Chemical composition and chemical properties. A critical review of recent developments*, Textile Progress, March 2007, Vol.39. No. 1, p. 1-66
11. P. C. Das Gupta, K. Sen, S. K. Sen, *Degumming of Decorticated Ramie for textile purposes*, Cellulose Chemistry and Technology, 1976, 10, p. 285
12. P.C. Dasgupta and S.K Sen, Gum of ramie fibre. *Proceedings of 58th Science Congress*, 1971, p. 184
13. P.C. Das Gupta and S.K. Sen. *Indian Patent 137-237 (1962)*
14. A. Kundu and A.B. Roy, Jute Bull. 25, 1962. p. 150.
15. L. Zheng, Y. Du, J. Zhang, *Degumming of ramie fibers by alkalophilic bacteria and their polysaccharide-degrading enzymes*, Bioresource Technology, 2001, 78, p. 89-94
16. F. Bruhlmann et. al., *Pectinolytic Enzymes from Actinomycetes for the Degumming of Ramie Bast Fibers*, Applied And Environmental Microbiology, June 1994, Vol. 60, No. 6, p. 2107-2112
17. B. Wang, D. Peng, L. Liu, Z. Sun, N. Zhang, and S. Gao, *An efficient adventitious shoot regeneration system for ramie (Boehmeria nivea Gaud) using thidiazuron*, Botanical Studies 2007, 48, p. 173-180.

18. F. Bruhlmann, M. Leupin, K. H. Erismann, A. Fiechter, Enzymatic degumming of ramie bast fibers, Journal of Biotechnology, 2000, 76. p. 43–50
19. X. Yuchui, *An investigation of ramizyme degumming process. Proceedings of 1st International Symposium on Ramie Profession*, Chang.sha. Hunan. China. 1989, p. 358-360
20. S. Majumder, A. B. Kundu, S. Dey & B. L. Ghosh, *Enzymatic Retting of Jute, International Biodeterioration*, 1991, 27, p. 223-235
21. S K Chattopadhyay and M. Ahmed, *Blended Textiles for Niche Market from Natural Fibres*, www.cicr.org.in, 2006-07
22. M. C. Mazumder, S. K. Sen and P. C. Das Gupta, *Blending of Ramie with Jute for fine yarn production*, Indian Textile Journal, 1975, January, vol. 85, p. 135
23. G. Basu and A.N. Roy, *Blending of Jute with Different Natural Fibres*, Journal of Natural Fibres, 2007, Vol. 4(4), p. 13-29
24. M. C. Mazumder, S. K. Sen and P. C. Das Gupta, *Processing of Degummed Ramie in Jute Machinery*, Indian Textile Journal, 1976, January, vol. 86, p. 87
25. S.K. Dey and S.K. Bhattacharya, *Perspective use of Ramie Fibre in Blends with Jute*, Proceeding of 24th IJIRA Technological Conference, 2002, p.123
26. T. Sen and H. N. J. Reddy, *Various Industrial Applications of Hemp, Kinaf, Flax and Ramie Natural Fibres*, International Journal of Innovation, Management and Technology, June 2011, Vol. 2, No. 3, p. 192-198
27. A.K. Ganguli, R.N. Aditya, N.C. Som, *Development of Products from Blends of Jute and Natural and Synthetic Fibres on Jute Spinning System- I&II*, Man-made Textiles in India, 1980, 23 (7 & 8), p. (317-331; 410-417)
28. S.O. Perum, B.N. Iliev, H.A. Zoneva, B.L. Ilieva, Method of production of Fine (Hemp) Jute Yarns or Like., 1985, EP 0, 129, 724: 2nd January, 1985. Priority Application: Bulgaria. Patent Classification D10G.

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