UTILISATION OF JUTE BY-PRODUCTS: A REVIEW

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ABSTRACT

Jute (the golden fibre) has been cultivated in India since time immemorial. About 5 million people get employment in jute farming, trading and industry though the crop occupies only 0.55% of the gross cropped area of the country. The traditional usage of jute has been sustained in packing as hessian, sacking, and carpet backing. However, in recent times jute has application prospects that ranges from geo-textiles to apparel, carpet, decorative items, upholstery, home furnishings, fancy non-woven etc. Though the diversification of jute fibre made it a very attractive industrial commodity, the farmers are not able to reap the benefits through its cultivation. Moreover, jute bye-products viz. jute leaves, jute stick, jute caddies (mill waste) and jute root cuttings are not used efficiently. If these bye-product resources can be utilized properly poor farmers will be benefited and it will be a boost to our national economy.

Key words : Jute fibre, Jute stick, Jute Caddies, Root cuttings, Particle board, Composite.

Jute fibre is obtained from two cultivated species viz. C. capsularis and C. olitorius. These are known as ‘white’ and ‘tossa’ jute respectively. In India, the plant is cultivated in the states of West Bengal, Bihar, Uttar Pradesh, Assam, Meghalaya, Orissa, and Tripura. The other jute producing countries are Bangladesh, China, Nepal, Myanmar, Thailand and Indonesia.

The plant parts after extraction of fibre viz. leaves, root cuttings, sticks and mill waste, caddies are not used properly. Therefore, the farmer get a very low return to this cash crop. However, if these parts can be utilized effectively in the development of value added products it will strengthen the economy of poor farmers.

Production statistics

The state wise jute production during last three years is shown in the table below. It shows that West Bengal and Bihar are the leading jute growing states in India. The total area under jute cultivation is about 0.80 million hectares and the production about 10 million bales i.e. 1.8 million tones.

Conventional uses of Jute

Jute is not only a major textile fibre but also a raw material for non traditional and value added non-textile products. Jute is used extensively in the manufacture of different types of traditional packaging fabrics, manufacturing hessian, saking, carpet backing, mats, bags, tarpaulins, ropes and twines. Recently jute fibres are used in a wide range of diversified products: decorative fabrics, chic-saris, salwar kamizes, soft luggage’s, footwear, greeting

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cards, molded door panels and other innumerable useful consumer products. Supported by several technological developments today jute can be used to replace expensive fibres and scare forest materials. The production of diversified jute products, consumer products, fashion products carving out new export market. The Indian Jute Industries Research Association (IJIRA) in association with Indian Jute Industry has recently developed Hydrocarbon free jute bags- a food grade jute bags and cloths confirming to international standard specifications. These bags are used for packaging food stuffs and in great demand throughout the world.

**Jute by-products**

Jute fibre, the main product is extracted from the bast of plants by retting which is a method of separation and loosening of the fibres from the sticks by decomposition of the cementing materials by microbial action. Apart from the fibre, the plant consists of useful parts that can be utilized in various economical ways.

**Jute stick**

Jute stick i.e. the woody core of jute plants left after the fibre is taken away on completion of retting is the major agro-residue (Pandey et al., 1995). It constitutes about 40 percent of the green plant. While the leaves are mostly used as manure, about 80 percent of the sticks are used as fuel wood by villagers and 15 percent as structural materials for fencing. But it is a potential raw material for production of particle boards, paper and paper boards. In view of depletion of forest resources and the government legislation in favour of preservation of forestry, there has been a scarcity of lignocellulosic materials for production of boards and paper goods. Jute stick falls under the category of hardwood and the annual production of jute sticks in the country is around 3.0 million tones (Bhattacharyya and Paul, 2006).

The technology of making particle boards from jute sticks by disintegrating the sticks to the required mesh, mixing them with binders like phenol formaldehyde, urea formaldehyde, melamine formaldehyde resin at 10-14 percent of the raw material followed by subsequent curing at high temperature (140-160°C) and pressure (10 kg/cm²) have been widely accepted and the particle boards are now being made commercially. The mechanical properties of the boards such as impact strength, flexural and tensile strength, sound and thermal insulation properties, nailing and screwing properties have been found suitable for use of boards for interior decoration, furniture, packaging, sound boxes, etc. Colour particle boards were also developed from jute sticks dyed with synthetic dyes and lamination of the boards is possible with polyethylene or polyester to add to the consumer appeal of the products.

Jute sticks, waste jute fibre or even the dried jute/mesta plants and seed plants can be pulped by chemical and chemi-mechanical processes viz. soda, kraft, alkaline sulphite processes etc. for making paper sheets, paper boards, paper bags both on a large or rural scale. Biopulping of jute sticks has been possible with basiomycetes phenerochaete chrysosporium and a combination of biopulping with mild chemical treatment can yield pulp and paper from jute stick at a low cost. Biopulping is environment friendly because the discharge of effluents will be very low in such processes. Jute sticks are very bulky and, therefore, using them as fuel or in the pulp and paper sector is difficult for handling, storage and transportation point of view. This problem can be overcome if sufficient compaction of the sticks is made by briquetting. The compacted materials can well be used for pyrolytic gasification in running IC engines, the calorific value of the briquettes being around 5000 kcal/kg. Several other products can be made from jute stick as follows:-

i) **Oxalic Acid**: A method of making oxalic acid from jute sticks by alkali and nitric acid fusion has been optimized.

ii) **Charcoal**: High grade charcoal having 90 percent carbon and low volatile content can be
obtained by pyrolysis of pressed sticks at about 5000°C in presence of inorganic salts for 2 hours. The charcoal can be used as a raw material for manufacture of carbon disulphide.

iii) **Viscose rayon**: Rayon grade pulp can be made from jute sticks by xanthation and subsequent regeneration of cellulose.

iv) **Carboxymethyl cellulose**: The material is very useful in making detergents, pharmaceutical formulations, textile sizing and as an ion exchanger. Carboxymethyl cellulose (CMC) was prepared from semi-bleached and rayon grade pulp with about 1% degree of substitution. 
v) **Furfural**: This solvent required for petroleum refining, synthetic rubber manufacture, preservation of wood and leather can be made from jute sticks by acidic hydrolysis.

**Jute Caddies**

Due to the drastic treatments as above, a lot of short fibres with dust accumulate in the mill floors as droppings and are called caddies. The basic chemical composition of the caddies is more or less similar to that of jute fibre except that it contains residual mineral oil applied at the time of piling. The caddies are the major industrial waste from the jute sector. The proximate analysis of the jute caddies shows the volatile matter at 40 percent, fixed carbon 12-13 percent with gross calorific value as 3200-3300 kcal/kg (Bhattacharyya and Paul, 2006). Jute caddies constitute about 4-6 percent of total jute consumed in the mills. These are mainly thrown away as waste material or charged into the conventional boilers of the mills.

Considering the calorific value of 5200 kcal/kg of coal and 10,000 kcal/kg of mineral oil, 1 kg of jute caddies is equivalent to 0.635 kg of coal or 0.33 kg of mineral oil. (Samani et al., 2003). Jute mills are energy intensive where either electrical or steam energy is consumed for running the machinery continuously. It is estimated that energy cost is 8 percent of the total cost of production. The efficiency of jute caddies as a fuel can be increased by compaction and briquetting as discussed earlier or by: (a) thermochemical conversion such as pyrolysis which is heating at high temperature with limited supply of oxygen, and (b) generation of biogas and utilization of the spent slurry in biogas production for manuring or for growing mushroom. Both these processes are environment friendly. Biogas

<table>
<thead>
<tr>
<th>State</th>
<th>Area (Mha)</th>
<th>Production (Mb)</th>
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<td>0.610</td>
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<td>1.055</td>
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<td>0.647</td>
<td>0.060</td>
<td>0.626</td>
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<td>0.006</td>
<td>0.050</td>
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<tr>
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<tr>
<td>Others</td>
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<td>-</td>
<td>0.011</td>
<td>0.043</td>
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<td>Total</td>
<td>0.792</td>
<td>10.316</td>
<td>0.814</td>
<td>10.219</td>
<td>0.786</td>
<td>9.634</td>
<td>0.810</td>
<td>10.486</td>
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Mha : Million Hectre, Mb : Million Bales One Bale = 180 Kg.
containing 55 percent or more by volume of methane can be produced from jute caddies by anaerobic fermentation in digesters using cattle dung as a source of inoculum. The lag period for production of the gas can be reduced by pretreatment of the caddies with mild caustic soda solution. Jute caddies are able to supply higher quantum of biogas due to their slow decomposing nature (Banik et al., 1993). The spent slurry left after biogas production is rich in mineral content and has high C:N ratio (about 100:1). The slurry can well be utilized as a manure for increasing the yield of jute crop by about 50 percent through enrichment of rhizosphere soil (Banik and Nandi, 2000). The slurry can also be utilized to increase the yield of Volvariella volvacea and Pleurotus sajor caju mushrooms when admixed with rice straw in 1:1 proportion to improve the protein and mineral content of the edible fungi. Proper disinfection of straw and biomanure with KMnO4 and formalin ensures contamination free mushroom beds, smooth spawn run and eventually enhancement of yield. Biogas from jute caddies can provide gaseous fuel for use of common people and recycling of spent slurry for manuring and mushroom production can supply protein rich food to them. Thus the industrial wastes are profitably utilized with protection of environment.

Non-woven technology is a forward one for production of fabrics without taking recourse to normal processes of spinning and weaving. (Pandey et al., 1990). This technology stands as a potential alternative to woven technology not only for cost advantage but also for recycling of caddies in a fruitful manner and to incorporate certain properties to the finished products which is not achievable in conventional products. The nonwoven fabrics can be made by: (a) adhesive bonded non-wovens, (b) needle punched non-wovens, (c) stitch bonded non-wovens, (d) thermally bonded non-wovens, and (e) spray bonded non-wovens. Studies on jute non-woven have been made with adhesive bonded and needle punched process mainly and are discussed below.

The jute caddies are cleaned and scoured. The binder is the key material in this process and may be applied in liquid or solid form depending on the binder and the final product to be made. Among the binders, the most important are rubber latex, polyvinyl acetate, polyvinyl chloride, dextrin, carboxymethyl cellulose, phenyl formaldehyde and acrylic resin (Sinha et al., 1975). These are applied either alone or in admixture. The process in brief consists of the following steps:

i) Preparatory step (opening and blending).
ii) Web formation.
iii) Impregnation with the binder.
iv) Drying and curing.
v) Finishing.

All these can be achieved through Callaghan non-woven fabric machine. Needle punching is a method of bonding fibrous fleeces mechanically without application of any binder or chemical (Majumdar et al., 2000, 2001). A board containing a multiplicity of barbed needles is reciprocated at high speed as the fibrous fleece passes under the needles.

Some of the needle punched non-wovens are produced with a support layer known as scrim cloth to improve the strength and stability of the final product. By the needle punching process fabrics from 27 to 3,000 gsm can be made by adjustment of machine parameters such as speed, feed rate, stroke frequency, needle density, punch density, etc. The needle punched non-wovens are totally environment friendly as these are made only with biodegradable jute. The adhesive bonded nonwovens using natural binding agents are also fully biodegradable.

Non-woven jute products have opened up a wide avenue for the jute sector as a number of products for different end uses can be made by adjusting the machine parameters. The potential uses are:

i) Air filters vii) Floor covering and carpets
ii) Automotive cloth viii) Handicrafts
iii) Blankets ix) Interlining in dress materials
iv) Brattice cloth x) Plaidding cloth
v) Disposable bags, disposable fabrics xi) Wall coverings and wipes
vi) Felts xii) Window screens

However, the great scope for jute non-wovens appears to be in the field of geotextiles and agrotextiles. Jute geotextiles have the unique property of holding soil for a particular length of time after which it becomes a part and parcel of soil. It can also hold water to a great extent (5 times of its weight) and release the water slowly when needed. All these properties have been utilized in using jute non-wovens in civil engineering applications for controlling soil erosion, making canal linings, protection of river banks and construction of roads. Jute non-wovens are better than jute wovens to be used as geotextiles because of better filtration and soil retention capacity of the former and it is easier with jute non-wovens to make tailor made products as per structure and contour of soil. Experimental trials have been conducted to construct roads with the non-wovens and the longevity of the roads with the fabrics are better than those where fabrics are not laid. The non-wovens make composites with soil and asphalt under pressure of wheel loads to enhance the life of roads. The jute nonwovens can well withstand the temperature of the heated stone and bitumen mixture.

Jute non-wovens can also be used as agrotextiles in agricultural mulch. It has been found that by application of the agrotextiles, weeds can be controlled to a great extent and the plant growth and fruit bearing are improved obviously due to slow release of nutrients from the fabrics. The non-wovens also arrest after washing of the essential nutrients from the soil to the benefit of vegetation coverage. Due to the same reason, horticultural pots made out of jute non-wovens showed better results as on decomposition, the contents of the fabrics enriched the soil nutritionally and during transport keep the seedlings in healthy condition by providing air and moisture.

Jute caddies can be successfully utilized in making needle punched non-woven fabrics of diverse characteristics (Mitra et al., 1998; Rana et al., 1999). Such non-woven fabrics were found suitable as reinforcing material in making fibre reinforced plastic (FRP) thereby replacing costlier glass fibre. Interior grade composite board was developed by reinforcing jute non-wovens in water soluble thermostetting resin viz., urea formaldehyde while water soluble phenolic resin was used for making exterior grade board which can well substitute plywood. To improve the compatibility of jute fibre and resin chemical or biochemical, modification of the substrates are needed. Besides the cost advantage of jute reinforced composites, the wear and tear of machinery is supposed to be lower when natural fibres like jute are used instead of glass fibre. The lower specific gravity and higher specific modulas of jute have been taken as an advantage to replace glass fibre with jute. A range of composite products were developed with jute non-wovens pretreated with alkali followed by scouring and bleaching. Marked improvement in mechanical properties of composites was achieved by these pretreatments. The products developed include corrugated sheet, cooling tower, fan blade, pipe, wash basin, serving tray, speaker box, automobile components, tool box, traffic signal light case, chair, table top, country boat, etc. The products have been evaluated and some of them are in regular use at NIRJAFT and await commercialization.

Jute Leaves

Jute leaves are the by-products from jute plant. However, it contains all the vital nutrients needed by the human body. It is a rich source of protein, fat, carbohydrate, calcium, phosphorus and vitamins like A, B and C (Shitanda and Wanjala, 2006). One half cup of Jute leaves (approximately 45g) contains 20k, 1.3 protein, 0.3g fat, 3.4g carbohydrates, 0.4g fiber, 87.3 mg calcium, 22.5mg phosphorus, 1330g, beta carotene or 222ug retinol.
equivalent (vitamin A), 1.0mg iron, 202mg thiamin, 0.04mg riboflavin, 0.3mg niacin and 10mg ascorbic acid or vitamin C.

It is observed that jute leaves are good to fight dysenteria, stomach pain and ulcer. It also helps to strengthen the immune system of children who are suffering from cough. The oils extracted from jute leaves are effective to heal skin diseases. Experiments revealed that jute leaves can help people look younger due to its high antioxidant activity and reduces the appearance of wrinkles and fine lines in the face and body.

Therefore, it is evident that jute leaves are quite nutritious and contain many health benefits. Its application in functional foods and hygenic preparations can play a major role in food processing industry, particularly the medicine sector.

**Jute root cuttings**

Another industrial waste in the jute sector is jute root cuttings, which are hard and un-spinnable portion of jute reed detached before processing. These constitute about 30 percent of the raw material and are either wasted to be used as fuel in boilers quite uneconomically or are admixed with other batches of jute to produce coarse yarn. A specific fungus Penicillium corylophium, has been isolated which has been found to soften the hard barks without any adverse effect on fibre cellulose. Application of the fungus with mineral oil emulsion at the time of piling facilitates processibility of the inferior material to make finer products (Paul et. al., 1976; Sarkar et al., 2001). By this process loss of raw materials is also reduced.

**Future prospectus**

With the acute shortage of forest resources, jute sticks can profitably be utilized for making particle board and paper by suitable chemical and microbial treatments or a combination of both. Particle boards can be made more attractive by colouration and lamination.

Jute caddies, the mill waste can be made into adhesive bonded and needle punched non-woven fabrics with a spectrum of application of these non-wovens viz. geotextiles, agrotextiles, blankets, carpets, felts, air filters, plaiding cloth, brattice cloth, handicrafts, upholstery goods, etc.

Jute leaves can be effectively used both as a supplementary food item and medicinal preparations. In the near future it will play a big role in functional foods.

Jute root cuttings which are unspinnable in nature, can be processed by application of suitable fungal treatment. These softened cuttings can be used in the normal processing system of the jute for end uses.

**CONCLUSIONS**

The future of jute crop will depend upon the value added diversified products from jute by-products. With the application of cutting edge technologies emerged from research and development, new products with various end uses will bring sea changes in jute sector. Every portion of agricultural and industrial wastes of jute crop can be processed into useful products by application of physical, chemical, mechanical or biological techniques. Hence in near future, it will help in the socio-economic development of the farmers in villages in particular and national economy in general.

**REFERENCES**


