Review on A Golden Fiber: Jute and its By Products

ABSTRACT:

The use of agricultural waste for any type of uses is limited in developing countries. For this study we have selected Jute i.e. Golden Fiber. The traditional uses of this have been sustained in packing, carpet backing, biomass energy after few operations, handmade paper etc. The aims of this study were therefore (i) To summarize the production data in India State wise and year wise. (ii) Special and specific properties of whole jute. (iii) Uses of jute as per its part: **Jute sticks, Jute Caddies, Jute Leaves, Jute Root Cuttings** in different areas. And after summarize all the uses; it is clear that these parts are not used efficiently. There is some gap between farmers and industrial uses. If these parts can be utilized effectively in the development of value added products, it will certainly strengthen the economy of poor farmers and country also.

Key Words: Jute Sticks, Jute Caddies, Paper, Biomass, Composite.

INTRODUCTION

Natural fiber-based thermoplastic composites are becoming more and more popular worldwide because they are easy to make, cost-effective, and have strong mechanical properties when compared to other types of composites [31]. Furthermore, natural fibers are good for the environment because they can break down naturally, are inexpensive to produce, widely available in nature, and have strong mechanical properties. However, because of intense global business competition, composite makers are looking for new and affordable plant-based materials or their leftovers as an option to natural fiber-based composites [32, 33]. Recently, there has been a renewed focus on researching jute plant cultivation and its various aspects, such as identifying and controlling diseases and pests, developing plant varieties, observing seed and plant variations, sequencing the genome, managing soil and fertilizer, and the retting process [38].

Moreover, scientists are exploring different uses for jute fiber in creating products like fiber-reinforced polymer composites, micro-crystalline cellulose, nano cellulose, activated carbon, jute pulp, and even using it for 3D printing. The increasing interest in jute fibers is mainly because they contribute positively to environmental, economic, and social sustainability [36].

Jute is commonly recognized as a biodegradable, reusable, and environmentally friendly fiber with a shiny golden appearance, earning it the nickname "Golden Fiber." It is an economical plant-based fiber obtained from the stem's inner layer, and it holds significant importance as a fiber, second only to cotton in terms of versatility, global use, and accessibility. Nowadays, natural dyes are gaining popularity in the textile industry due to their sustainability considerations [34,35].

In India, the industrialization of paper is approximately 110 years old, and is continuously increasing year by year. This industry is directly dependent upon the raw materials of cellulose which is obtained from

the forest resources (resources such as hardwood/bamboo etc), agricultural residue (straw and bagasse etc) and waste paper as well. Forest resources are unable to supply the raw materials needed to produce medium- and high-quality paper at the required growth rate, and the pulp made from agricultural residues is of lower quality. In order to meet the demand for high-quality products, it is necessary to search for an alternative to fibrous raw materials. Recently, whole jute or kenaf has gained popularity as a potential source of fibre due to its strengthening qualities, which are comparable to those of hardwood.

"Jute fiber plays an important role in Median economy. It is obtained from two cultivated species viz. C. capsularis & C. olitorius" [1]. "These are known as 'white' and 'tossa' jute respectively. In India, these are 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 (Burma), Thailand and Indonesia". [41]

"The plant parts after extraction of fiber viz. leaves, root cuttings, sticks and mill waste, caddies are not used efficiently. Therefore, the farmers 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 rather strengthen the economy of poor farmers" [2].

"The Jute industry generates about 40,000 tonnes of processing waste as by products, commonly known as *Jute Caddies"* [3]. "The major constituent of this waste is unspinnable jute fiber. The other constituents are batching oil, machine oil, barks and inorganic dirts. These waste materials can be used for a variety 0of purposes, such as the creation of biogas, non-woven goods, biomass energy, and handmade paper. They can also help to further sustainable development" [4].

STRUCTURE:

"The Jute plant is an annual plant and grows to a height of 5- 16 feet and normally do not have significant branches. The diameter of the stem may reach up to 10 to 20 mm on maturity. The stem portion has two distinct zones viz. bark and core. The bark portion becomes loosely attached to core when the plant is dry. The dry bark is dark brown in color and the core (wood) is pale yellow or cream colored" [37].

PHYSICAL AND CHEMICAL PROPERTIES:

The physical properties of Jute raw material are furnished in Table 1. 36% of the total weight of the jute is made up of bast fibre, with core wood making up the remaining 64%. It should be observed that the bulk densities of entire jute and jute bast fibre are significantly lower than those of hardwood and softwood, respectively, and core wood. There are drawbacks to the raw jute fiber's bulkiness in terms of volumetric loading, etc. Impregnation of chips with liquor also is affected due to high bulkiness, as the chips tend to float.

Table 1: Physical Properties

S.N.	Particulars	Whole Jute	Bast Fibre	Core Fibre
1	Ratio of Bast and Core, %	-	36	64
2	Bulk Density, kg/m3	93.4	69.2	110.5

A complete proximate analysis of whole jute, bast fiber and core wood was carried out. The results are furnished in Table 2. Because the bast component contains superfluous silica, the ash concentration of the bast is higher. In comparison, the amount of holo-cellulose in the bark is greater. Thus, a higher α-cellulose concentration in the bark predicts a much higher pulp yield level and an increase in pulp strength at the same time [39].

Table 2: Chemical Properties of Raw Materials

S.N.	Particulars	Whole Jute	Bast Fibre	Core Fibre
1	Ash Content, %	3.58	4.43	1.89
2	Cold Water Solubility, %	4.12	4.51	2.44
3	Hot Water Solubility, %	4.88	8.57	2.98
4	1/10 NaOH Solubility, %	26.21	30.05	23.30
5	Alcohol Benzene, %	2.65	3.73	2.75
6	Klasson Lignin, %	21.13	15.30	24.23
7	Acid Soluble Lignin, %	1.04	1.10	1.20
8	Holo-cellulose, %	79.50	81.40	75.50
9	α- Cellulose, %	43.52	54.72	36.50
10	β- Cellulose, %	19.88	14.60	25.90
11	λ – Cellulose, %	16.15	12.08	13.10
12	Pentosan, %	15.3	14.57	16.04

‘‘A lot of short fibers with dust gets accumulated on the mill floors as droppings, and are called Caddies. The basic chemical composition of caddies are more or less similar to that of jute fibers except that it contains residual of mineral oil applied at the time of Piling. In jute sector of Industries the major industrial waste product is Caddy. The proximate analysis of the jute caddies shows a volatile matter at

40 percent, fixed carbon 12-13 percent with gross calorific value as 3200-3300 kcal/kg [5]. Jute caddies constitute about 4-6 percent of total jute consumed in the mills. The jute caddies are cleaned and scoured. The key component in this process is the binder, which can be applied in either a liquid or solid state depending on the binder and the finished product. The most significant binders include acrylic resin, rubber latex, polyvinyl acetate, polyvinyl chloride, dextrin, carboxymethyl cellulose, and phenol formaldehyde". [41] They can be used separately or in combination. The steps in the procedure are as follows, to put it briefly:

1. *Preparatory step (opening and blending)*
2. *Web formation*
3. *Impregnation with the binder*
4. *Drying and curing*
5. *Finishing.*

Production Statistics:

"The jute industry is one of the oldest and most important industries in India. The main states producing jute are West Bengal, Assam, Bihar, Orissa, and Andhra Pradesh, with West Bengal being the most significant due to having more mills. Around 3.7 lakh workers are employed in the industry, including those connected to its various aspects. The total land area used for growing raw Jute and Mesta is about 800,000 hectares. The Indian jute industry plays a crucial role in the country's economy. Jute, known as the golden fiber, is considered ideal for safe packaging because it is natural, renewable, biodegradable, and eco-friendly. In India, the jute industry manufactures various products like hessian or burlap, sacking, food-grade jute cloth, yarn, carpet backing cloth, blankets, decorative fabrics, floor coverings, and shopping bags. The country has a production capacity of over 50 million spindles and 8,42,000 rotors" [40].

The state wise jute production during last few years is shown in the given Table 3. It shows that West Bengal and Bihar are the leading jute growing states in India.

Table 3: State wise Production:

STATE WISE PRODUCTION & RAW JUTE — QTY : IN lakh bales

(A = Area IN '000 Hect.; P = Prod. In '000 bales of 180 k.g per bale ; PY = Productivity in QTLS/Hect.)

(APRIL / MARCH)	2012 – 2013			2013 – 2014		
	A	P	PY	A	P	PY
STATE						
ASSAM	70	823	2166	81	823	1829
MEGHALAYA	12.6	86.31	1236	0	0	0
WEST BENGAL	577	8349	2605	0	0	0
BIHAR	139.1	1690	2182	0	0	0
ORISSA	22.4	177.7	1427	578	8522	2654
ANDHRA PRADESH	25	225	1620	133	1540	2084
TRIPURA	1.3	11	1523	22	176	1440
NAGALAND	4.63	40.2	1564	15	142	1704

UTTAR PRADESH	0.4	4.5	2025	1.2	9.8	1470
OTHERS	20	0	0	36.3	203.6	1010
TOTALS	827.7	11406.7	2353	866.5	11416	2372

STATE WISE PRODUCTION & RAW JUTE QTY : IN lakh bales

(A = Area IN '000 Hect.; P = Prod. In '000 bales of 180 k.g per bale ; PY = Productivity in QTLS/Hect.)

(APRIL / MARCH)	**2014-2015**			**2015-2016**		
	A	P	PY	A	P	PY
STATE						
ANDHRA PRADESH	7	50	1286	5.6	0	0
ASSAM	75	795	1908	76.4	767	1917
BIHAR	111.2	1500	2428	113.4	0	0
CHATTISGARH	1.1	2.2	360	0	0	0
JARKHAND	0	0	0	0	0	0
KARNATAKA	0	0	0	0	0	0
MADHYA PRADESH	0.3	0.8	480	0	0	0
MAHARASTRA	0	0	0	0	0	0
MEGHALAYA	0	0	0	8	0	0
NAGALAND	0	0	0	3	0	0
ORISSA	12.9	67.8	946	14.3	0	0
TAMIL NADU	0.2	4.3	3870	0	0	0
TRIPURA	0	0	0	1.1	0	0
UTTAR PRADESH	0	0	0	0	0	0
WEST BENGAL	576.1	8969	2802	519	8075	2801
OTHERS	19.1	104.9	989	1.7	0	0
TOTALS	802.9	11494	2577	742.5	8842	

The total area under Jute Cultivation is about 0.80 million hectares and the production is approximately 10 million bales i.e. 1.8 million tones.

CONVENTIONAL USES OF JUTE:

‘‘Jute is not only a major textile fiber but is also a raw material for non traditional and value added non-textile products. Jute is used extensively in the manufacturing of different types of traditional packaging fabrics, hessian, saking, carpet backing, mats, bags, tarpaulins, ropes and twines’’. [41]

‘‘Recently jute fibers are used in a wide range of diversified products: decorative fabrics, chic-saris, ethinic dresses, soft luggage carrier, footwear, greeting cards, molded door panels and other innumerable useful consumer products which is supported by several technological developments. Today jute can be used to replace expensive fibers and scare forest materials and can be economical to people.The production of diversified jute products, consumer products, fashion products is carving out new Export marketing. The Indian Jute Industries Research Association (IJIRA) in association with Indian Jute Industry has recently developed a Hydrocarbon free jute bags- a food grade jute bags and clothes

confirming to international standard specifications. These bags are used for packaging food stuffs and are in great demand throughout the world. Jute fibers, the main product is extracted from the bast of plants by retting which is a method of separation and loosening of the fibers from the sticks by the decomposition of the cementing materials through Microbial action. Apart from the fibers, plant consists of useful parts that can be utilized in various economical ways just like Jute sticks, Jute Caddies, Jute Leaves, Jute Root Cuttings". [41]

a) Jute sticks : "It is a woody core of jute plants left after the fiber is taken away on completion of retting as a major agro-residue"[6]. "It approximately constitutes 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 the production of particle boards, paper and paper boards. Jute sticks are classified as hardwoods, and the nation produces about 3.0 million tonnes of them annually".[2,5]. "Several other products can be made from Jute stick, for example: Oxalic acid,Charcoal, Viscose Rayon, Carboxymethyl Cellulose, Furfural" [5]

b) Jute Caddies: "The caddies are the major industrial waste from the jute sector. The proximate analysis of the jute caddies shows the volatile matter approx 40 percent, fixed carbon 12-13 percent with a gross calorific value as 3200-3300 kcal/kg" [5]. "Jute caddies constitutes 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. One kilogramme of jute caddies is equal to 0.635 kg of coal or 0.33 kg of mineral oil when taking into account the calorific values of 5200 kcal/kg of coal and 10,000 kcal/kg of mineral oil".[7]. Jute mills are energy intensive where either electrical or steam energy is consumed for running the machinery continuously. It is estimated that the 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 ie, by:

(a) Thermochemical conversion such as Pyrolysis which is heating at high temperature with limited supply of oxygen, and

(b) Generation of bio-gas and utilization of the spent slurry in bio-gas production for manuring or for growing mushroom.

Both these processes are environmental friendly. By enriching the rhizosphere soil, the slurry can be used as manure to increase the production of jute crop by approximately 50%[8].Fibrous fleeces can be mechanically bonded together via needle punching without the use of a binder or other chemical [9]. In order to improve the compatibility of jute fiber and resin chemical or biochemical, modification of the substrates is mandatory. In addition to their reduced cost, jute-reinforced composites are expected to reduce machinery wear and tear because they use natural fibres rather than glass fibres. Jute's greater specific modules and lower specific gravity have been considered as a beneficial benchmark for switching from glass fibres to jute. A variety of composite products were developed with jute non-wovens pre-treated with alkali followed by scouring and bleaching. The advancement of non-woven technology makes it possible to produce fabrics without using the standard spinning and weaving processes. [2,4].

Products Made Of Composites From Jute Caddies: In order to make Fibre Reinforced Plastics (FRP), Jute Caddies based on non-woven fabrics were discovered to be an appropriate reinforcing material[10]. In certain product applications, jute's lower specific gravity and higher specific modules are crucial.

Corrugated sheet, cooling towers, fan blades, pipes, washbasins, serving trays, speaker boxes, auto parts, tool boxes, traffic signal light cases, chairs, table tops, country boats, etc. are among the products created with these applications.[2,4].

Future Prospects for the Development of Diversified Jute Caddies Products: Jute caddies may be pre-treated for product diversification and value addition. Textile pre-treatment methods like scouring, bleaching, and grafting are used to improve the quality of jute material. [11,12,13] noted that grafting polymers based on monomers like methacrylonitrile and ethyl methacrylate onto jute fibre could improve its dimensional stability and hydrophobicity with a slight reduction in breaking load. Jute-based fiberboard and fiber-reinforced plastics may be developed by applying such polymer finishing to cleaned jute caddies. The development of nonwoven household upholstery may result from the conversion of jute caddies into needlepunched nonwoven fabrics that are 100% jute based or jute/cotton based, then functionally finished to add dimensional stability, flame retardancy, and water resistance***.*** [14,15]. The suitability of bastfibers for pulp and papermaking is determined by factors such as the flexibility, slenderness, and Runkel ratios [16]. Jute caddies have fibres that range in length from 2.0 to 3.0 mm, making them an excellent source for pulp and papermaking. Blending high-quality jute fibre with pectinolytic-treated jute waste can improve the mechanical properties of the resulting composite product [17]. High moisture-holding capacity wooden chips are used as cooling pads in subtropical climates [18,19, 20]. Because jute is hygroscopic, it can be used in place of traditional wooden chips in cooling pads [18, 19, 20]. Traditionally, a partially automated spinning system is used to spin bastfibers into yarns [21]. Since it is a bast fibre, it can be combined with other vegetable fibres to make crafts or decorative items.

Jute Caddie Biogas Production: By using cattle dung as an inoculum source for anaerobic fermentation in digesters, Jute Caddies can be used to produce biogas with a methane (CH_4) content of at least 55% by volume. Applying a mild caustic soda solution to the Caddies beforehand can shorten the time it takes for the gas to be produced. Because jute candies break down slowly, they can produce larger amounts of biogas***.*** [22,23].

Making Briquettes Out of Jute Caddies: When combined with other agricultural residues such as rice husk, sawdust, and jute stick, jute caddies can be briquetted at the ideal moisture content of 10% to 15%. Jute caddies briquettes were found to have a gross calorific value of 3000–3200 Kcal/kg [24]. One kilogramme of jute caddies briquettes is equal to 0.635 kg of coal or 0.33 kg of mineral oil when compared to coal (5200 kcal/kg) and mineral oil (10,000 kcal/kg). [2,5,18].

Reduced Production of Jute Caddies: The morphology of the retted fibre, the type of retting process, and the quality of the jute fibre can all affect the formation of caddies [18]. They stated that retting from C-718 and OF-390 varieties produced higher quality and quantity of white fibres with fewer cuttings than other varieties like C.olitorius (OM-1) and from C.capsularis (C-2035, C-2005, and C-2143) in all respects. According to [25, 26], choosing high-quality jute fibres may also help to reduce the production of jute candies. It was also suggested that 276 Tex, a type of jute yarn, performs better at medium

speeds than at any other breaker card cylinder speed, which also helps to reduce the production of jute candies.

***Customised Paper Made with Jute Caddies*:** Pretreatment, mechanical pulping, beating, sheet creation, drying, trimming, and calendaring are just a few of the unit operations that can be used to turn jute Caddies from the mills into hand-made paper [27]. Owing to its lengthy fibre, Jute Caddies are crucial to the Paper Industries**.** [28,29].

c) Jute Leaves : "These are the by-products from jute plant. However, it contains all the vital nutrients mandatory for human body as it is a rich source of protein, fat, carbohydrate, calcium, phosphorus and vitamins like A, B and C" [30]. "It is also observed that jute leaves are good
to fight dysenteria, stomach pain, ulcer and other issues related to digestive system. It also helps in developing the immune system of children suffering from cough. The oils extracted from jute leaves are effective to healskin diseases. Even though experiments revealed that these jute leaves can help people look younger due to its high antioxidant activity and reduces the appearance of wrinkles and fine lines on their face and body. Therefore, it is an evidence that jute leaves are quite nutritious and contain many health benefits. Its application in functional foods and hygienic preparations can play a major role in food processing industries as well and particularly in the medicine sector" [2,5,18].

***d) Jute Root Cuttings: "**It is another industrial waste in the jute sector, which are hard and un-spinnable portion of jute reed detached before processing. 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 product" [10].

Conclusion: The future of jute crop will depend upon the value added diversified products from jute byproducts. 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. Lifestyle of consumers are now dictated by fashion trend to a considerable extent. Besides, this concept of fashion keeps on changing constantly. Customers are becoming more and more demanding in terms of quality, design etc. They also want newer fabric varieties to choose from. Therefore, a rethinking along with reintegration is needed in the textile production processes and the type of textiles to be produced in order to satisfy the customer's requirement. In this context, it is worthwhile to channelize a part of the production facilities for the manufacturer of such unconventional and novel textiles from natural fibers. This will help to create niche market segments enabling textile manufacturers to survive in this fast changing competitive sector.

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