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## Jute Fibre: A Suitable Alternative to Wood Fibre for Paper and Pulp Production

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### ABSTRACT

Cellulose is the most common of all naturally occurring organic compounds belonging to carbohydrate group. It makes up at least one third of all the vegetable matters in the world. Virgin soft and hard woods used as main source of cellulose for raw materials of paper production. These can be replaced by jute plant to a great extent as it is considered as one of the most promising alternatives. Pulp and paper production on a huge amount from jute can increase jute usage and thus a vast quantity of jute will be consumed by a single product which will eventually help revitalize the jute sector of Bangladesh. So the study was conducted to use jute, an alternative to non-wood fibre to get paper pulp and pulp products like cellulose derivatives through an easily adaptable process. The experimental processes are outlined. The physico-mechanical properties of handmade papers are estimated by standard procedure. Maximum whiteness of paper sheet is 76.70%, which is almost similar to offset paper. Basic weight of papers was estimated that ranges from 180 to 340 gsm. The study indicates that these hand-made papers can be used for making eco-friendly paper bags, packaging material which will be suitable alternative to the non-biodegradable plastic, a cause of ecological and environmental pollution.

**Keywords:** Cellulose, Jute fibre, Jute caddies, Cuttings, Non-wood fibre, Pulp production, and Handmade paper.

### INTRODUCTION:

Cellulose is the predominating constituent of plant tissues and the structural basis of the vegetable kingdom. Chemically, it is a linear polymer of long chain molecule built up by combining several thousands anhydroglucose units. It contains the elements: carbon (44.4%), hydrogen (6.2%) and oxygen (49.4%), (Moffatt, 1964). At present, the majority of paper pulp, other pulp products like cellulose derivatives, viscose, etc. are obtained from wood. Although there is substantial increase of recycled fibre, the necessity for virgin pulp increases constantly. The need of cellulosic fiber from yearly plant is

thus unavoidable as the forest resource cannot meet the demand. So in many developing countries, non-wood cellulosic fiber is an important source for paper-making.

Most papermakers and many consumers are anxious about the environment and campaign vociferously in opposition to the use of primary wood fibers in paper-making. It should also be kept in mind that fibers harvested annually have a high biomass production potential. Some non-wood plants even give more pulp per hectare per year than wood. Bangladesh has the potential to become a major pulp and paper producer from green jute. The country produces 40 per cent of

the world's raw jute and imports 500-600 tonnes of pulp annually worth US\$600 million. Setting up plants to get quality pulp from jute can meet domestic demand as well as create export opportunities. It will also help to protect the surroundings and provide a big relief to the jute farmers. Presently, around 250 different types of products are being produced from jute in Bangladesh (Rabiul *et al.*, 2020; Akter *et al.*, 2020).

Addition of jute based paper to the list would be a major advancement in the diversification of jute products-with significant value addition. It will provide benefits to a great number of stakeholders. Moreover, conventional forest resources used as main sources for raw materials in paper industry in Bangladesh: gewa wood, gamar, bamboo, bagasse, etc. are decreasing day by day. Khulna newsprint Mills and North Bengal Paper Mills have already been shut down and Karnaphuli Paper Mills, only running pulp mill in Bangladesh, is facing difficulties for the inadequate supply of these raw materials. Therefore, to find out alternative sources of fibrous raw materials is essential. The morphological and chemical properties of jute support it as pulping raw material (Nahar 1987 and Jahan *et al.* 2007). As a result, numerous studies have been conducted on the pulping of jute in home and abroad (Akhtaruzzaman and Shafi, 1995, Jahan, 2001, Jahan *et al.*, 2005 and Roy *et al.*, 1998). Along with jute fibre, about 15 % jute cuttings and 3 % caddis are produced in jute fibre processing. Around 810,000 MT of jute fiber are produced in Bangladesh in 2004-2005 (Anon, 2007). So, about 1, 20,000 MT jute cuttings and 24,300 MT caddis remained left over in jute mills. These may also be used as pulping raw materials. In this investigation, studies of jute fiber for handmade paper production were carried out in respect to chemical and morphological properties and the properties of handmade paper sheets were estimated.

## MATERIALS AND METHODS:

**Materials** - Jute fibres of tossa jute variety O-9897 were used for this experiment. Samples were collected from Agricultural Wing and the study was conducted at Microbiology and Biochemistry Department of Bangladesh Jute Research Institute. The fibre was collected after 120 days of maturity.

## Methods

### Determination of chemical properties of jute fibre -

The physical, mechanical and chemical properties of jute fibre were tested using standard method. For the determination of fats, alpha-cellulose, hemicelluloses and lignin content samples of fibre were ground mechanically by a grinding machine and subjected to the following analyses.

**Determination of fats content** - 1 gm powder sample of fibre was extracted with petroleum ether (b.p 60-80 °C) in an electro thermal soxhlet apparatus for 8 hours. The extract was evaporated to dryness and dried in an electric oven at 105 °C and weight to a constant weight.

**Determination of lignin** - Fibre powder (1 gm) was taken in quickfit ground bottom flask (250 ml). The content of each flask was then digested with 10 ml 72% (v/v) sulphuric acid by immersing the flask in each case in ice bath. The digestion is allowed for 2 hours with occasional stirring by means of dried and polished glass rod. The content of the flask was then refluxed for about 6 h after diluting the content of each flask with 200 ml distilled water. The mixture was cooled and filtered through a sintered crucible (porosity-2) carefully and washed exhaustively with hot water until free from acid. The lignin was dried at 100-105 °C for 10-15 hours to a constant weight.

$$\text{Lignin percentage} = \frac{\text{Weight of dry lignin}}{\text{Weight of dried fibre powder}} \times 100$$

**Determination of alpha-cellulose** - The holocellulose (5 gm) was taken in a flask (250 ml) and was treated with potassium hydroxide solution (24%, w/w, 100 ml) in an atmosphere of nitrogen with vigorous shaking for 6 hours. The alkali extract was recovered by filtration through Buchner funnel by using a suction pump and the residue was washed with water. The residual material was washed successively with aqueous acetic acid, water, alcohol, petroleum ether (b.p 40-60 °C). The sample was air dried, and weighed as alpha cellulose. Percentage of alpha cellulose was thus obtained by the formula

$$\text{Alpha cellulose percentage} = \frac{\text{Weight of dry cellulose}}{\text{Weight of dry fibre powder}} \times 100$$

**Determination of hemicellulose** - The lignin free samples were extracted with 9.3% sodium hydroxide solution in cold by stirring for 4 hours. After three treatments with this reagent, the total extracts were neutralized with acetic acid and then precipitated by alcohol and centrifuged. The isolated hemicelluloses were then washed with alcohol and finally with acetone and dried in vacuum and then dried at 105 °C to constant weight. The percentages of hemicellulose were then calculated by the following formula

$$\text{Hemicellulose percentage} = \frac{\text{Weight of dry hemicellulose}}{\text{Weight of dried fibre powder}} \times 100$$

**Pulp production**

**Opening and cleaning of fibre** - The fibres contain remnants of plant bark, thick fibrous roots and some dust. To clean the fibres opening and cleaning of jute was carried out. Otherwise, dotted with tiny dark spots of bark and dust particles will be appeared.

**Pre-treatment** - Pre-treatment is normally done to swell the fibres before subjecting them to pulping. Swelling of fibre was done in water for 24 h.

**Pulping** - One cm chopped jute fibres were used for pulp production. Bio-chemical and mechanical processes were used to make pulp. The fibres are bleached after pulping. H<sub>2</sub>O<sub>2</sub> bleaching was used in this experiment. pH of the process was adjusted to 10.0. Washing of pulp was done with hot water.

**Paper-making** - Standard hand-made paper-making equipments were used for transforming the pulp to hand-made paper. Calendering was done after paper production.

**Estimation of physical and mechanical properties** - The paper sheets were tested for physical and mechanical properties by standard methods.

**RESULTS AND DISCUSSION:**

**Estimation of chemical properties of jute fibre** - Chemically, two kinds of chemical composition are found in the formation of jute fibre. One is the major composition and other is the minor composition. These chemical compositions exist in different proportions. From **Table 1** it can be observed that the

fat content of the jute fibre of O-9897 was 0.88%. Cellulose, hemicellulose are the most abundant constituents of jute fibre and in these samples these constituents were 62.35 and 19.51%, respectively. Lignin content of the studied fibre sample was 15.75 %.

**Table 1:** Fat, alpha cellulose, hemicellulose and lignin content of 0-9897 jute fibre

Chemical properties	Percentage
Fat content (%)	0.88
Alpha cellulose content (%)	62.35
Hemi cellulose content (%)	19.51
Lignin content (%)	15.75
Plant ages in days	120

Lignin is the third major constituent in jute fibre which is resistant to detrimental effects of chemicals and microorganism and hinders and protects the fibre from the microbiological attack. From the literature it can be concluded that the major chemical constituents of jute fibre are holocellulose (82-85%) and lignin (12-16%). Again, holocellulose is composed of two constituents: alpha cellulose (58-64%) and hemicellulose (18-24%). The minor constituents are: waxes (0.4-0.8%), pectin (0.2-0.5%), protein (0.8-1.5%) and mineral matters (0.6-1.2%) consisting of Cu, Fe, Si, Mg, Ni, Ca, etc. and traces of tannin and colouring matters (MacMillan 1957). It is observed that the variation in the composition of fibre arises due to growing conditions and retting processes. The compositions may vary in the different parts of the fibre: top, middle and bottom.

**Whiteness property of handmade paper sheets** - Paper whiteness quantifies a paper’s ability to equally reflect a balance of all wavelengths of light across the visible spectrum. Whiteness is a measurement of light reflectance across all wavelengths of light comprising the full visible spectral range (approximately 380 nm - 720 nm). Whiteness of the sample papers was estimated through standard method.

From **Table 2** it can be observed that the lowest whiteness of handmade paper was 67.46% which was higher than newsprint paper noted as control 2 (60.90%). A maximum whiteness extent of approximately 77% was recorded for paper sample 2 which

was better than whiteness property of offset paper (control 1). Whiteness of other paper sheets varied from 69.44 to 75.38% which were almost similar to offset paper (73.03%) and much better than newsprint paper.

**Table 2:** Whiteness percentage of different handmade paper sheets made of jute fibre

Handmade paper sheets	Whiteness percentage
Sample 1	74.50
Sample 2	76.70
Sample 3	74.94
Sample 4	67.46
Sample 5	75.38
Sample 6	69.44
Control 1	73.03
Control 2	60.90
Control 3	64.82

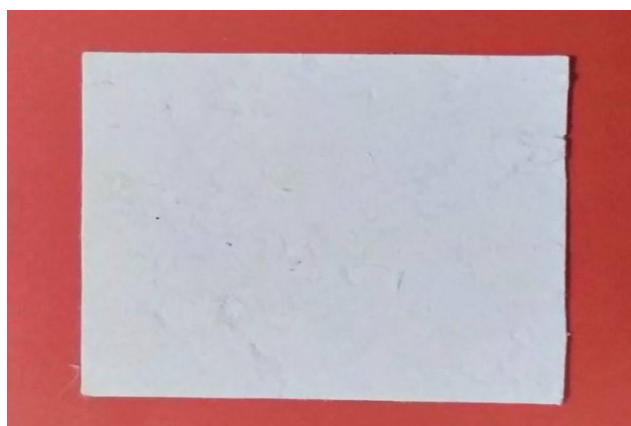
**Basis weight of paper sheets made of jute** - The basis weight or grammage is basic physical property of paper and paperboard. It is denoted by the weight per unit area and mainly expressed as GSM (grams per square meter). For paper production, for quality and productivity of paper, it is very essential (Karim *et al.*, 2019). Fluctuation of basis weight hampers the quality of paper and bad formation, uneven drying and calendaring, calendar cutting, bad mother roll development, blackish etc. are the results of fluctuation. Basic weight of paper sheets made from jute fibre is presented in **Table 3**. Lowest value of basic weight of paper was estimated to 180 gsm. Sample 2 showed highest basic weight which was 340 gsm.

**Table 3:** Basic weight of handmade paper sheets made of jute fibre

Handmade paper sheets	Basic weight (gsm)
Sample 1	330
Sample 2	340
Sample 3	240
Sample 4	180
Sample 5	310
Sample 6	260
Sample 7	250
Control 1	80



**Fig 1:** Handmade paper sheet produced from jute fibre (Sample 1)



**Fig 2:** Handmade paper sheet produced from jute fibre (Sample 2)

Basic weights of other paper sheets varied from 240 to 330 gsm and for control offset paper of 80 gsm was used. The result shows that these papers can be used for shopping bag, book cover, packaging material, etc. For making paper bags for shopping and grocery, packaging material, cover page of books, magazine, etc., the properties of hand-made paper prepared from jute fibre by a simple process of swelling and biochemical and mechanical pulping indicate its suitability (**Fig 1**, and **Fig 2**).

The technology is easily adoptable with little energy consumption and large amount of jute can be transformed to hand-made paper sheets and paper bags. Due to the adverse environmental effects of non-biodegradable plastic carry-bags, eco-friendly paper bags, packaging material have an excellent market prospective in view of increasing control on plastic

bags usages. The technology is viable and easily adoptable mostly in the rural areas as it requires less capital investment and has potential for creating employment opportunities.

### CONCLUSION:

Paper is a product of various grades, varieties and its raw materials are also of diverse origins. Newsprint, high value industrial paper and a number of paper grades necessitate softwood fibre to serve as reinforcement pulp. Short-fibred wood, agricultural and industrial wastes are the main raw materials available for paper production in Bangladesh. For a potential long-fibre substitute for softwood pulp, jute can be suggested as a suitable answer.

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### CONFLICTS OF INTEREST:

The author (s) declared no potential conflicts of the interest with respect to the research, authorship and/or publication of this article.

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