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Jute Retting: An Overview

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Abstract: Jute fibre quality depends to a very great extent on the process of retting. Much research has been done so far on retting of jute but still the jute growers face various practical difficulties in implementing the proper procedure for retting. Jute retting can be done by microbial or chemical process. Improper retting causes defective fibers which reduce the acceptability of these fibers for various industrial uses. Various methods have been devised for effective retting of jute which needs further research and development to systematize the entire retting process.

Key words: Jute, retting, bacteria, fungi

Introduction

Jute (*Corchorus capsularis* and *Corchorus olitorius*), kenaf (*Hibiscus canabinus*) and roselle / mesta (*Hibiscus sabdariffa*) constitute very important fibers and cash crops of the world. Of the total global production of about 3 million tons of jute / kenaf, harvested from about 2.5 million hectares, the six producing member countries of the International Jute Organization (IJO), namely Bangladesh, China, India, Indonesia, Nepal and Thailand account for about 95% of the production (Basak *et al.*, 1993). These countries except Indonesia, are net exporters, accounting for about 98% of the world exports of raw fibre and finished products. Jute, as a commodity, is facing competition on two fronts. Jute is facing stiff competition from synthetics at the consumer's end, while on the other, from more remunerative crops at the grower's end. In order to face the dual challenge confronting jute both at consumers' end and at the producers' end, we have to adopted a strategy which consists of agricultural research and development, industrial research and development and market promotion of both traditional and diversified jute products.

Jute retting: The process of separation and extraction of fibers from non-fibrous tissues and woody part of the stem through dissolution and decomposition of pectins, gums and other mucilaginous substances is called retting (Gupta *et al.*, 1976, Majumdar and Day, 1977). The quality of the fibre is largely determined by the efficiency of the retting process. In retting, pectic materials are broken down and the fibers are liberated, (Bhattacharayya, 1973-74). Fibre quality is dependent (Chi *et al.*, 1966) on retting in different natural conditions and duration of retting. Generally, the bottom portion of the jute plant is thick and hard which takes a longer time for retting than the upper portion. Owing to over maturity, variety and improper retting, the bottom portions of these unretted bark materials are cut down in the jute mills and are known as cuttings. In addition to these, there are some jute fibers which are naturally spicky, course, harsh and less pliable. These fibers are known as low-grade jute and have less utility than normal jute, which amount 30-40% of the total fibers, are not suitable for spinning.

Jute retting mechanism: In this process, plant absorbs water when steeped in it and swell, ultimately bursting occurs at several places and the soluble constituents which include sugars, glucosides and nitrogenous compounds are liberated (Ali *et al.*, 1976, Ali, 1958, Ali and Islam, 1963) creating the surrounding environment a good start medium for the growth of micro-organisms present in water as well as in the plants. These organisms gradually develop and multiply by utilizing free sugars, pectins, hemicelluloses, proteins etc. of the plants as nutrients (Majumdar and Day, 1977, Mohiuddin *et al.*, 1978, Sarkar, 1963-64). Specific enzymes secreted by the organisms cause degradation of the complex organic materials to simpler compounds which are then metabolized for their life processes. A series of biochemical reactions go on as (Chaudhuri, 1951) a result of which the chemical composition and pH of the water continuously change during the retting process. It is evident that the ash content is very high in jute ribbon which is due to the presence of polyuronides or pectins as their metallic salts. In the ash of ribbon, calcium (Ca), magnesium (Mg) and iron (Fe) were detected (Majumdar and Day, 1977), ∝-cellulose is higher in the top portion and lowest at the bottom which again contains the highest cutin, water-soluble and pectic matters. Decomposition (Ali *et al.*, 1976) of the free sugars takes place at early stages of the process, followed by the breakdown of pectins and decomposable hemicelluloses and nitrogenous compounds (chiefly proteins) are degraded at the later stage. Analysis of retting water revealed the presence of (Ali *et al.*, 1968) decompose products such as organic acids (acetic, lactic, butyric ∝-ketoglutarics), acetone, ethyl alcohol, butyl alcohol and various gases (Debsharma, 1976). If this process is continued beyond the optimum period, micro-organism begin to degrade the fibre cellulose. Such a condition is known as "over retting".

Retting process: Extraction of the fibre involves decomposition of the cementing material by micro-biological method or its dissolution by chemical method by which the fibre bundles are loosened from the adhering tissues and are removed by washing (Gupta *et al.*, 1976, Bhattacharyya, 1974). The quality of the fibre produced and the ease with which it is spun into yarns fibers depends to the proper control of the process (Shorllon, 1975). Plants should be harvested at small pod stage and optimum temperature for retting is 34°-35°C (Bose, 1969).

Microbial retting: Attempts have been taken to isolate and identify the microbes. Among the fungi, *Aspergillus niger*, *Macrophomina phaseolina*, *Mucor*, *Chaetomium* sp., *Phoma* sp. (Ahamed, 1963) and several *Penicillium* sp. have been found to be good retting agents. Several aerobic bacteria (Jalaluddin, 1965) of the genus *Bacillus*, viz., *B. subtilis*, *B. polymyxa*, *B. mesentericus*, *B. macerans* (Bhatacharyya, 1973, 1974) and anaerobic bacteria of the genus *Clostridium*, viz., *C. tertium*, *C. aurantibutyricum*, *C. felsineum* etc. (Alam, 1970) have been isolated from retting water. The aerobic organisms grow first and consume most of the dissolved oxygen, ultimately creating an environment favorable for the growth of anaerobes. It has been stated that the greater part of decomposition is carried out by anaerobic species (Ali *et al.*, 1972). In microbial retting, pectin and hemicellulose are decomposed into water soluble compounds by specific enzymes secreted by the micro-organisms present in water and in plant. *Bacterium felsenium* considerably shorten the retting period and improve the fibre quality (Ali *et al.*, 1972). Microbiological retting conditions are difficult to maintain in actual retting operation. There is no test method to determine the end of retting period to extract the fibre. Biological retting is the cheapest and still universally practiced method for the commercial extraction of jute (Munro and Couchman, 1959).

Chemical retting: In chemical retting, the cementing material can be removed by dissolution with certain chemicals. The fibre obtained by chemical method of retting seems to be a little coarser, rough in the feel and stiff. The gravimetric fineness values do not differ very much from that of microbially retted fibre. The fibre strands after drying needs to be softened by rubbing with hand to open up the fibre and to remove the stiffness of the strand. A cationic softener may be used to the extent of 0.2% on the weight of the fibre. Ammonium oxalate and sodium sulphate was found to be suitable, as in chemical retting the fibers are extracted under controlled condition and the fibre properties are not affected by the treatment, the procedure may be adopted as a standard method of fibre extraction from jute (also mesta) ribbons (Gupta *et al.*, 1976). The process is, however, costly and is not practicable in the cultivator's field. The method has no adverse effect on the fibre properties.

Factors affecting in the retting: The efficiency of retting depends on a number of factors (Bhattacharyya, 1974, Ghose and Bose, 1973, Asaduzzaman *et al.*, 1985). Some of these factors are within the easy control of the cultivators, whereas other are dependent on nature. The factors are as follows:

Plant age: As the jute plant grows older, the tissues become more and more matured; the structure of the decomposable matters like pectins and hemicelluloses may be modifies to more resistant forms and their quantity may increase. As a result micro-organisms take longer time to ret a plant. Usually, fibre loss is 17.3% if 75 days old plant is ribboned and 9.5% if plants of 120 days is ribboned.

Fertilization of crop: Higher dose of nitrogenous fertilizer applied to the crop has been found to reduce the retting period. The reverse happens when phosphatic fertilizers are used.

Retting water: Retting is a biochemical process in which various decomposition is carried out in stagnant water, accumulation of these products causes hindrance to the growth and activity of the causative micro-organisms. Vary fat moving water, removes these toxic substances quickly, but it carries away the microbial population along with it resulting in uniform retting. Retting is best (Kundu *et al.*, 1952) carried out in slow moving clear water (canal, river, etc.) with low content of materials as salts, iron and calcium content is preferable for good retting. It is desirable to change water to keep the pH about 7 and 35°C temperature.
When retting water is soft, the quality of fibre is better than when hard water is used. The presence of iron, particularly ferrous iron, is not desirable as it imparts a dark colour to the fibre. Good results are obtained when nearly 15 cm water is left over the top layer of the charge of plant bundles, bundles of jute stems to be retted are approximately 20 cm in diameter and plant water ratio is nearly 1:20. In laboratory trials, partial aeration may accelerate the retting indirectly by oxidizing the decomposition products formed.

pH and temperature: Laboratory experiments have shown that two pH values are optimum for retting, one being in the acidic region (around pH 5.0) and the other in the neutral or slightly alkaline region and that the retting period is relatively shorter in acidic pH. Natural water from different sources have pH between 6.0 and 8.0 and are used for retting purposes (Ali and Alam, 1973). The optimum temperature for jute retting was 34°C. Retting takes a longer time when the temperature deviates from 34°C.

Activators: Retting is accelerated in the presence of several activators. Natural activators like dhaincha (*Sesbania aculeata*) and sunnhemp (*Crotalaria juncea*) plants are generally introduced into the jute stem bundles put for retting. These leguminous plants being rich in nitrogen content help the growth and activity of the retting microbes by supplying additional nutrients to them. Indian Central Jute Committee used tribasic calcium phosphate, dibasic potassium phosphate, ammonium sulphate, ammonium oxalate, dibasic ammonium phosphate, calcium carbonate, monobasic potassium phosphate, sodium oxalate, calcium nitrate, potassium nitrate, bone dust and gelatin with retting water as activators of jute retting. Only bone dust and ammonium sulphate when added singly or in combination reduced the retting period considerably. Stems of sunnhemp or dhaincha when put in the bundles of retting jute shortened the retting period (Ali *et al.*, 1972).

Neutralization of retting liquor: The retting speed can be accelerated and quality of fibre can be improved significantly if the retting liquors are neutralize by chemicals like $NaHCO_3$. During the process of flax retting, butyric, lactic and acetic acids were produced in the retting liquor.
In *C. capsularis*, although the addition of sodium carbonate and sodium bicarbonate turned the retting liquor dark at the end, this color did not at all have any effect on the color of the fibers. This eliminates the usually common contention that whenever the retting liquor is dark the fibers are likely to be dark (Ali *et al.*, 1972). It might be suspected that the tannin-iron-reaction may be responsible for the dark color and is possibly operative only at a particular hydrogen-ion concentration of the retting liquor having different chemical properties. These properties do not exclude the possibility of the influence of phenolic compounds of jute plants. In *C. olitorius*, only the phenolic compound is responsible for the dark color. *C. capsularis* is far darker than that of *C. olitorius*.

Urea: Retting water incorporated with urea ahead higher count of bacteria (both aerobic and anaerobic) maintained higher pH favorable to the bacterial growth and provide increase supply of total nitrogen which increase retting (Ali *et al.*, 1972).

Acidity and total nitrogen: The retting water become acidic which impaired the proper multiplication and activity of retting bacteria of the retting water, since it is known that the optimum growth of most bacteria is towards the neutrality. The growth of retting bacteria is not favorable, will effect the qualit y of the fibers, neutralization of the acidity of retting liquor could be useful approach for conducting retting in more favorable conditions (Ali *et al.*, 1972).

Harvesting time: Considering the quality of the fibre it seems advantageous to harvest jute about 25 days earlier than the usual recommended stage of average flowering. The slightly lower yield obtained because of the early harvest is likely to be compensated by the improved quality of the fibre (French, 1959).

Fibrous matter: Speed of retting depends on the non-fibrous matters and soluble carbohydrates contents of the stem which provide food to the retting microbes and eventually get decomposed into organic acids. Jute plants contain much more non-fibrous matter that can ret effectively.

After effect of imperfect retting: Imperfect retting cause defects in fibers which cause processing difficulties for the industry. Some of these defects are carried even to the finished goods and devalue them to the point of even rejection. The more common defects are described below (Bhattacharyya, 1973-74).

Rooty fibre, centre root, runner, hunka: In all these defects, fibre is masked by barks. In rooty fibre, barks remain at the bottom, in centre root at the central region, in runners along the entire half of the bottom and in hunka all over the stem. These defects may be due to unusual developments in some portions of the plant or to improper retting (Haarer, 1958).

Creppy and gummy fibre: Fibers with top ends rough and hard are called creppy, while fibers which are held together by undissolved and undecomposed gummy substances, they are called gummy.

Sticky fibre: If not properly cleaned after extraction, fibers may contain adhering sticks; these may create trouble in the processing machinery.

Shamla fibre: Presence of excessive iron in retting water or use of weighting materials rich in tannin, such as, banana stems, freshly cut mango trees, etc. may impart dark color to the fibre. This dark colored fibre is known as shamla jute.

Upgradation of low grade jute: The Jute Technological Research Laboratories, Calcutta, has developed a fungal culture method for softening barky jute (Basak *et al.*, 1987), which involves treatment of barky jute with a pectinolytic fungus, *Penicillium corylophilum* Dierckx. By using this fungal culture, an inferior quality barky jute may be upgraded by 1-3 grades (Bhattacharyya and Basu, 1981). It is believed that the pectin in the middle lamella of the softer parenchyma, which holds the fibre bundles together, decomposes because of fungal attack (Chaudhuri and Ahmed, 1968). This loosens the fibre strands which are then easily separated. It was observed that á-cellulose and lignin content remain unaffected while the pectin content in the treated samples with *P. corylophilum* Dierckx decreases considerably by about 54.5% (Ahmed and Choudhuri, 1968). As the basal medium of jute does not contain any carbon source the fungus utilizes the carbon from the barky jute for its growth and multiplication. Basak *et al.*, (1993) suggested that the fungus utilizes the pectinous material of the barky jute as its carbon source. This helps in softening the hard barks by removing a significant amount of pectin which acts as a binding material for the fibre strands. The fungus grow profusely on the surface of the barky jute. On the other side of the surface, which remains towards the stick, the fungal growth is less than that on the upper surface. It was (Ghosh and Dutta, 1980) stated in previous report that when barky jute is inoculated with the fungus *P. corylophilum* Dierckx, it utilizes and grows mainly on the pectin present on the surface of the barky jute and between the fibre strands. The cellulose and lignin contents of the barky jute remain unaltered after the fungal treatment. The fungal culture are the economically viable microbes for upgradation of jute because- (a) they can ret the jute in shorter time then bacteria, (b) they are easily available and can grow in cheapest medium, © they can be preserved in pure form for longer time and (d) they require less water than bacteria for ribbon retting.

A large proportion of the total production of raw jute in Bangladesh is of very poor quality having 20-40% of cuttings (hard basal parts) in the bottom portions of the fibre. A good number of factors are responsible for the production of SMR and low-grade barky fibers. Over maturity of jute plants, hardness of the bottom portions of jute plants due to waterlogging, scarcity of good retting water facilities, faulty retting practices, fall in day temperature during retting, excessive number of rettings in the same water pool during the short retting season and quality and quantity of micro-organisms present are the important factors responsible for the production of SMR (Haque *et al.*, 1989) and low grade barky fiberes. The low quality barky jute fibers, so produced, are usually not suitable for spinning and need softening treatment before processing in the jute mills.

Paul and Bhattacharyya (1974) indicated that a pectinolytic fungus *P. corylophylum* Dierckx could upgrade the inferior quality fibre. It was found that the fungus *Penicillium frequentans* could maverate potato discs, jute barks and jute stems and fungus *Cortitium rolfsii* could soften hard jute cuttings in much shorter time and improve the fibre quality. Ahmed and Chaudhury (1968) stated that a fungus used in the jute cuttings softened the cuttings and improved the fibre colour. Basak *et al.* (1987) indicated that the *fungus P. corylophylum* could soften thebarky jute without affecting the cell walls of the fibers. Haque *et al.* (1989) reported that SMR and seed-cut barky fibers could effectively up-graded when treated with cultures of *Aspergillus niger* or *Sclerotium* sp. grown on wheat bran media. Percentage of pectin and hemicellulose content of the fibre after treatment separately with the micro-organisms such as *Sclerotium* sp. and *Aspergillus niger* reduced appreciably. The pectinous matters of the barky jute acted as carbon sources and enhanced the growth and multiplication of fungus on the hard basal portions resulting in the softening of the hard barks by removing a significant amount of pectin and as the fibre quality will be upgraded.

Recently, Bhattacharyya and Basu (1982) reported that kaolin powder, which is a complex aluminium silicate and nearly chemically inert and nonabrasive, may be used for preservation of the *Aspergillus* sp. for at least 90 days without any contamination with retention of its activity in softening and upgrading barky jute. Culture in liquid suspended form as well as in admixture with a solid carrier showed almost equal efficiency in softening barky jute and the carrier based fungus can be easily preserved and transported.

Jute fibers are one of the most important cash product of our country which earn foreign currency. Moshiuzzaman and Choudhuri (1986) have shown that jute fibre, produced by retting the jute plant for 20-25 days under water, can be used for the preparation of carboxymethyl cellulose, cellulose nitrate, cellulose phosphate, cellulose sulphate and cellulose acetate. Raw jute fibre without prior delignification may be utilized for the preparation of cellulose nitrate and cellulose acetate. Moreover, jute are still mainly used for producing traditional goods like sacking, hessian, yarn, twine, wool pack, cotton bagging and carpet backing cloth. The farmers grow these crops also to meet their domestic needs such as for making ropes, constructing thatched houses with sticks and as fuel wood etc. Recently, the whole plant of jute is being used for making pulps. Extensive research regarding proper retting of jute plants are needed in order to up-grade the fibre quality.

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