http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 6 (16): 1463-1467, 2003
ISSN 1028-8880

Study of the Chemical Composition of Different Pipeline Varieties of Jute Fibres

[1]Zakaria Ahmed, [2]Md. Shamsul Haque, [2]Firoza Akhter and [1]Mahmuda Begum
Fibre Quality Improvement Division, [2]Fibre Chemistry Department
[1]Bangladesh Jute Research Institute, Manik Mia Avenue, Dhaka-1207, Bangladesh

Abstract: Chemical composition of different pipeline varieties of jute (*Corchorus capsularis* and *C. olitorius)* fibres has been studied. The promising varieties which have been taken were C-718, C-2005, C-2193, C-2035 and OM-1 and experiment was carried out to know their moisture content (%), cellulose content (%), hemicellulose content (%), lignin content (%), ash content (%) and fat content (%) in three different parts of plant- top, middle and bottom. Moisture content was found highest (12.6855%) in bottom part of C-2035 variety and lowest (8.24%) in top part of C-2005 variety. In bottom part of C-718, cellulose content was found lowest (58.24%) and highest was found in the top part of C-2035 variety. Hemicellulose was found highest (23.73%) in top part of OM-1 and lowest (16.39%) in middle part of C-718. In case of lignin content, it was observed that 17.98% was found in bottom part of C-718 which seem to be highest and lowest (13.61%) was found in top part of C-2193 variety. In the top and bottom part of C-2005, ash content was found lowest (0.112%) and highest (0.995%) respectively. Fat content was highest (2.172%) in OM-1 variety and lowest (1.099%) in C-2193.

Key words: Lignin, cellulose, hemicellulose, variety

Introduction

Jute, the multi-cellular and viscoelastic bast fibre, is a unique crop of major economic importance in Bangladesh. All the cultivated varieties used belong to the species *Corchorus capsularis* and *C. olitorius*. Each of these species has some better characters than its counterpart. Fibers of *C. capsularis* is weaker than that of *C. olitorius* and the former species is also more susceptible of fungal diseases and pests than the latter and can be grown in low lying areas where *C. olitorius* cannot resist flood water and generally grows in highland conditions (Mia and Shaikh, 1967). The farmers of Bangladesh have been growing jute plants using old varieties for long time. In recent years a good number of jute varieties having high yield potentiality have been released to the farmers (Sobhan, 1980; Sobhan *et al*., 1981 and Mohiuddin *et al*., 1981) and some are awaiting to release called pipeline variety.

Jute consists of cellulose cemented by uncelluloses materials such as lignin, pectin and hemicelluloses, etc. The usual composition of this chemical in jute is- alpha-cellulose (58-63%), hemicellulose (21-24%), lignin (12-14%), wax (0.4-0.8%), pectin (0.2-0.5%), protein (0.8-2.5%), mineral matter (0.6-1.2%) and tannin and other coloring pigments (tress) (Macmillam, 1957; Abdullah *et al*., 1978 and Bishiruzzaman *et al*., 1964). Besides the 60-70% of pure cellulose, the other accessory components of the cell wall of jute fiber mainly consists of lignin, hemicellulose, uronic acid, pectin, including a small amount of fat, resin, wax, etc. Jute is also constituted with crystalline and non-crystalline part as with other fibers. Crystalline and non-crystalline parts of cellulose have everything similar except in non-crystalline part, there is some lignin and other non-carbohydric matter whereas in non-crystalline part of fiber, there is no periodicity of hydrogen bond as it occurred in crystalline part (Sen Gupta, 1958; Doric, 1950. Various fiber properties like obsorbility or accessibility, swelling, flexibility, fiber extension etc. are more or less dependent of the ration of crystalline and non-crystalline parts of a fiber (Abdullah *et al*., 1978 and Majumdar and Dey, 1977). Jute hemicelluloses consist of xylan, hexosans and polyuronide and their presence has importance in determining the quality and strength of the fiber (Islam *et al*., 1978 and Swaminathan *et al*., 1961). Chemical investigation of the different parts of the plants e.g. leaves, seeds and sticks (Ahmed *et al*., 2001; Khuda *et al*., 1970 and Islam *et al*., 1978) have been made by different authors. Some studies have also been made on the hemicelluloses of finished jute fiber. It was reported that hemicelluloses act as the cementing materials for the small ultimate cells of jute. Partial removal of hemicelluloses (hexosans mainly) from jute makes the fiber soft and more flexible. It is assumed that this characteristic has some relationship with the quality and better utilization of jute fiber. It also observed that the hemicelluloses have a short length and contains many hydrophilic-OH groups, they are colloidal in nature and readily absorb water and swell, thereby causing the fall in wet strength of the fiber. The structure of lignin, a collective term for a group of highly

polymerized compounds of very similar chemical properties but of very different molecular weight, is yet to be know. The major part of the methoxyl content of the wood is carried by lignin (Mohiuddin *et al*., 1978 and Sarkar, 1933). The content of these different chemicals present in jute influences the quality of fiber significantly. In our previous study, we reported that among all the fibers of the different varieties (C-718, C-2035, C-2005, C-2143, OM-1 and OF-390) white fiber with fewer cuttings and A and B grade fibers were obtained by retting from C-718 and OF-390 varieties, respectively yielding higher quantity of fibers (Haque *et al*., 2001). But no study was carried out so far about the chemical properties of these varieties. So the current study reports the chemical composition of cellulose, hemicellulose, lignin, ash and moisture content of these varieties. The present paper describe the percentage of different constituents of jute plants of different pipeline varieties in three parts of plant-top, middle and bottom and for thus ascertain the better variety in order to produce good quality fiber.

Materials and Methods

Jute plants of different promising pre-released varieties were retted under water for 21 days. The fiber and stick were separated manually and sun-dried. These samples were collected from Central Research Station of Bangladesh Jute Research Institute, Dhaka, Bangladesh. The fibers were cut into three parts viz. top, middle and bottom. These were then ground into powdered form by a grinding machine named Wiley mill with a 1.0 mm screen. The moisture content was measured by dry weight basis following the method described by Mohiuddin *et al*. (1978) where a small amount (about 100 g) of each varieties of sample was heated in a previously cleaned oven dry (temperature 100-105°C) weighing bottle and dried at that constant temperature in the oven for 2-4 h. By repeated drying of sample to a constant weight in an electric oven has been given the percentage of moisture content. Fatty material was extracted with petroleum ether in a soxhtel apparatus and was determined by the method described by Khuda *et al*., (1976).

The following steps were then carried out throughout the investigation before going for isolation of cellulose, hemicellulose (Islam, 1978). Jute samples were extracted with petroleum ether (60-80°C) in a soxhlet apparatus for 6-8 h. After extraction the residue was dried in an oven 105°C and powdered, this process is called defatting. Then the defatted powdered samples were then made pectin free (depectinization) by refluxing with 0.5% ammonium oxalate for 4-8 h and then filtered, washed with water and dried. Finally the pectin free samples were first treated with 0.7% sodium chlorite solution at near boiling point for about 30 min and subsequently extracted with 0.5% sodium bi-sulphite solution of pH 5.5 at 20°C. The process was repeated three to four times. After this the samples were again treated with 2.8% sodium chlorite solution followed by subsequent extraction with 0.5% sodium bi-sulphite solution. The process was also repeated twice.

Isolation, extraction and Determination of alpha-cellulose and Hemicellulose: The samples were scoured with 3% solution of NaOH in 1:2 liquor rations for 1 h at boiling temperature for the extraction of cellulose. From the above scored sample Cross and Bevan cellulose was prepared according to Doric (1950) and Abdullah (1978). With these Cross and Bevan cellulose, alpha-cellulose was prepared by treating it with 17.5% NaOH solution (Abdullah, 1978). The lignin free powdered samples (100 g) were extracted with aqueous 80% ethanol (5X80 ml, 30 min each time) at reflux temperature followed by chloroform (3X500 ml, 30 min each time) also at reflux temperature. The extractive-free material was treated with water (2X800 ml, 5 h each time) at 96°C. The water extract was discarded and the residue (97 g) was extracted with aqueous 1 M NaOH (400 ml) for 18 h at room temperature with stirring in an atmosphere of nitrogen. The mixture was neutralized (pH 7.0) with acetic acid and freeze-dried, affording hemicellulose (15.2 g). 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 (Mashihuzzaman *et al*., 1985).

Isolation, extraction and determination of lignin: To remove the substances that may interfere lignin determination, the fine powdered (60 mesh) of each sample was first extracted with benzene in a soxhlet apparatus for about 6 h and then washed with hot water. Samples were then dried to a constant weight at about 105°C, which were ready for investigation. Sample (1 g) was taken in quickfit ground bottom flask (25 ml). The content of each flask was then digested with 10 ml of 72% (v/v) sulphuric acid by immersing the flask in each case in ice bath. The digestion was allowed for about two hours by occasional stirring with 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. After cooling at room temperature, the mixture was filtered through previously cleaned, dried and weighed sintered crucible of porosity 5. Lignin on each crucible was washed exhaustively with hot water until free from acid and then dried at 100-105°C to a constant weight (Mohiuddin *et al*., 1978). The lignin in the sample was

then determined by TAPPI standard method (TAPPI, 1952).

Determination of ash content: About 1.5 g of dried sample of each variety was taken in a previously cleaned, dried and weighed porcelain crucible. Content of each crucible was then heated to 750-800 °C for about 6 h in a muffle furnace. Crucible was then cooled to room temperature in desiccators. Ash content of each sample was calculated by the following equation:

$$\text{Percentage of Ash} = \frac{\text{Initial weight of sample} - \text{Dry weight of sample}}{\text{Weight of sample}} \times 100$$

Results and Discussion

It has been observed that non-lignified tissue contains large amount of pectic substances, small amount of hemicellulose whereas lignified tissue contains large amount of hemicellulose and lignin but hardly any pectic substances (Mohiuddin *et al*., 1978). From the Fig. 1 it was observed that the moisture content was found highest (12.68%) in bottom part of C-2035 variety and lowest (8.24%) in top part of C-2005 variety. In bottom part of C-718, cellulose content was found lowest (58.24%) and highest was found in the top part of C-2035 variety (Fig. 2). Figure 3 indicated that the hemicellulose was found highest (23.73%) in top part of OM-1 and lowest (16.39%) in middle part of C-718. Mashihuzzaman *et al.* (1985) have reported structural studies of the water-soluble hemicelluloses from unretted jute bark and stick (Ahmed *et al*., 2001) and showed that the hemicellulose fraction isolated from unretted jute stick by 1.0 M alkali is a xylan.

In case of lignin content, it was observed that 17.98% was found in bottom part of C-718 which seem to be highest and lowest (13.61%) was found in top part of C-2193 variety (Fig. 4). Mohiuddin *et al*., 1978 stated that pectic substances are changed during development into hemicellulose and that they are transformed into lignin either directly or through hemicellulose. Kertesz (1951) and Arangzeb and Biswas (1964) suggested that lignin might be formed from some carbohydrate of the glucosan-xylan series, which usually occur in association with it in plant. Usually, the inferior grades of jute contain high percentage of lignin and pectin than that of superior grades. The increased lignin and pectin contain in inferior jute results from over maturity and under retting of jute plants. So knowledge of jute cultivation and grading is equally important for the growers for producing good quality jute as well as to get a fair price (Asaduzzaman *et al*., 1983). Asaduzzaman *et al.* (1985) reported that both lignin and pectin contain increased gradually from the top towards the bottom parts of the plants, which is due to deposition of high lignin and pectin at the bottom part of

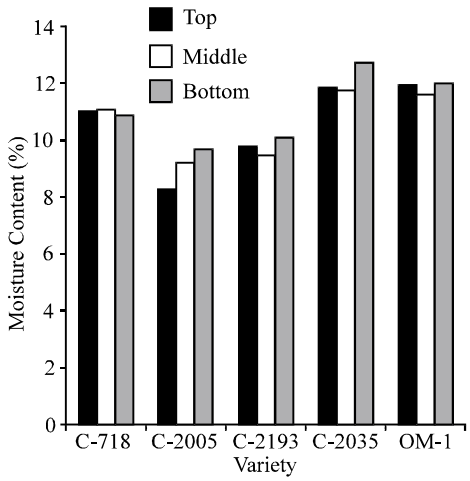

Fig. 1: Moisture content of different variety

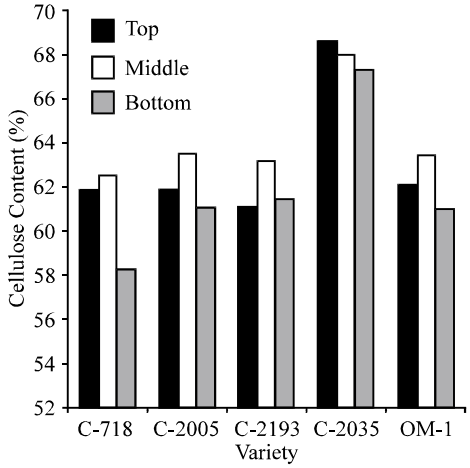

Fig. 2: Cellulose content of different varieties

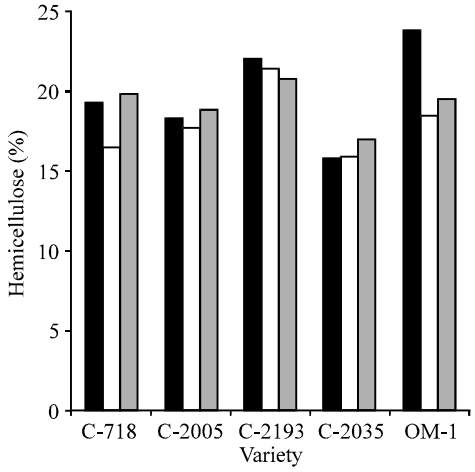

Fig. 3: Hemicuellulose content of different varieties

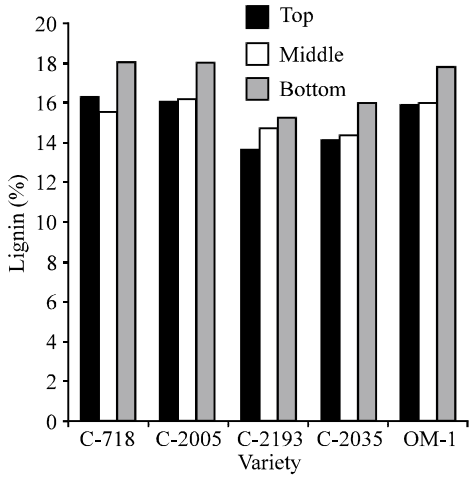

Fig. 4: Lignin content of different variety

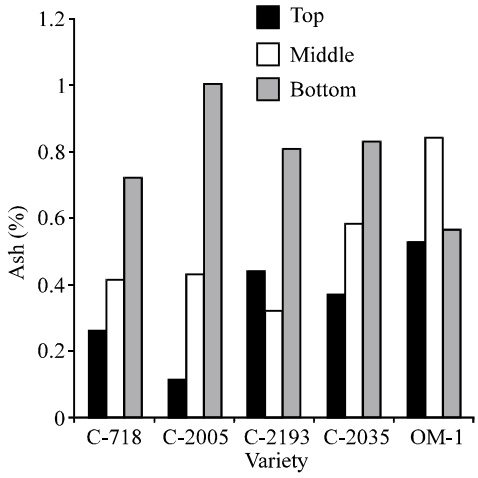

Fig. 5: Ash content of different variety

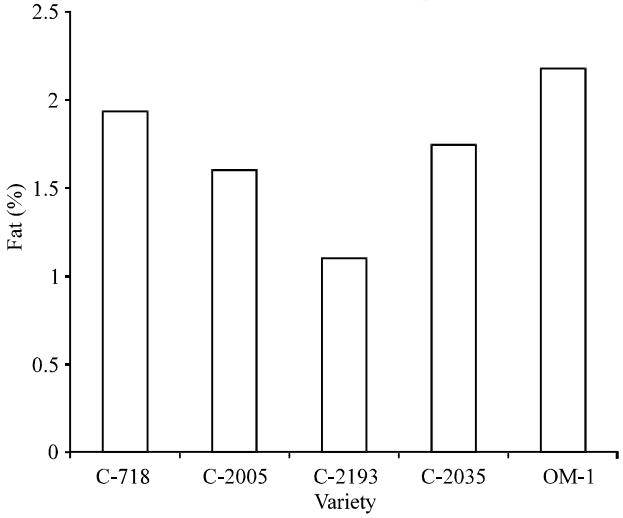

Fig. 6: Fat content of different varieties

the plants that makes the portion harder. Mohiuddin *et al.* (1978) concluded that lignin content of cuttings was higher in *C. capsularis* and this content gradually increases from top to bottom of the fiber. They stated that higher lignin content in cuttings is one of the reasons for the non-softening of cuttings with the fiber simultaneously. In the top and bottom part of C-2005, ash content was found lowest (0.11%) and highest (0.99%) respectively (Fig. 5). On the other hand, in Fig. 6 the fat content was found highest (2.17%) in OM-1 variety and lowest (1.09%) in C-2193. Islam *et al.* (1978) found that the quantitative variation of the constituents in the two species has a marked effect on the retting period. During retting, the loss of hemicelluloses in *C. capsularis* is double than that in *C. olitorius* (Islam *et al.*, 1978). They also reported that considerable amount of hemicelluloses are removed during retting. The lesser percentage of hemicelluloses in green plants is present due to the presence of large amount of cuticular substances in the bark.

Jute is being used extensively for the preparation of gunny bags, carpets, blankets and many other wearing apparels. Technological efforts are being made in blending cotton with jute to save expensive import of cotton and for the purpose, it warrants the necessity of good quality fiber of jute. Quality fiber in jute always associated with length and breath of fiber cells. The highest length and the thinnest breath of fiber cells involved with the highest length/breath ratio indicate the better quality of fiber (Ali, 1986). According to Ali (1986), Hosne Ara *et al.* (1978) and Khandakar *et al.* (1980), the middle portion contained the longest fibre cells; likewise their highest breath was observed at the bottom followed by middle. It may be concluded from the result of this report that this study may be treated as a guideline for establishing a chemical method for fiber grading which is very much needed to remove bias during fiber grading in the primary or secondary markets. From the chemical point of view, it can be concluded from the present study that moisture, hemicellulose and lignin contents in all the varieties are more or less similar but they differ in cellulose, ash and fat content. Thus, among the variety tested, C-2035 and C-2193 were found better one.

References

Arangzeb, S. and A.C. Biswas, 1964. Comparative study of ultimate fiber cell length of different varieties of *Corchorus capsularis*. Pak. J. Sci., 16: 53-55.

Ali, M.A. 1986. Variability and correlation study of ultimate fire in white jute (*Corchorus capsularis*). Bangla. J. Jute Fib. Res., 11: 1-5.

Ahmed, Z., H. Banu, F. Akhter and K. Izumori, 2001. A simple method for D-xylose extraction from jute stick and rice husk. OnLine J. Biol. Sci., 1: 1001-1004.

Abdullah, A.B.M., C.A.F.M. Rahman, N.N. Khan and M.A. Salam, 1978. Preparation of micro-crystalline cellulose from jute. Bangla. J. Jute Fib. Res., 3: 39-43.

Asaduzzaman, M., A.K.M. Eshaque and S. Alam, 1983. Relationship between grade of jute fiber (Kucha and Pucca grade) with their lignin and pectin content. Bangla. J. Jute Fib. Res., 8: 55-57.

Asaduzzaman, M., S. Alam, A.K.M. Eshaque and M.M. Ali, 1985. Relationship between plant maturity, lignin-pectin content and quality of jute fiber. Bangla. J. Jute Fib. Res., 10: 49-53.

Bishiruzzaman, M., A.J. Miah and M.M. Hoque, 1964. The chemical constituents and molecular weights of cellulose in different parts of jute. Fiber J. Textile Res., 34: 910-911.

Doric, C., 1950. The method of cellulose chemistry. Chapman and Hall Ltd., 2nd Ed. London, pp: 255.

Haque, M.S., Z. Ahmed, F. Akhter, M. Asaduzzaman, M.M. Rahman and M.A. Hannan, 2001. Comparative studies of retting properties of different released varieties of jute. J. Biol. Sci., 1: 998-1000.

Hosne Ara, B., B.S. Arangazeb and M.A. Sobhan, 1978. Studies of ultimate fibre cells of three breeding lines and two varieties of *Corchorus capsularis* L. Bangla. J. Jute Fib. Res., 4: 67-71.

Islam, R., A.M. Bhuiyan and R. Islam, 1978. Effect of retting on hemicelluloses of jute fibers at different time intervals. Bangla. J. Jute Fib. Res., 3: 7-16.

Khandakar, K., A. Muttalib and M. Husain, 1980. Studies on the quality of ultimate fiber cell in some pre-release variety/strains of *Corchorus olitorius*. Bangla. J. Jute Fib. Res., 5: 65-69.

Khuda, M.M., A.S.M. Serajuddin, N. Amin and A. Islam, 1970. Scientific grading of jute. Part II: Determination of cellulose in different grades of jute- using methods of cross and Bevan. Pak. J. Sci. Res., 12: 418-421.

Khuda, M.M., A.S.M. Serajuddin, N. Amin and A.A. Khan, 1976. Determination of cellulose in different grades of jute. Pak. J. Sci. Ind. Res., 11: 51-52.

Kertesz, Z.I., 1951. The pectic substances. Inter Science Publishers Inc., N.Y., pp: 333-380.

Mia, M.M. and A.Q. Shaikh, 1967. Gamma radiation and inter-specific hybridization in jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.). Euphytica, 16: 61-68.

Mohiuddin, G., M.I. Chowdhury, R. Kabir and S.K.A. Hasib, 1978. Lignin content of jute cuttings in the white and tossa varieties of Bangladesh. Bangla. J. Jute Fiber Res., 3: 27-32.

Macmillam, W.G., 1957. Jute the golden fiber. Pakistan Today Press. 60-Tanti Bazar, Dacca, East Pakistan, pp: 151.

Mashihuzzaman, M., N. Rahaman, M. Rahman and A.J. Mian, 1985. Structural studies of hemicelluloses from jute fiber and stick (*Corchorus capsularis* Linn). Bangla. J. Jute Fiber Res., 10: 7-13.

Mohiuddin, G., S.H. Talukder and S.K.A. Hasib, 1981. Chemical constituents of cuttings, Part I : Determination of pectin and wax. Bangla. J. Jute Fiber Res., 6: 77-80.

Majumdar, A.K. and A. Dey, 1977. Chemical constituents of jute ribbon and the materials removed by retting. Food farming and Agriculture, India, 4: 25-26.

Sen Gupta, A.B., 1958. Non-cellulose constituents and chemical modification of jute. Jute and Gunny Rev., 10: 1973-81.

Swaminathan, M.S., R.D. Iyer and K. Subbha, 1961. Morphology, cytology and breeding behaviour of hybrides between *Corchorus olitorius* and *Corchorus capsularis*. Curr. Sci., 30: 67-68.

Sobhan, M.A., S. Alam, A.C. Biswas, P.B. Mandal and F.A.H. Talukder, 1981. Preliminary study on the performance of jute (*Corchorus capsularis* L.) under farmers condition. Bangla. J. Jute Fib. Res., 6: 23-31.

Sarkar, P.B., 1933. The chemistry of Jute lignin. Part II, Potash fusion of lignin. J. Indian Chem. Soc., 10: 263-269.

Sobhan, M.A., 1980. Characteristics of jute varieties recommended for Bangladesh. Jute and Jute Fabrics Bangladesh, 6: 5-9.