POTENTIAL AGRICULTURAL LIGNOCELLULOSIC WASTE MATERIALS FOR BIOCONVERSION

M.N. Bari*, F. S. Shashi, M.H. Habib, M.M. Islam & M.M. Hassan

Department of Civil Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh
**Corresponding Author: niamulbari@yahoo.com*

ABSTRACT

Characterization experiment for ash content, lignin content, cellulose and hemicelluloses content were carried out of some agricultural wastes of wheat straw, sugarcane stem and mustard plant through the laboratory analysis to evaluate the potentiality for bioconversion. The highest cellulose content of 45.67±1.29% of dry matter was obtained from sugarcane stem followed by 32.56±1.96% from wheat straw and 26.20±0.67% from mustard plant. Therefore, sugarcane stem might be the potential substrate for bioconversion.

Keywords: Agricultural waste; lignocellulosic; potential; bioconversion; value added product

INTRODUCTION

Lignocellulosic material is composed of carbohydrate polymers (cellulose, hemicellulose), and an aromatic polymer (lignin). The presence of high amount of Cellulose and Hemicellulose certify one biomass having capability of producing bio-fuel. Lignocellulose in the form of forestry, agricultural and agro-industrial wastes is accumulated in large quantities every year. These materials are mainly composed of carbohydrates of plants are in the form of lignocellulosic which are made up of mainly cellulose, hemicellulose, pectin, and lignin. Lignocellulose is generally found, for example, in the stems, leaves, husks, straws and cobs of plants or leaves, branches, and wood of trees. The herbaceous material, agricultural residues, forestry residues, municipal solid wastes, waste paper, and pulp and paper mill residues etc can also be said the lignocellulosic materials. Agricultural wastes and in fact all lignocellulosics can be converted into products that are of commercial interest such as ethanol, glucose, single cell protein, organic acid and enzymes (Bari, et al., 2010a; Kassebullah, 2006).

Lignocellulosic agricultural wastes are among the causes of environmental pollution. Their conversion into useful products may ameliorate the problems they cause. There are various lignocellulosic agricultural wastes like millet husks, banana peels, wheat bran, rice husk, wheat straw, coir waste and saw dust were selected for the cellulase production (Jadhav, *et al*., 2013; Masutti, *et al*. 2012). Cellulase are a group of enzymes that breakdown cellulose into glucose monomers. Cellulase enzyme has importance due to major role in industrial applications. It is used for bio-remediation, waste water treatment, food processing, drying of beans, food supplement, protoplast isolation, plant virus's investigations, metabolic and genetic modification studies, ethanol production and also for single cell protein (Ali and Saad, 2008; Shah, 2007; Alam, 2005). Organic acid like citric acid has also produced from palm oil empty fruit bunch (EFB) (Alam, et al., 2010).

Now-a-days when environmental pollution is a great concern; agricultural waste is one of the major causes of this problem. The elimination of this problem is possible by their conversion into useful products. Moreover, by Solid State Fermentation, it is possible to produce enzymes, organic acids, bio-pesticides, bio-surfactants, aroma compounds, degradation of toxic compounds, bio-transformation, and nutritional improvement of crops. However, huge quantities of agricultural wastes are producing every year in Bangladesh. Therefore, the aim of this study is to characterize some agricultural wastes to evaluating the potentiality of using as raw materials for production of any value added production through bioconversion.

METHODOLOGY (SECTIONS)

Abundantly produced agricultural wastes in and around the Rajshahi city such as wheat straw, sugarcane stem, mustard plant were considered for characterization. The samples of were collected from RUET campus and prepared by cleaning, drying, grounding, and sieving (Bari, et al., 2010b). Acid insoluble lignin was determined according to TAPPI T222 om-88 test method and acid soluble lignin was determined according to TAPPI Useful Method UM-250. The total lignin content was estimated with the sum of acid insoluble and acid soluble lignin contents. Alphacellulose (true cellulose) content was determined according to TAPPI T203os-61 (TAPPI, 1961) test method. The quantity of hemicellulose was estimated by subtracting the quantity of alphacellulose from the quantity of holocellulose. Holocellulose content was determined according to method developed by Wise et al. (1946). Residual ash content was also determined by burning at 550ºC in a furnace.

RESULTS AND DISCUSSIONS

The justification of new material as a potential substrate for any bioconversion product depends on its chemical and physical characteristics. The vision of this study was to characterize the selected agricultural wastes materials.

Lignin is a constituent of the cell walls of almost all dry land plant cell walls. It is the second most abundant natural polymer in the world, surpassed only by cellulose. Of the polymers found in plant cell walls, lignin is the only one that is not composed of carbohydrate (sugar) monomers. Lignin is polymer consisting of phenyl-propane units. The lignin contents of tested lignocellulosic materials are presented in Fig. 1.

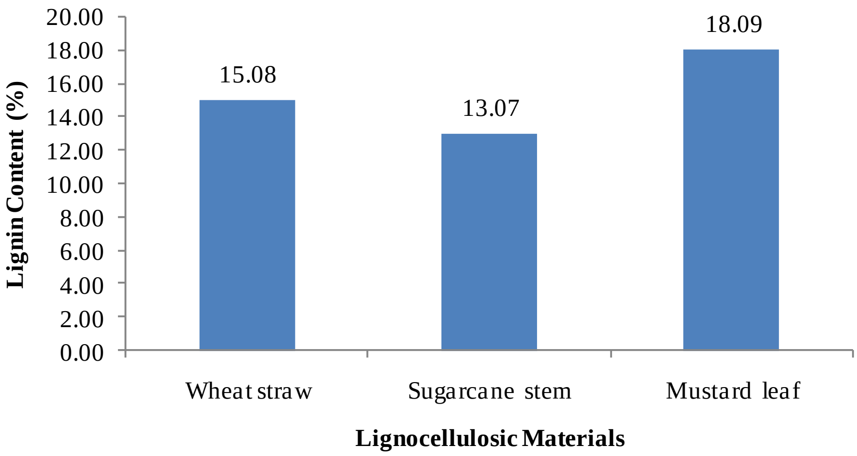

Fig.1: lignin content of different lignocellulosic materials

The lignin which is a complex chemical compound and an integral part of the cell walls are varying from 13±0.7% to 18±0.4%. The highest value is for mustard leaf and the lowest for sugarcane stem. The contents of lignin of these materials are small compared to woody substances. It is the most abundant organic polymer on Earth after cellulose, employing 30% of non-fossil organic carbon and constituting from a quarter to a third of the dry mass of wood.

Cellulose is a natural polymer, a long chain made by the linking of smaller molecules. It is a long chain of linked sugar molecules that gives wood its remarkable strength. It is the main component of plant cell walls. Generally the cellulose content of wood varies between the ranges of 40-50%. But some lignocellulosic materials can have more cellulose than wood. Cellulose is a homo-polysaccharide composed of D-glucopyranose units linked to each other by β-(1→4) glycoside bonds. The molecules are completely linear and have a strong tendency to intermolecular hydrogen bonds. This leads to bundling of cellulose molecules into micro-fibrils, which in turn form fibrils and finally cellulose fibers (Christiane, 2005). The results of cellulose contents are shown in Fig. 2.

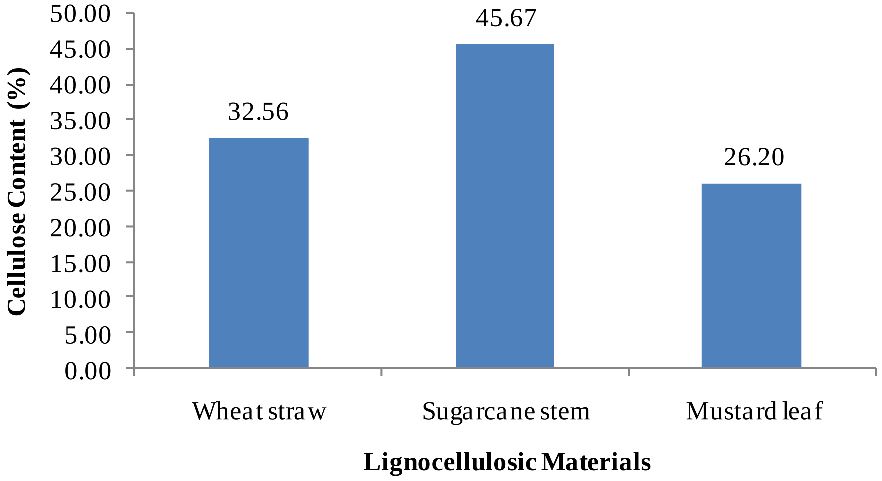

Fig. 2: Cellulose content for different lignocellulosic materials

It is evident from figure that the highest content of cellulose is obtained in sugarcane stem while the lowest is in mustard leaf. The cellulose content of 45.67±1.3% is very encouraging value because the cellulose is a major part of lignocellosic material which is almost 50% of the total material.

The α-cellulose which is called true cellulose is composed of polysaccharide $[(C_6H_{12}O_6)_n]$. The fraction or quantity of this constituent is important for any metabolic product by microbial bioconversion. The contents of α-cellulose are shown in Fig. 3. The highest quantity of α-cellulose obtained was 44.68±1.36% of dry sugarcane stem which is 1.5 time and 2 times of α-cellulose obtained from wheat straw and mustard plant, respectively.

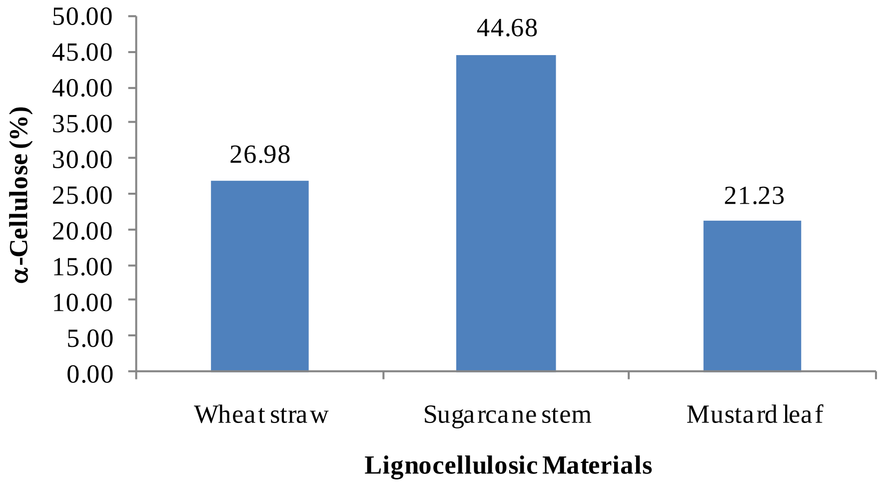

Fig. 3: α-cellulose content (%) of different lignocellulosic materials

Hemicellulose (also known as polyose) is any of several hetero-polymers (matrix polysaccharides), such as arabino-xylans, present along with cellulose in almost all plant cell walls. While cellulose is crystalline, strong, and resistant to hydrolysis, hemicellulose has a random, amorphous structure with little strength. It is easily hydrolyzed by dilute acid or base as well as myriad hemicellulose enzymes. Unlike cellulose, hemicelluloses consist of different monosaccharide units. In addition, the polymer chains of hemicelluloses have short branches and are amorphous. Because of the amorphous morphology, hemicelluloses are partially soluble or swell able in water. Among the most important sugar of the hemicelluloses component is xylose. Their anhydrous-glucose units are linked by □-(1, 4)-glycoside bonds. Fig. 4 shows hemicelluloses contents.

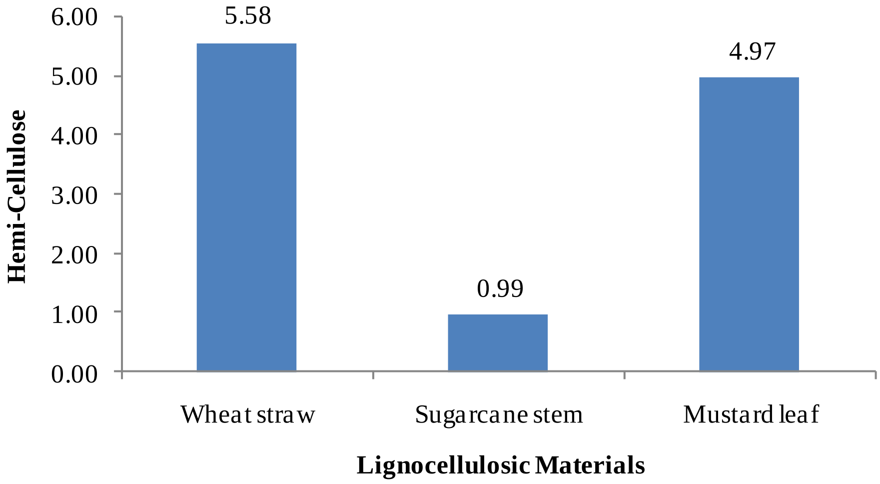

Fig. 4: Hemicellulose content of different lignocellulosic materials

The hemicellulose contents of wheat straw, sugarcane stem and mustard leaf are obtained as 5.58±0.16 %, 0.99±0.1% and 4.97±0.17%, respectively. Therefore, amorphous part is very less in sugarcane stem compared to wheat straw and mustard leaf. In these situation additional initial sucrose might be required for the initial growth of microbes for bioconversion.

Ash is the inert portion of any lignocellulosic materials that will not contribute in bioconversion product. Less amount of ash content is desirable for any material to be used for bioconversion as substrate. Ash contents of wheat straw, sugarcane stem and mustard leaf are presented in Fig. 5.

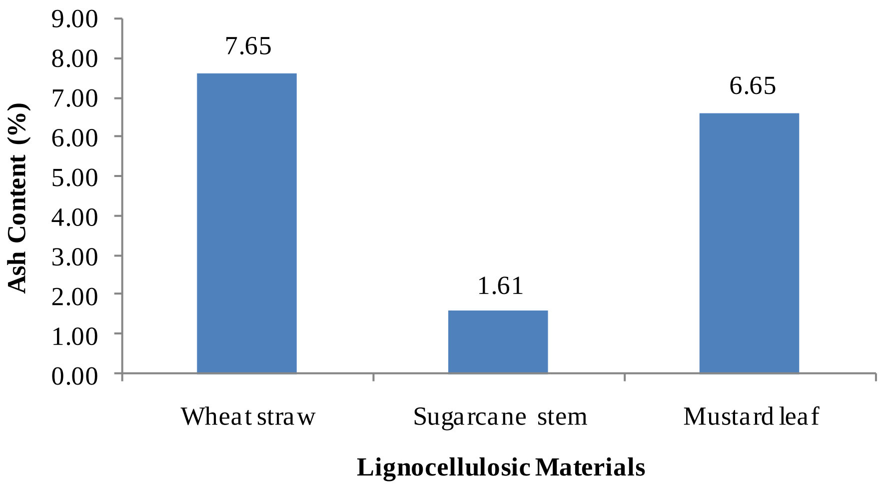

Fig. 5: Hemicellulose content of different lignocellulosic materials

It is found from the result that the ash (inert material) content of sugarcane stem is very low compared to wheat straw and mustard plant which contain 7.65±0.70% and 6.65±0.26%, respectively while 1.61±0.18% for sugarcane stem on dry weight basis.

CONCLUSIONS

From the result it is clear that wheat straw and sugarcane bagasse contain comparatively high amount of cellulose or hemicellulose and low amount of lignin. On the other hand mustard leaf contains low amount of cellulose and hemicellulose and comparatively high amount of lignin. Usually for the production of bio ethanol, cellulase enzyme, fermented sugar can be produced in the presence of high amount of cellulose and hemicellulose. So it can be said that, Wheat straw and sugarcane bagasse can be used in the production of bio-ethanol, cellulase enzyme and fermented sugar. On the other hand, as mustard leaf contain high amount of lignin it can be used for producing lignin per-oxidase enzyme.

REFERENCES

Alam, MZ; Muhammad, NM and Erman, MM. 2005. Production of Cellulase Enzyme from Oil Palm Biomass as Substrate by Solid State Bioconversion. *American J Applied Sci*., 2: 569- 572.

Alam, MZ; Bari, MN; Suleyman, AM; Jamal, P and Mamun, AA. 2010. Solid State Bioconversion of Oil Palm Empty Fruit Bunches for Production of Citric Acid by Wild Aspergillus Niger. *Food Biotechnology*, 24(1):19-36.

Ali, UF and Saad EHS. 2008. Production and Partial Purification of Cellulase Complex by Aspergillusniger and A. nidulans Grown on Water Hyacinth Blend. *J Applied Sci. Res*., 4: 875.

Bari, MN; Alam, MZ; Suleyman, AM; Jamal, P and Mamun, AA. 2010a. Statistical optimization of process parameters for the production of citric acid from oil palm empty fruit bunches. *African Journal of Biotechnology*, 9 (4):554-563.

Bari, MN; Alam, MZ; Suleyman, AM; Jamal, P and Mamun, AA. 2010b. Effect of Particle size on Production of Citric Acid from Oil Palm Empty Fruit Bunches as New Substrate by Wild Aspergillus niger. *Journal of Applied Sciences*, 10 (21):2648-2652.

Jadhav, AR; Girde, AV; More, SM; More, SB and Khan, S. 2013. Cellulase Production by Utilizing Agricultural Wastes. Res. *J. Agriculture and Forestry Sci.*, 1(7):6-9.

Kassebullah, MB. 2006. Production of cellulase enzyme from aspergillusterreussuk-1 using sugar cane waste: the effect of substrate concentration and assay temperature. http://umpir.ump.edu.my/538/1/Mohd._Nazip_Kassebullah.pdf

Masutti, DC; Borgognone, A and Setti, L. 2012. Production of Enzymes from Rice Husks and Wheat Straw in Solid State Fermentation. *Chemical Engineering Transaction*, 27:133-138.

Shah, N. 2007. Optimization of an enzyme assisted process for juice extraction and clarification from Litchis (Litchi ChinensisSonn.*)*. *Int J Food Eng*., 3:1-17.

TAPPI, 1961. TAPPI Test method, T203os-61. Technical Association of the Pulp and Paper Industry.

Wise, LE; Murphy, M and D'Addieco, AA. 1946. Chlorite holocellulose: its fraction and bearing on summative wood analysis and on studies on the hemicelluloses. *Paper Trade J.*, 122:35-43.