Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Der ChemicaSinica, 2015, 6(2):25-28

ISSN: 0976-8505
CODEN (USA) CSHIA5

Compositional analysis of lignocellulosic biomass from certain fast growing tree species in India

***N. Senthilkumar, S. Murugesan, R. Sumathi and D. Suresh Babu**

Division of Bioprospecting, Institute of Forest Genetics and Tree Breeding, Coimbatore, Tamilnadu, India

---

ABSTRACT

Compositional analysis of fast growing short rotation tree species such as Casuarina equisetifolia, Eucalyptus camadulensis, Gmelina arborea, Leucaena leucocephala, Melia dubia, Swietenia macrophyla, Thespesia populnea, Acacia auriculiformis, Anthocephalus cadamba, Dalbergia sissoo has been conducted to understand the cellulose, hemicelluloses and lignin contents necessary for biorefinery industries. Maximum of 48.7 percent cellulose was found in C. equesitifolia followed by M. dubia 48.3%, and E. camadulensis 47.18%. Hence, these species may be scaled up in larger areas in order to provide sustainable feed stock to biorefinery industry.

Key words: Compositional analysis, lignocellulosic biomass, trees, biethanol and biorefinery

---

INTRODUCTION

Biomass, or plant derived material, is of interest as a fuel source for several reasons. Foremost, when managed wisely, it has the potential to become a sustainable source of transport fuels. It is a leading near-term solution to fill the gap between growing global energy demand and dwindling petroleum availability. The conversion of biomass to renewable fuels has the potential to be carbon neutral, where carbon dioxide produced during fuel production and consumption is utilized by the next generation of plants during growth cycles. Finally, many geographic areas contain some type of plant material that can be utilized as a fuel source, eliminating the need for long-distance fuel transport. Plant derived biomass consists of many different constituents, but the principal constituents are structural carbohydrates (cellulose, hemicelluloses), lignin, protein, and ash. Cellulosic biomass feedstocks can be processed in several ways to make fuels. In the biochemical conversion process, the cellulosic biomass is converted to monomeric sugars, which are then fermented to ethanol and other platform chemicals. Alternative conversion techniques include thermochemical conversion to either pyrolysis oil or synthesis gas, or catalytic conversion of the monomeric carbohydrates using enzymes in aqueous solution. The techniques for biomass feedstock compositional analysis are largely independent of the conversion process, although the analyses of process intermediates are obviously dependent on the conversion process. The structural carbohydrates are typically divided into two groups, cellulose and hemicellulose. Cellulose is a polymer with a rigid structure of repeating glucose units, and is highly stable and resistant to chemical attack. It has a high degree of hydrogen bonding, which contributes to the rigidity of the structure. Hemicellulose is a polymer consisting of shorter, highly branched chains of sugars. Hemicellulose can contain five-carbon sugars, such as xylose and arabinose, as well as six-carbon sugars, such as glucose, galactose, and mannose. The backbone may be mannose or xylose, with a variety of side chain sugars [1]. The branched character of hemicellulose causes it to be more amorphous and easier to break down compared to cellulose. Aside from carbohydrates, the major structural material present in lignocellulosic biomass is lignin. Lignin is a polymeric structure that is highly aromatic and branched. It has a high molecular weight and a complex structure. Lignin assists in holding the cells together, provides the plant with rigidity, and gives it some resistance to insect and biological degradation. Biomass compositional analysis to understand the constituents and their percentage is a crucial step in bioconversion of biomass into fermentable sugars for bioethanol and other platform chemicals production. In India, sustainable availability of biomass is 137 mt annually from forest residue and expected to increase 180 mt by 2047. Since, biofuel policy in India restricts to use food crops like, corn, wheat, cassava, wheat and sugarcane for bioethanol to use in automobiles, dependency on lignocellulosic biomass from forest resources is warranted. Therefore, tree species suitable for outside forest areas and other wastelands are being promoted to increase biomass. More importantly, fast growing tree species such as *Casuarina equisetifolia, Eucalyptus camadulensis, Gmelina arborea, Leucaena leucocephala, Melia dubia, Swietenia macrophyla, Thespesia populnea, Acacia auriculiformis, Anthocephalus cadamba, Dalbergia sissoo* are being planted widely in southern part of India. Hence, compositional analysis of these fast growing tree species gains importance in bioethanol industry. Therefore, a study on compositional analysis of aforementioned tree species has been conducted using standard methods as described by NREL for biomass compositional analysis.

MATERIALS AND METHODS

Essentially, compositional analysis methods begin with an extraction step to remove the non-structural material from the biomass sample. Wood samples of 10gms each of the said tree species were collected from our field research station at Panampally, Kerala. They were milled to the size recommended by NREL. Then the extraction is made using standard methods recommended by NREL. The extracted material then undergoes acid hydrolysis (typically a concentrated acid hydrolysis step performed at room temperature followed by a dilute acid hydrolysis step at elevated temperature) to break down the structural carbohydrates to their monomeric forms, which can then be measured chromatographically. Lignin is typically measured gravimetrically as the acid-insoluble residue as methods used at the National Renewable Energy Laboratory for biomass compositional analysis [2] NREL-LAP, at *http://www.nrel.gov/biomass/analytical_procedures.html).* The result of the analysis is presented below.

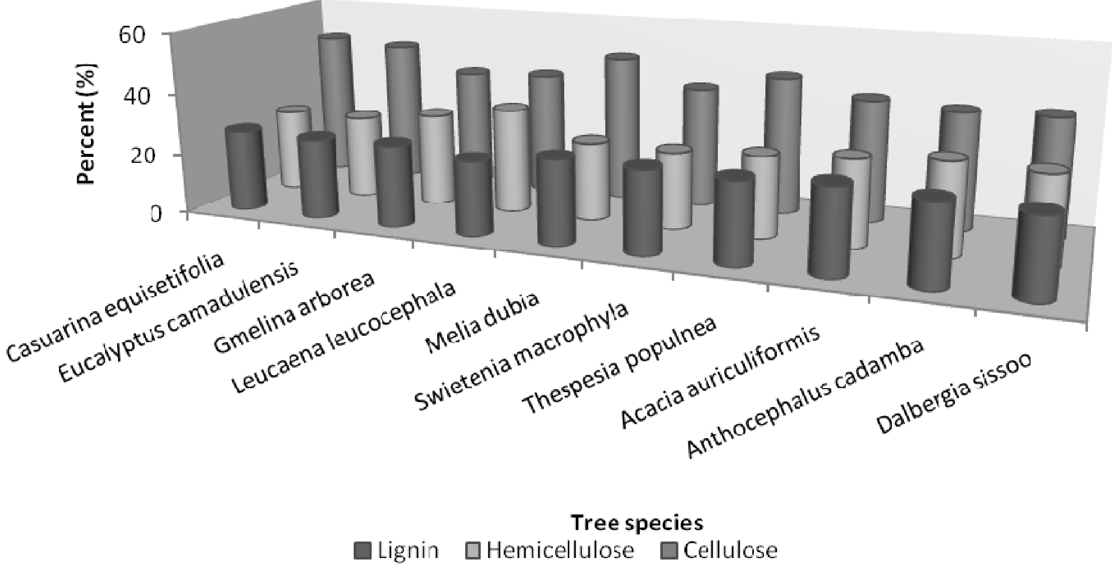
RESULTS AND DISCUSSION

An ideal biomass resource will be high yielding, have low production costs, be readily available, and have consistent desirable chemical concentrations. The feasibility of a new energy crop will depend largely on its production costs, cost of converting the biomass to usable energy, and cost of competing fuels. Forest-derived biomass, specifically from fast growing short rotation tree crops such as *Casuarina equisetifolia, Eucalyptus camadulensis, Gmelina arborea, Leucaena leucocephala, Melia dubia, Swietenia macrophyla, Thespesia populnea, Acacia auriculiformis, Anthocephalus cadamba,* and *Dalbergia sissoo* are studied for their chemical composition. Table 1 lists cellulose, hemicelluloses and lignin content in ten fast growing tree species (Fig. 1.). *C. equestifolia* yielded 48.70% cellulose; 27.13% hemicelluloses and 26.64% lignin contents on a dry matter basis, followed by *M. dubia*, *E. camadulensis*, *T. populnea* and so on (table 1). It was reported maximum of 37.6, 37.5 and 37.3 % cellulose in wheat straw, corn stover and switch grass respectively [3]. However, it was reported that cellulose, hemicelluloses and lignin contents in poplar, eucalyptus, switch grass and corn stover and found 42.2, 48.07, 33.7 and 37.12% of cellulose respectively [4]. In the present study, *A. cadamba* is found to have low level of 38.62% cellulose; 30.22% hemicelluloses. Other potential biomass crops have levels of lignocelluloses when compared to *C. equisetifolia* and *M. dubia*. Cellulose content in tree species of various countries viz., Borneo, Brazil, Cambodia, Chile, Colombia, Costa Rica, Ghana, Japan, Mexico, Mozambique, Papua New Guinea, the Philippines, Puerto Rico, Taiwan, USA and the USSR were also reported [5]. It was reported 51% of cellulose in *Lannea discolor* from Mozambique and 47% in *Gmelina arborea* from Ghana. Since biorefineries will require consistent supply of feed stock and the feed stock should have high levels of cellulose and hemicelluloses to harvest maximum fermentable sugars for bioethanol production. Based on the present study tree species such as *C. equisetifolia, M. dubia, E. camadulensis, T. populnea* may be considered for large scale plantation for sustainable supply of feed stock to biorefineries.

Table 1. Compositional analysis of certain fast growing tree species in India

S. No.	Tree crops	Cellulose	Hemicellulose	Lignin
			%	
1	*Acacia auriculiformis*	40.17	28.30	27.62
2	*Anthocephalus cadamba*	38.62	30.22	26.18
3	*Casuarina equisetifolia*	48.70	27.13	26.64
4	*Dalbergia sissoo*	39.30	29.05	25.26
5	*Eucalyptus camadulensis*	47.18	27.18	26.21
6	*Gmelina arborea*	39.16	30.17	26.71
7	*Leucaena leucocephala*	40.19	34.29	24.23
8	*Melia dubia*	48.30	25.68	27.52
9	*Swietenia macrophyla*	39.64	25.14	26.93
10	*Thespesia populnea*	45.22	26.61	26.43

Fig. 1. Compositional analysis of certain fast growing tree species in India



CONCLUSION

Biorefinery industries required sustainable supply of lignocellulosic feed stock for bioethanol production which could contain high holocelluloses with less lignin content. The present study revealed that fast growing short rotation tree species with high cellulose and low lignin contents such as *Casuarina equisetifolia*, *Eucalyptus camadulensis*, *Leucaena leucocephala*, *Melia dubia*, *Thespesia populnea*, and *Acacia auriculiformis* with rotation period of 4-5 yrs yield 40-80 tonns/hac of biomass fetches around 1.5 lakhs may be considered for large scale plantation to supply raw material for bioethanol industry.

REFERENCES

[1]Hames BR, Thomas SR, Sluiter AD, Roth CJ, Templeton DW, *Applied Biochemistry and Biotechnology*, **2003,** (105:1-3), pp. 5-16.
[2]Sluiter A, Hames B, Ruiz R, Scarlata C, Sluiter J, Templeton D, Crocker, D, Determination of Structural Carbohydrates and Lignin in Biomass Laboratory Analytical Procedure (LAP), **2012,** *http://www.nrel.gov/biomass/analytical_procedures.html).*
[3]Roger C. Pettersen, The chemical composition of wood. In: Rowell, Roger M., Ed. The Chemistry of solid wood. Advances in Chemistry series 207. Washington, DC. American Chemical Society, **1984,** 56-127
[4]Do Kyoung Lee, Vance N Owens, Arvid Boe, Peter Jeranyama, Composition of Herbaceous Biomass feedstocks. http://ncsungrant.sdstate.org/uploads/publications/SGINC1-07.pdf **2007.**
[5]Poulomi Sannigrahi, Arthur Ragauskas, Gerald A. Tuskan. *Biofuel Bioprod Bioref,* **2010,** 4, 209–226