CHEMICAL CHARACTERIZATION OF BANANA(*Musa sp.*) AGROWASTE: AS A POTENTIAL RENEWABLE ENERGY SOURCE

A comparative study of major banana cultivars grown in Nanded district of Maharashtra (India)

Sunita R. Mukkawar
Department of Microbiology
B. Raghunath ACS College, Parbhani, Maharashtra (India)
E. Mail ID: mukkawars@yahoo.com
Mobile No.: 9422415911

ABSTRACT:

Agricultural residue like banana waste is one of the major biomass categories that can be used for various purposes. The aim of this work is to determine chemical composition of banana leaves, pseudo-stem and rhizome which are thrown in field as waste. The promising cultivars popularly grown in Nanded district of Maharashtra which have been taken for this study were Ardhapuri-1, Ardhapuri-2 and tissue culture variety, G-9. Experiments were carried out to know their moisture content (%), cellulose content (%), hemicellulose content (%), lignin content (%) and ash content (%).

Moisture content was found highest (96.70%, 97.70% and 95.90%) in the pseudostem whereas lowest in the rhizome (90.30 %, 87.20% and 90.90%) in all the three varieties respectively as mentioned above. Cellulose content was found lowest (10.74%) in the rhizome of Ardhapuri-2 cultivar and highest (33.84%) in the leaves of G-9 cultivar. Hemicellulose was found highest (65.40%) in the rhizome of G-9 cultivar whereas lowest (19.77%) in the leaves of Ardhapuri – 2. Highest content of lignin (9.56%) was observed in pseudostem of Ardhapuri-2 cultivar whereas lowest lignin content (1.04%) was found in rhizome of G-9. Lowest ash content was found in the rhizome and highest in the pseudostem of all the three cultivars indicating pseudostem as rich source of minerals. Rhizome of all the three cultivars showed less percentage of all the analyzed constituents when compared with leaf and pseudostem.

KEY WORDS: Pseudostem, cellulose, hemicellulose, lignin, ash, minerals etc.

INTRODUCTION:

India is one of the largest producers of banana. Major banana producing states of India are Maharashtra, Kerala, Tamil Nadu, Gujarat, Bihar and West Bengal, (Desai *et al.*,2016). Annually 26.2 million tons, of banana is produced in India which is contributing about 23% of world banana production. Leaves, pseudostem and rhizome contribute as major biomass, which is normally left in the plantation area after harvesting of fruits and creating huge biomass. This biomass is a rich source of total carbohydrates with respect to cellulose (Saravanan *et al.*, 2011). In past, some researchers have demonstrated utilization of banana pseudo-stem and leaves for extraction of fibers on a small scale. In India, the fibers are basically used for preparing handicrafts, ropes etc., Presently, this biomass is discarded as waste in many countries (Khan *et al.*, 2013) and dumped on road side or burnt which causes severe environmental pollution. (Dawn *et al.*, 2016c). These lignocellulose materials vary in their proportions of cellulose, hemicellulose and lignin. Typical biomass contains 40% to 60% cellulose, 20% to 40% hemicellulose and 10% to 25% lignin. Extractives and minerals generally account for less than 10% of the dry biomass weight.

The amount of cellulose in agro-waste influences the utility of agro-waste for various applications e.g. the agro-waste having higher cellulose content would be preferable for textile, paper and other fibrous applications whereas byproduct with higher hemicellulose content would be preferable for producing ethanol and other fermentation products because hemicellulose is relatively easily hydrolysable into fermentable sugars. Therefore, the value of the product and its potential application in large extent determined by cellulose content. The banana agro-waste has composition of cellulose, hemicellulose, lignin and ash as 60 to 65%, 6 to 8%, 5 to 10% and 4 to 7% respectively (Majumdar and Chanda 2001, Satyanarayana *et al.*, 1986, and Kulkarni *et al.*, 1983).

Reports are not available for the chemical composition of the banana agrowaste cultivars of this area. Hence this study is aimed to know the chemical composition of banana agrowaste of the popularly grown cultivars of Maharashtra so as to exploit it as a valuable source for production of novel products and reduce environmental pollution.

MATERIALS AND METHODS:

Agro-waste Sample: Banana agro-waste samples were collected from the Ardhapur region of Nanded District. The samples comprised of leaves, pseudostem and rhizome of the three popularly grown cultivars of banana plant, viz. Ardhapuri-1, Ardhapuri-2 and Tissue culture G-9.

Chemicals: All the chemicals of analytical grade were procured from Qualigens, S.D. Fine Chemicals and Spectrochem.

Instruments:

i. UV - Visible Spectrophotometer : Elico-1601.
ii. Muffle Furnace : Indfur -OR-54.
iii. ICP-ES : Perkin Elmer.
iv. Centrifuge : Remi C-120.

METHODS:

Analysis of agro-waste for chemical composition:

Sample collection and sample preparation:

The banana plants were collected from the Ardhapur region of Nanded district where this crop is grown for successive 10 years. Plants of three cultivars i.e. Ardhapuri- 1, Ardhapuri-2 and the tissue culture variety G-9 were collected from the field. The whole plant, which is to be discarded, was brought in the laboratory. Leaves, pseudostem and rhizome were separated. Each part was thoroughly washed with tap water to remove extraneous dust. The excess water was drained off and it was blot dried. Each part was separately chopped into pieces of 2 cm. Chopped pieces were air dried for 72 hours and then oven dried at 45^0C to constant weight. The samples were ground into fine powder by using electric grinder and stored in polythene container.

Determination of cellulose, hemicellulose and lignin content:

Cellulose, Hemicellulose and Lignin content of the powdered sample was determined according to the methods described in AOAC (Van Soest *et al.*, 1991) by determining Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin (ADL).

Determination of Neutral Detergent Fibre (NDF):

One gram of powdered sample was taken in reflux flask. 10 ml. of cold neutral detergent solution was added to it. Then 2 ml. of decahydro-napthalene and 0.5 g. sodium sulphite was added in the same flask. The contents were heated to boiling and refluxed for 1 hour. The flask was cooled at room temperature and the contents were filtered through sintered glass crucible (G-2) by suction. The residue on the crucible was washed with hot water. Finally, it was washed twice with acetone. The residue was transferred to a pre-weighed crucible and dried at 100^0C for 8 hours. The crucible was cooled in desiccator and weight of the residue was determined to obtain NDF value.

Determination of Acid Detergent Fibre (ADF):

One gram of powdered sample was taken in a round bottom flask and 100 ml. of acid detergent solution was added to it. The flask was heated to boil for 5-10 min. Then heat is reduced to avoid foaming and the flask was refluxed for 1 hour after the onset of boiling. After boiling, the flask was removed and the contents were filtered through a pre-weighed sintered glass crucible (G-2) by suction and residue was washed twice with hot water. Finally, the residue was washed with acetone to break up the lumps. Acetone washing was repeated until the filtrate is colorless. The contents were heated at 100^0C overnight and weight of the contents was recorded after cooling in desiccator. The ADF in percentage was determined as,

$$\% \text{ ADF} = \frac{W}{S} 100$$

Where W = Weight of Fiber.
S = Weight of sample.

Determination of Acid Detergent Lignin (ADL):

ADF was transferred to a 100ml. beaker containing 25-50 ml. of 72% sulphuric acid. It was allowed to stand for 3 hours with intermittent stirring with glass rod. After 3 hours, contents were diluted with distilled water and filtered with pre-weighed Whatman No.1 filter paper. The filter paper was dried at 100^0C and weight of the filter paper was taken after cooling in desiccator. The filter paper along with the contents was transferred to a pre-weighed silica crucible and heated in muffle furnace at 550^0C for 3 hours to get ash. The crucible was cooled in a desiccator and weight was recorded to calculate the ash content. The ADL in percentage is expressed as,

Weight of 72% H_2SO_4 washed fibre - Ash

$$\% \text{ ADL} = \frac{\text{.....}}{\text{Weight of sample}} \times 100$$

Cellulose, hemicellulose and lignin content was determined by referring the equations as

Hemicellulose	=	NDF – ADF
Cellulose	=	ADF – Residue after extraction with 72% H_2SO_4
Lignin	=	Residue after extraction with 72% H_2SO_4 - Ash.

Determination of protein content:

Protein content of the sample was determined by the method of Lowry *et al.,* (1951) with bovine serum albumen (BSA) as a standard.

Determination of moisture content:

Known amount of chopped sample was taken in a pre-weighed crucible and dried in oven at 105^0C to a constant weight. The weight of crucible before drying the material and after drying was recorded to calculate loss in weight and the moisture content is determined by the formula,

$$\textbf{Moisture content (\%)} = \frac{\text{Initial wt. of sample - Wt. of sample after drying}}{\text{Initial wt. of sample}} \times 100$$

Determination of ash content:

Ash content of powdered sample was determined by the procedures described by Zakaria *et al., (*2003). 1.5 g. of previously dried powdered sample was taken in a pre-weighed silica crucible and heated at 750-800^0C. for 6 hours in muffle furnace. The crucible was then cooled in desiccator and the weight of crucible was taken to calculate ash content of the sample.

Percentage of ash was determined by the formula,

$$\textbf{Percentage of ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Determination of mineral components:

Mineral composition of the ground sample was determined according to the methods described in AOAC (18th edition 2005). Mineral contents were assayed by ICP analysis of ashes obtained after raw material calcination.

RESULT & DISCUSSION:

The chemical analysis data of banana agro-waste revealed that the three banana cultivars studied have less than 7% lignin content therefore these banana cultivars agro-wastes can be utilized by microorganisms for decomposition. However, the leaves, pseudostem and rhizome of Ardhapuri-1 banana cultivar contain high cellulose, hemicellulose and protein content compared to Ardhapuri-2 and tissue culture G-9 cultivar.

Oliveira *et al*., (2007) also analyzed chemical composition of different morphological parts from Dwarf Cavendish banana plant and reported 37.3% cellulose in leaf sheath, 15.7% in floral stalk; lignin 24.3% in leaf blades and 10.5% in rachis and 11.6 to 26.8% ash which was mainly composed by potassium, calcium and salicium salts whereas hemicellulose in banana plant was from 5.5% in floral stalk and 21.55 in petiole and midrib. 8.3% of protein was also reported in leaf blades.

Khalil *et al.,* (2006) also revealed chemical composition of pseudostem of Malaysian cultivar of banana. These include holocellulose 65.2%, ash 1.5% and lignin 18.6%. Li *et al*., (2010) also reported banana pseudostem has high holocellulose and low lignin content. The monomeric content of holocellulose of banana pseudostem consists mainly of glucose 17.76%, followed by xylose 11.20%, arabinose 7.34%, galactose 2.2%, mannose 0.58% and galacturonic acid 7.09%.

The study on chemical composition from different morphological parts of banana cultivars revealed that banana plant varies significantly. The major extremes were found in contents of holocellulose, lignin, hemicellulose, ash, and protein however holocellulose content has at higher extremity and lignin towards lower side in studied banana cultivar. The high cellulose content and less lignin content in banana cultivars acts a best substrate for the growth of bacteria, actinomycetes and fungi.

CONCLUSION:

Results of this study revealed that the agrowaste (leaves, pseudostem and rhizome) of all the cultivars of banana frown in the area is rich with cellulose, hemicellulose, lignin and mineral contents. Hence after bioconversion of this waste, it can be converted into a potential energy source for production of value-added products.

REFERENCES:

1. Abdul Khalil, H.P.S., M.S. Alwani and A.K. Md.Omar, 2006; Chemical composition, anatomy, lignin distribution and cell wall structure of Malaysia plant waste fibres. *BioResour.* **1** (2): 220-232.
2. Dawn, C.P. Ambrose, Lakshman, R. and Naik, Ravindra ,2016c; Studies on the drying kinetics and quality assessment of banana pseudostem waste for effective utilization as a value-added product. *Internat. J. Farm Sci.,* **6**(2): (2016): 276-285.
3. Desai, C.S., Desai, C.D., Desai, S.K., Mistry, P.S., Patel, J. M. and Vaidya, H.B. 2016; **Preparation** of flavored candy from central core of banana pseudostem. *Asian J. Dairy & Food Res.*, **35** (4): 341-342.
4. Khan, M.Z.H., Sarkar, M.A.R., Md. Forhad, I.A.I. and Raimo, O.M. 2013; Fiber morphology and pulping study of banana pseudo-stem. *Internat. J. Fiber & Textile Res.,* **3**(1): 31–35.
5. Kulkarni *et al.* (1983, cited in Reddy and Yang, 2004). Mechanical properties of banana fibers. *J. Mater. Sci.* **18**: 2290-2296.
6. Li, K., S. Fu, H. Zhan, Y. Zhan, L. A.Lucia, 2010; Analysis of the chemical composition and morphological structure of banana pseudostem. *Bio-Resour.* **5**(12): 576-585.
7. Lowry, O.H., N.J. Rosenborough, A.L. Farr and R.J. Randall, 1951; Protein measurement with the Folin phenol reagent. *J. Biol. Chem.* **193**: 265-271.
8. Majumdar, P. and S.Chanda, (2001, cited in Reddy and Yang, 2004). Chemical profile of some lignocellulosic crop residues. *Ind. J. Agric. Biochem.* **14** (1&2): 29-33.
9. Nurhayati Abdullah, Fauziah Sulaiman and Rahmad Mohd Taib, 2013; Characterization of Banana (*Musa* spp.) Plantation Wastes as a Potential Renewable Energy Source Article *in* AIP Conference Proceedings · May 2013
10. Oliveira L., N.Cordeiro, D.V. Evtuguin,I.C. Torres and A.J.D.Silvestre, 2007; Chemical composition of different morphological parts from Dwarf Cavendish banana plant and their potential as a non-wood renewable source of natural products. *Ind. Crops. Proudcts.* **26**(2): 163-172.
11. Satyanarayan *et al.* (1986, cited in Reddy & Yang, 2004). Materials science of some lignocellulosic fibers. *Metallography*, **19**: 389-400.
12. Saravanan, Kandasamy and Somaradhya, Mallikarjuna Aradhya,2011; Potential nutraceutical food beverage with antioxidant properties from banana plant bio-waste (Pseudostem and rhizome). *Food Funct.*, **2:** 603-610
13. Van Soest, P.J., J.B.Robertson and B.A.Lewis. 1991; Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle. *J. Dairy Sci.* **74**: 3583-3597.
14. Zakaria Ahmed, Md. S. Haque, Firoza Akhter and Muhmada Begum, 2003; Study of the chemical composition of different pipeline varieties of Jute fibres. *Pak.J.Bio.Sci.* **6** (16): 1463-1467.

Table 1: Chemical composition of leaves of Banana cultivars.

Sr. No.	Component (%)dry wt.	Banana Cultivar		
		Ardhapuri-1	Ardhapuri-2	Tissue Culture G-9
1	Holocellulose	62.68	47.14	56.48
2	Cellulose	28.24	27.37	33.84
3	Hemicellulose	34.44	19.77	22.64
4	Lignin	5.96	1.04	7.09
5	Proteins	7.40	4.60	7.00
6	Ash	12.54	16.04	12.89
7	Moisture	93.80	91.40	92.00

Each value represents average of three samples.

Table 2: Chemical composition of pseudostem of Banana cultivars.

Sr. No.	Component (%)Dry wt.	Banana Cultivar		
		Ardhapuri-1	Ardhapuri-2	Tissue Culture G-9
1	Holocellulose	69.72	62.18	61.65
2	Cellulose	29.86	28.44	31.57
3	Hemicellulose	39.86	33.74	30.08
4	Lignin	7.77	9.56	9.25
5	Proteins	2.20	1.40	2.20
6	Ash	16.30	16.00	16.02
7	Moisture	96.70	97.70	95.90

Each value represents average of three samples.

Table 3: Chemical composition of rhizome of Banana cultivars.

Sr. No.	Component (%) Dry wt.	Banana Cultivar		
		Ardhapuri-1	Ardhapuri-2	Tissue Culture G-9
1	Holocellulose	75.85	65.79	78.3
2	Cellulose	13.60	10.74	12.90
3	Hemicellulose	62.25	55.05	65.40
4	Lignin	3.05	3.250	1.042
5	Proteins	1.80	1.00	1.80
6	Ash	5.00	7.92	5.35
7	Moisture	90.30	87.20	90.90

Each value represents average of three samples.

Table 4: Mineral composition of Banana cultivars (Leaves, pseudostem and rhizome).

Sr. No.	Mineral g/kg DM	Plant Parts								
		Leaves			Pseudostem			Rhizome		
		Ard-1	Ard-2	G-9	Ard-1	Ard-2	G-9	Ard-1	Ard-2	G-9
1	Magnesium	4.60	6.30	5.3	14.2	14	4.5	2.4	14.6	2.4
2	Potassium	19.50	12.00	18.9	36	34.3	55.4	21	37.1	16
3	Calcium	18.20	24.40	19.1	18.4	18.2	4.6	1.4	19.3	2.5
4	Sodium	0.20	0.40	0.4	0.8	0.2	0.2	0.7	0.5	0.2
5	Phosphorous	1.30	1.20	1.2	0.7	0.7	1.7	1	1.3	0.8

Legend
Ard-1 = Ardhapuri-1cultivar
Ard-2 = Ardhapuri-2 cultivar
G-9 = Tissue culture cultivar
DM = Dry material

S