

Evaluating the Potentials of Banana and Plantain Peels for Biofuel Production in Nigeria

ABSTRACT

This study was carried out to assess the potentials of banana and plantain peel as feedstock for biofuel production. The proximate and mineral composition of banana and plantain peel were determined using AOAC method. Bacteria were isolated from dried banana and plantain peel using the standard microbiological method. The proximate composition of the two biomass showed a high concentration of carbohydrate content at 68.12 and 68.30% for banana and plantain peels. While a high amount of sodium (Na) at 119.17 and 106.67 mg/kg from banana and plantain peels. Three (3) bacterial genera were isolated namely *Bacillus circulans*, *Bacillus brevis* and *Bacillus pumilus*. This study showed the potential of banana and plantain peels biomass for the production of fermentable sugar which can be further fermented to biofuel.

Keywords: Mineral contents ,Proximate analysis, *Bacillus brevis*, *Bacillus pumilus*

Introduction

Banana (*Musa acuminata*) and plantain (*Musa paradisiaca*) are perennial crops that take the appearance of trees as they mature. More than 100 million tons of banana and plantain were produced worldwide in 2007 according to Food and Agricultural Organization (FAO) estimates. Banana is grown in nearly 130 countries and Nigeria is the fourth in rank in producing banana and plantain. They are cultivated in a wide variety of environments. Plants produce fruit year-round, can produce for up to one hundred years and are suitable for intercropping (IITA, 2006). Banana is a valuable source of potassium, fibre, vitamin B and C. The fruit can be eaten raw or as a cooked vegetable. Ripe banana fruits can be used in a variety of products such as ice cream, yoghurt, cake, bread, nectar and baby food, and can also be dried and eaten or sliced, canned with syrup and used in bakery products, fruits salads and toppings (Haslinda *et al.*, 2009). Plantain contains a higher fibre content, and thus is capable of lowering cholesterol and helps to relieve constipation and hence prevention of colon cancer. Its high potassium content is also found to be useful in the prevention of raising blood pressure and muscle cramp (Ng and Fong, 2000).

Plantain waste materials have been considered for use as organic fertilizer in Somalia (Omole *et al.*, 2008). In Nigeria, plantain production is becoming a significant economic activity for income generation for both large scale and small holder farmers, especially for those who produce them within their home compounds or gardens. Plantain also plays an important role in the structuring of rural landscape throughout the producing areas in the country. The gross value of plantain and banana in terms of their annual product exceeds that of several other crops such as maize, rice, cassava and sweet potato in sub Saharan Africa (FAO, 2001a). This research aimed at investigating the potentials of using peels from banana and plantain as a feedstock for biofuel production. Therefore, it is based on the following specific objectives To isolate and characterize Bacteria from Banana and plantain peels and to determine the proximate and mineral composition of the peels before and after pretreatment.

Materials and Methods

Sample Collection and Processing

Banana and plantain peels were collected from fruit vendors at Gawon-nama area, Sokoto metropolis, Nigeria. The fruits were identified and authenticated as UDUH/ANS/0120 for banana and UDUH/ANS/0121 for plantain peels at the Herbarium laboratory of Usmanu Danfodiyo University Sokoto (UDUS), Botany unit in the Department of Biological Sciences and a voucher specimen was deposited in the herbarium. After identification, the samples were taken to Microbiology Research and Agricultural Science Laboratory, UDUS for processing.

Isolation and Identification of Bacteria from banana and plantain peels

The minimum salts medium (MSM) was prepared as described by Evan *et al.* ., (1991). The composition of minimal salt medium are as follows; NH_4PO_4 3.0 g/L, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ 0.200 g/L, FeSO_4 0.100 g/L, Agar 20 g/L, Monopotassium Phosphate 2.00 g/L, Dipotassium phosphosphate 2.00 g/L. All ingredients were suspended into 1000 mL of distilled water and pH was adjusted to 6.5. It was heated gently to dissolved completely. One (1g) gram of each samples (banana and plantain peels) were added into 49 mL of medium (MSM) in a 100 mL Erlenmeyer flask. All the

flasks were sterilized by autoclaving at 121⁰C for 15 minutes. After sterilization, it was allowed to cool and then poured into sterile Petri dishes to solidify. The sample suspension was prepared by weighing 1.0 g of the soil sample to 10 mL of sterile distilled, which was shaken for 15 minutes homogenization. Each suspension was serially diluted from 10⁻¹ to 10⁻⁷, 0.1 mL of the sample was Pipetted into each plate of minimum salt medium (MSM) and then spread with a glass spreader. The plate was incubated at 37⁰ C for 24 hours. Each colony that appeared was considered as one colony forming unit (cfu). The isolates were subcultured using nutrient agar to obtain pure culture (Evan *et al.*, 1991)

Identification and Characterization of Isolated Bacteria

Bacteria isolates were characterized and identified on the basis of their cultural, morphological, physiological and biochemical properties according to Holt *et al.*, (2000). The tests employed in this study were motility, gas production, starch hydrolysis, citrate utilization test, indole test methyl red, vogues-proskauer, catalase, urease and sugar fermentation and gas production.

Proximate Analysis

Proximate composition of the samples was analyzed chemically according to the official method of analysis recommended by Association of Official and Analytical Chemist (AOAC, 2008). The crude protein of the sample was determined using micro-Kjeldahl method. Crude lipid was determined by Soxhlet extraction method using hexane as extracting solvent (AOAC, 2008).

Determination of Ash

Five gram (5 g) of sample were weighed into an already weighed crucible and then placed in a muffle furnace at 600⁰C. The sample was kept for 3 hours. After 3 hours, the crucible was removed and cooled in the desiccators. The sample was weighed after cooling after cooling the percentage ash was calculated (AOAC, 2008).

RESULTS

Table 1 presents the morphological and biochemical characteristics of isolated bacteria from dried banana and plantain peels. A total of 3 genera of bacteria were isolated from banana and plantain peels. These are *Bacillus circulans*, *Bacillus brevis* and *Bacillus pumilus*.

Table 1: Morphological and biochemical characteristics of the isolated bacteria

Sample	Gram	Shape	Spore	Catalase	Urease	Indole	MR	Vp	Citrate	Starch	Glucose	Lactose	Sucrose	Motility	Gas	H ₂ S	Organism
Banana	+	R	+	+	-	-	-	+	+	-	+	-	+	+	-	-	<i>Bacillus circulans</i>
Banana	+	R	+	+	-	-	-	+	-	-	+	+	-	+	+	-	<i>Bacillus brevis</i>
Plantain	+	R	-	+	+	-	-	+	-	-	-	+	-	-	-	-	<i>Bacillus pumilus</i>

Key: R=Rod, + = positive, - = Negative, H₂S = Hydrogen Sulphide, MR = methyl red, VP=Vogel proskauer

The result presented in **Table 2** shows the proximate analysis of banana and plantain peels before and after pretreatment: moisture content of banana and plantain peels before pretreatment yields the highest percentage mean of 84.17 and 74.17% respectively, followed by carbohydrate content of banana and plantain peels after pretreatment with a mean percentage of 68.12 and 68.30%. While nitrogen of banana and plantain peels after pretreatment has the least mean percentage concentration of 0.51 and 0.56% respectively.

Table 2: Proximate Analysis Before and After Pretreatment of banana and plantain peels

Parameters	Banana peels		Plantain peels	
	Before	After	Before	After
Moisture (%)	84.17 ± 0.29	9.17 ± 0.29	74.17 ± 0.29	10.00 ± 0.05
Ash content (%)	13.83 ± 0.29	8.17 ± 1.26	10.83 ± 0.29	8.16 ± 0.58
Lipid (%)	10.83 ± 0.29	9.67 ± 0.76	9.67 ± 0.29	8.16 ± 0.29
Fibre (%)	14.67 ± 0.29	1.67 ± 0.29	7.83 ± 0.29	1.83 ± 0.28
Nitrogen (%)	0.77 ± 0.01	0.15 ± 0.02	0.80 ± 0.02	0.57 ± 0.02
Crude protein (%)	4.81 ± 0.09	3.12 ± 0.10	5.02 ± 0.10	3.53 ± 0.10
Carbohydrate (%)	55.85 ± 0.21	68.12 ± 1.93	66.65 ± 0.86	68.30 ± 1.16

All values are mean ± standard deviation(S.D) of triplicate measurement

Table 3 shows the mineral composition of banana and plantain peels, the highest amount of potassium 3066.66 and 2633.33mg/kg, followed by sodium with a mean percentage of 119.17 and 106.67mg/kg. While the least concentration at 0.37 and 0.28mg/kg of calcium was found on banana and plantain peels.

Table 3: Mineral composition of the Banana and Plantain peels

S/N	Minerals Composition (mg/kg)	Banana peels	Plantain peels
1.	Sodium (Na)	119.17 ± 3.82	106.67 ± 3.82
2.	Potassium (K)	3066.66 ± 152.75	2633.33 ± 57.73
3.	Calcium (Ca)	0.37 ± 0.03	0.28 ± 0.03
4.	Magnesium (Mg)	0.47 ± 0.03	0.58 ± 0.03
5.	Phosphorus (P)	7.93 ± 0.01	7.04 ± 0.01

All values are mean ± standard deviation(S.D) of triplicate measurement

Discussion

Bacillus circulans, *Bacillus brevis* and *Bacillus pumilus* are *Bacillus* species which more adaptable to the environment they inhabit than other bacteria (Park *et al.*, 2003). The presence and abundance of various species of *Bacillus* may not be surprising as *Bacillus pumilus* resides in soils and some plants whereby has antibacterial and antifungal activity (Pan *et al.*, 2004). Pannerselvam and Elvarasi (2015) reported *Bacillus subtilis* isolated from garden soil is known to produce α -amylase.

The proximate analysis of before pretreatment of banana and plantain peels decrease in most of the substrate after pretreatment. For example, Moisture content of 84.17 and 74.17% observed before pretreatment of banana and plantain peels could be due to the fact that the moisture contents were determined with fresh peels. The result is in agreement with Sanchez *et al.* (2014) who revealed that banana peels had the highest moisture content of 86.30%, while mango peels had the lowest moisture content of 68.54%. It has been reported (Kaur *et al.*, 2004; Berardini *et al.*, 2005; Aguiar *et al.*, 2008; Brooks, 2008; Li *et al.*, 2010) that the peels of oranges, mangoes and bananas could be a rich, low cost source of dietary fiber composed mainly of hemicelluloses and pectin polysaccharide. The moisture content of foods or its processed product give an indication of its freshness and shelf life and high moisture content subject food item to increased microbial spoilage, deterioration and short shelf life (Adepoju and Onajunya, 2008).

Although the carbohydrate was determined by difference, the two substrate had high carbohydrate content and can be good sources of reducing sugar for biofuel production. The values before pretreatment are 55.85 and 66.64% for banana and plantain peels respectively. While after pretreatment the value are 68.12 and 68.30% of banana and plantain peels.

According to Adeleke *et al.* (2008) who stated that pretreatment improve biodegradability of lignocellulosic biomass with increased amount of carbohydrate. Saquido *et al.* (1983) reported that since carbohydrate are the main carbon sources for organisms. It would be reasonable to predict that fungal and yeast growth on banana wastes which are largely compose of carbohydrate would be substantial. These rich sources of carbohydrates could be utilized as substrates for the production of biofuel.

The crude fiber measures the cellulose, hemicellulose and lignin comprises polymers of phenolic acid and hemicelluloses made up of heteropolymers (Zakpaa *et al.*, 2010) . The value of 14.67 and 7.83% obtained for banana and plantain peels respectively is below 18.47% reported in the bract of *Musa paradisia* (plantain) according to Adeolu and Enesi (2013).

The crude lipid content of banana and plantain was high and comparable with the value obtained from *Barassus aethiopum* mart which contain low level of crude lipid (0.01% DW) that is lower than 1.49% DW reported by Umar, *et al.* (2015). It can also contribute significantly to energy content of the feeds that can be prepared with the wastes (Okareh, *et al.*, 2015). This agreed with Essien *et al.* (2005) who recorded crude protein and crude fat contents of 7.8 and 11.6%, respectively in banana peels and that can be utilized as alternative source of energy and fermentative ethanogenic microbial growth.

The mineral analysis of the sample revealed that Potassium has the highest value of 3066.66 and 2633.33 mg/kg for banana and plantain peels respectively. While phosphorus, magnesium and calcium has the lowest value. High content of potassium and sodium content might be associated to the initial high moisture content of the whole fruit. According to Aro *et al.*, (2008) who revealed that these elements are essential to life and could be use to increase soil fertility for plant growth.

Conclusion

This study concludes that banana and plantain peels has potential as a sustainable and low-cost biomass for the production of biofuel. A genera bacteria are *Bacillus circulans*, *Bacillus brevis* and *Bacillus pumilus* were Identified. The proximate and mineral composition of the two biomass showed high concentration of carbohydrate content for banana and plantain peels which

is important for biofuel production and their utilization for this purpose should be encouraged, thereby enhancing solid wastes management and reducing environmental pollution .

References

- Adeleke, O. A., Matanmi, H. and Ogunniyi, L. T (2008). Application of the Normalized profit functions in the estimation of the profit efficiency among small-holder farmers in Atiba local Government Area of Oyo state, *Nigeria Journal of Economic Theory*, **2**(3):71-76
- Adeolu, A.T. and Enesi, D.O. (2013). Assessment of proximate, mineral, vitamin and phytochemical compositions of plantain (*Musa paradisiaca*) bract; An agricultural waste. *International Research Journal of Plant Science* 4 (7): 192-197.
- Adepoju ,O.T., and Onasanya, L.O.(2008). Nutrient composition, antinutritional factors and contribution of native pear (*Dacryoides edulis*) pulp to nutrient intake of consumers. *Nigerian Journal of Nutritional Science* 29 (2):15- 23.
- Aguiar, L., Marquez Montesinos, F., Gonzalo, A., Sanchez, J, L., and Arauzo, J. L. (2008). Influence of temperature and particle size on the fixed bed pyrolysis of orange peel residue. *Journal Analysis Applied Pyrolysis* 83 (1):124-130.
- AOAC (Association of Official Analytical Chemist) (2008). Official methods of analysis (20th edition). Washington, USA 250-500.
- Aro, S. O. (2008).Improvement in the nutritive quality of cassava and its by-products through microbial fermentation, *African Journal of Biotechnology* 7 (**25**):4789-4797.
- Beraidini, N., Knodler, M., Schieber, A. and Carle, R.(2005). Utilization of mango peels as a source of pectin and polyphenolics . *Innovation Food Science and Energy Technology* 6 (**4**):442-452.
- Brooks, A. A. (2008) “Ethanol production potential of local yeast strains isolated from ripe banana peels,” *African Journal of Biotechnology* 7(**20**): 3749-3752.
- Essien, J., Akpan, E., and Essien, E., (2005). Studies on mould growth and biomass production using waste banana peel. *Bioresources Technology* 96 (**13**):1451–1456.
- Evans, P. J., Mang, D. T. and Young L.Y.(1991).Degradation of toluene and m-xylene and transformation of o-xylene by denitriying enrichment cultures. *Applied Environment Microbiology*. **57** (2):450-4
- Food and Agriculture Organization of the United Nations (2001a). FAOSTAT Statistics Database, Agriculture, Rome, Italy 46:361.

- Food and Agricultural Organisation (2001b). *Technical Report on Banana and Plantain*, 1-103.
- Haslinda, W. H., Cheng, L. H., Chong, L. C. and Noor, A. A. (2009). Chemical composition and physicochemical properties of green banana flour. *International Journal of Food Sciences and Nutrition* 60 (4):232-239.
- Holt, J. G., Kreig, N. G., Peter, H. A., Sneath, S. T and Williams, S.T.(2000). *Bergeys Manual Of Systemic Bacteriology*, 9th Edition; Lippincott Williams And Wilkins Publisher, U S A Pp 175-528.
- International Institute for Tropical Agriculture (IITA) (2006). Musa Africa: Abstract from the *International Conference on plantain and banana for Africa*, 103.
- Kaur, M., Singh, N., Sandhu, K. S and Guraya, H. S. (2004)."Physicochemical, Morphological, Thermal and rheological properties of starches separated from kernels of some indian mango cultivar (*Mangifera indica* L). *Food Chemistry* 85 (1):131-140.
- Li, K., Fu, S. M., Zhan, H., Zhan, Y. and Lucia, L. A.(2010). Analysis of chemical composition and morphological structure of banana pseudo-stem. *Bioresources* 5 (2):576-582.
- Ng, S. P. and Fong, C. S. (2000). Banana enhances your anticancer power. In: health discovery. *Nigerian Journal of Nutrition Science* 27(1):22-26.
- Okareh ,O.T., Adeolu, A. T. and Adepoju, O.T. (2015). Proximate and mineral composition of plantain (*Musa paradisiaca*) wastes flour: A potential nutrients source in the formulation of animal feeds. *African Journal of Food Science and Technology*.6 (2):53-57.
- Omole, A. J., Ajasin, F. O., Oluokun ,J. A. and Obi, O. O.(2008). Performance characteristics of weaned rabbit fed plantain peel as replacement for maize. *Journal of Nutritional Food* 38:559-563.
- Pan, J., Huang, Q. and Zhang, Y. (2004).Gene cloning and expression of an alkaline serine protease with dehairing function from *Bacillus pumilus*. *Current Microbiology* 49 (3):165-9.
- Panneerselvam, T. and Elvarasi, S. (2015).Isolation of α -amylase producing *bacillus subtilis* from soil. *International Journal of Current Microbiology and Applied Sciences* 4 (2):543-552.
- Park, J. J. C., Yoon, P. S., Eung, H.K., Yeon-Jae, C. and Kwang-Soo,S. (2003).Characterization Of The Proteolytic Activity Of Bacteria Isolated From a Rotating Biological Contactor. *Journal of Microbiology* 41:73-77.
- Sanchez, R. O., Hernandez, P. B., Morales, G. R., Nunez, F, U., Villafuerte, J. O., Lugo, V. L., Ramirez, N. F., Barrera Diaz, C. E. and Vazquez, P. C.(2014). Fruit residue to ethanol. *Bioresources* 9 (2):1873-1885.

Saquido, M. A.P., Cayabyab, V. A and Vyenco, F. R. (1983). Production of microbial protein for feed banana rejects. Natural Science Research Centre, University Of Philippines Quezon City, Philippines, pp 177.

Umar, K. J., Abdullah, B. M., Muhammad, B., Muhammad, S., Hassan, L. G., and Sani, N. A. (2015). Nutritional and Antinutritional profile of *Borassus aethiopum* Mart (African Palmyra Palm) shoot. *International Journal Of Sciences: Basic And Applied Research* 24 (3):39-49.

Zakpaa, H. D., Mak-Con, A., Cos Mensah, E. E. and Johnson, F. S., (2009). Production of bioethanol from corncobs using *Aspergillus* and *Sacchromyces cerevisiae* in simultaneous saccharifation and fermentation. *African Journal of Biotechnology* 3 (13):3018-3022.

UNDER PEER REVIEW