Journal of Energy Research and Reviews

11(3): 43-49, 2022; Article no.JENRR.81747
ISSN: 2581-8368

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

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JENRR/2022/v11i330281

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/81747

Original Research Article

Received 15 November 2021
Accepted 26 January 2022
Published 09 June 2022

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 the 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 pumilu*. 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.

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1. 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 [1]. 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 [2]. 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 [3]. 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 [4].

Plantain waste materials have been considered for use as organic fertilizer in Somalia [5]. 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 the 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 [6]. 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.

2. MATERIALS AND METHODS

2.1 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.

2.2 Isolation and Identification of Bacteria from Banana and Plantain Peels

The minimum salts medium (MSM) was prepared as described by Evan et al, [7]. The composition of the minimal salt medium is as follows; NH_4PO_4 3.0 g/L, $MgSO_4.7H_2O$ 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 the 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 121^0C 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 37^0C 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 [7].

2.3 Identification and Characterization of Isolated Bacteria

Bacteria isolates were characterized and identified based on the their cultural, morphological, physiological and biochemical properties according to Holt et al*.,* [8]. 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.

2.4 Biological Pretreatment

This was carried out as described by Ekunsaumi (2006). Mandels culture medium was prepared by adding (gl¬¬-1): Urea 0.3,(NH4)2SO4 1.4, KH2PO4 2,CaCL2 0.3, MgSO47H2O 0.3, bacto peptone 0.75 and yeast extract 0.25. Trace elements were also added, using a 1%(v/v) solution of salts (mll-1):FeSO47H2O 0.5,MNSO4 0.16, ZnSO4 0.14,CoCl2 2g. The pH was adjusted to 5.5 before sterilization. The medium was measured as 100ml,150ml and 200ml and the substrates (Banana and plantain peels) were added as 5g, 10g and 15g into 250ml Erlenmeyer conical flasks .The medium was then sterilized by autoclaving for 121 OC at 15 minutes. All the flasks were inoculated with 1ml of the test organism (Mucor racemuses). The flasks were incubated at 28°C (ambient laboratory temperature) on an orbital shaker at 200 rpm for 5 days. After 5 days the mixture was separated by filtration through a Whatman filter paper No 1. The filtrate was then used for further studies.

2.5 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 [9]. 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 [9].

2.6 Determination of Ash

Five gram (5 g) of sample were weighed into an already weighed crucible and then placed in a muffle furnace at 600^0C. 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 [9].

2.7 Statistical Analysis

All the work experiments were conducted in triplicates. All data obtained were expressed as mean and standard deviations using the statistical package for Social Science Package (SPSS) Version 16.

3. 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.*

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 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.

4. DISCUSSION

Bacillus circulan, Bacillus brevis and *Bacillus pumilus* are *Bacillus* species which more adaptable to the environment they inhabit than other bacteria [10]. Bacteria (E.coli, Bacillus sp) can utilize carbohydrates from lignocellulosic biomass directly or after pretreatment and enzymatic hydrolysis to produce liquid biofuel such as ethanol, butanol, etc. 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 [11]. Pannerselvam and Elvarasi [12] 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. [13] 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 [14-18] 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.

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_2S	Organism
Banana	+	R	+	+	-	-	-	+	+	-	+	-	+	+	-	-	*Bacillus circulans*
Banana	+	R	+	+	-	-	-	+	-	-	+	+	-	+	+	-	*Bacillus brevis*
Plantain	+	R	-	+	+	-	-	+	_	-	-	+	-	-	-	-	*Bacillus pumilus*

Key: R=Rod, + = positive, - = Negative, H_2S = Hydrogen Sulphide, MR = methyl red, VP=Vogue proskauer

Table 2. Proximate analysis before and after pretreatment of banana and plantain peels

	Banana peels		Plantain peels	
Parameters	**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. 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

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, deteriotion and short shelf life [19].

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. [20] who stated that pretreatment improve biodegradability of lignocellulosic biomass with increased amount of carbohydrate. Saquido et al. [21] 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 [22]. 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 [23].

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. [24]. It can also contribute significantly to energy content of the feeds that can be prepared with the wastes [25].This agreed with Essien et al. [26] 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., [27] who revealed that these elements are essential to life and could be use to increase soil fertility for plant growth.

5. 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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