Original Research Article

BIOHYDROLYSIS OF BANANA AND PLANTAIN PEELS FOR THE PRODUCTION OF BIOFUEL

ABSTRACT

This study was carried out to assess the potentials of banana and plantain peel as feedstock for biofuel production. Fungi were isolated from spoiled banana, burkutu and spoiled bread using the standard microbiological method. The concentration of reducing sugar of the peels were measured using DNS calorimetry method and biofuel were measured using chromium (VI) reagent by Ultraviolet-Visible Spectrophotometer. *Aspergillus niger*, *Saccharomyces cerevisiae* and *Mucor racemusus* were isolated. A reducing sugar concentration of 59.12 mg/g and 56.62 mg/g was observed for the banana and plantain peels. The highest concentration was found to be 0.35 mg/L for banana peels and 0.10 mg/L for plantain. The IR characterization of the banana and plantain sample revealed an intense strong broad band of alcohol O-H and alkane C-H stretching. The GC-MS result revealed the presence of benzaldehyde in all the biomass while 2,3-butanediol was only detected in the plantain peels biomass. This study showed the potential of banana and plantain peels biomass for biofuel production.

Keyword: Biofuel, banana peels, plantain peels, hydrolysis, *Saccharomyces cerevisiae* ,*mucor racemus.*

INTRODUCTION

Biofuel has been used in large scale since the implementation of Brazilian alcohol program (Goldemberg, 2008). The production of biofuel from lignocellulosic materials also called Second-generation is proposed as an alternative without adverse effects. These fuels include Bioethanol, Biodiesel, Bioether, Biogas etc (Pimentel *et al*., 2005). In Nigeria, all stages of the fruit (from immature to over ripe) are used as a source of food in one form or the other. Banana and plantain peels represent 40% of the total weight of fresh banana or plantain. Musa species are rich in vitamin C, B_6, minerals and dietary fiber. They are also a rich energy source, with carbohydrates accounting for 22% and 32% of fruit weight for banana and plantain (Tchobanoglous *et al*., 1993). Biofuels are considered as a replacement for fossil fuels and the answer to poverty and even the climate crisis. They are presented as being both renewable and environment friendly (Bassey, 2010). Increasing attention is being focused on the production of biofuels as the alternatives that will contribute to global reduction in greenhouse gas emissions (Oniemola and Sanusi, 2009). Currently, there is a growing interest for ecological sustainable bio-fuels all over the world. The aim of this research is to consider the possibility of

biohydrolysis of banana and plantain peels for biofuel production, which are common agricultural wastes in this part of the world. The objectives herein are to isolate and identify *Saccharomyces cerevisiae* from burukutu, *Aspergillus niger* and *Mucor racemuses* from spoiled banana and bread respectively. Biological pretreatment with *Mucor racemosus* and reducing sugar contents were determine from banana and plantain peels sample and finally to identify the biofuel produced in banana and plantain feedstock fermentation broth using Gas Chromotography, Mass spectroscopy (GC-MS) and Fourier Transform Infrared (FT-IR).

MATERIALS AND METHODS

Sample Collection

Banana (*Musa acuminate* - colla) and plantain (*Musa paradisiaca* - linnaeus) peels were collected from fruit vendors at Gawon-nama area, Sokoto metropolis. The banana and plantain peels were washed with distilled water to remove dirt and other contaminants. The samples were chopped into small pieces and allowed to air dried. It was grounded to powdered form using mortar and pestle and collected in a transparent polythene bag.

Isolation and identification of *Aspergillus niger*

Small portion of spoiled banana was aseptically picked with wire loop and inoculated at the middle of the prepared media PDA (Potato dextrose agar) plate. The plate were incubated at 27°C temperature for 7 days for colonies development. Pure culture of *Aspergillus niger* was obtained by streak plate method. All observed colonies were maintained on agar slants at 4°C (Devanathan *et al.*, 2007).

Isolation and identification of *Sacchararomyces cerevisiae*

The burukutu samples were serially diluted up to 10^5 tubes. An Aliquot of 0.1 mL of burukutu was spread on the surface of yeast potatoes dextrose agar (YPDA) plate and incubated at 30˚C for 3 days. Colonies suspected to be *Sacchararomyces cerevisiae* based on colonial characteristics were sub-cultured on PDA. A smear of the isolate was examined microscopically after staining. The isolates were identified by comparing their characteristics with those of known taxa using the schemes of Domsch and Grams (1970), as described by Oyeleke and Manga (2008) .

Isolation and identification of *Mucor racemosus*

A small portion of the spoiled bread was aseptically picked with wire loop and inoculated at the middle of prepared solidified media sabourand dextrose agar (SDA). It was incubated at 30 ^{O}C for 5 days. Colonies suspected to be *Mucor racemosus* based on colonial characteristics were sub cultured on PDA. For identification, One (1) drop of lectophenol blue was dropped on dried grease free slide, little portion of the growth was picked with inoculated needle and emulsified. Cover slide was used to cover and viewed at 10x objective and confirmed by 40x (David *et al.*, 2007).

Biological pretreatment

The biological pretreatment was carried out as described by Ekunsaumi (2006). Mandels culture medium was prepared by adding (gl^{-1}): Urea 0.3,$(NH_4)2SO_4$ 1.4, KH_2PO_4 2,$CaCL_2$ 0.3, $MgSO_47H_2O$ 0.3, bacto peptone 0.75, and yeast extract 0.25. Trace elements was also added, using a 1% (v/v) solution of salts (mll-1):$FeSO_47H_2O$ 0.5, $MNSO_4$ 0.16, $ZnSO_4$ 0.14, $CoCl_2$ 2g at pH of 5.5. The medium was measured as 100 mL, 150 mL and 200 mL and the substrate (banana and plantain peels) were added as 5g, 10g and 15g into 250 mL Erlenmeyer conical flasks. The medium was then sterilized by autoclaving at 121 ^{O}C at 15 minutes. All the flasks was inoculated with 1 mL 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.

Enzymatic Hydrolysis

Enzymatic hydrolysis was carried out on the biological pretreated samples. Distilled water was dispensed into the substrate across the labeled flask and heated gently on a hot plate to ensure dissolution. The mixture was autoclaved at 121^{o}C for 15 minutes for sterilization. After cooling at room temperature of 30^{o}C it was inoculated with *Aspergillus niger* suspension using Mcfarland turbidity standard at 0.5, 1.0 and 1.5 mL using sterile syringe. The flasks were incubated at 28^{o}C for five (5) days for hydrolysis to take place. Then, Concentration of reducing sugar was quantified from the hydrolysate obtained from enzymatic using dinitrosalicylic colorimetric method (DNS) as described by (Oyeleke *et al.*, 2012).

Determination of Reducing Sugar

After hydrolysis the sample were filtered using Whatman's filter paper no 1 and presence of reducing sugar in each sample was determine using dinitrosalicylic colorimetric DNS (Miller, 1959). One (1.0) mL of the sample was added to 1 mL of 3,5 dintrosalicylic acid, followed by boiling for 10 minutes. The absorbance was measured at 540 nm with a spectrophotometer (Jenway 6100).

Fermentation of Hydrolysate

To obtain a broth after the hydrolysis step, the fermentation media was filtered using whatman no 1 filter paper. The flasks containing the filtrate were covered with cotton wool wrapped in aluminum foil then autoclaved at 121^{o}C for 15 minutes. The sterile hydolysate was allowed to cool and *Saccharomyces cerevisiae* suspension were inoculated at 0.5, 1.0 & 1.5 mL and incubated at 30^{o}C ambient temperature for 5 days to monitor ethanol production.

Distillation

The fermented broth were filtered using Whatman no 1 filter paper. Each sample were weighted into kjeldahl flasks and heated at 78^{o}C (boiling point of ethanol) on the Microkjeldahl apparatus until solution turns colorless.

Determination of biofuel Quality

Determination of biofuel quality was according to the method described by Patel *et al.* (2007).This was carried out using UV-VIS quantitative analysis of alcohol using chromium VI reagent. A quantity (1ml) of standard ethanol was diluted with 100 mL of distilled water to give a concentration of 1%.Then, each of 0, 2, 4, 6 and 8 mL of the ethanol was diluted to 10 mL with distilled water to produced 0, 0.2, 0.4, 0.6 and 0.8% of the ethanol. To each of the varying ethanol concentrations 2 mL of chromium reagent was added and allowed to stand for an hour for colour development. The absorbance of each concentration were measured at 588 nm using UV -VIS spectrophotometer and the readings used to developed standard ethanol curve. Then 1ml of each biofuel samples were put into test tubes and treated with 2 mL of the chromium reagent. The mixture was allowed to stand for an hour and the absorbance measured at 588 nm using the Ultraviolet-Visible spectrophotometer (Rabah *et al*., 2011).

Determination of compounds present in the Biofuel produced

Gas Chromatography and mass spectrometry (GC-MS) analysis of the produced bio-ethanol was conducted at General Science Laboratory, Usmanu Danfodiyo University, Sokoto on Agilent technologies 6890N Network GC System and Agilent technologies 5973 network mass selective detector coupled with 7683B series injector. During the analysis, the oven temperature was maintained at 50°C for 5 minutes. The injector and detector temperature were 120°C and 160°C respectively. The flow rate for carrier gas (Helium) was set at 1.2ml/min and the injection volume were 1NL (Mei-ling *et al*., 2003). The inlet temperature was maintained at 230 ^{0}C. The oven was programmed again to increase to 300^{o}C at a rate of 10^{o}C ending with 25 minutes and this temperature was held for 15 minutes, total runtime were 45 minutes. The mass spectrometry (MS) transfer line was maintained at a temperature of 250^{O} C. The source temperature was also maintained at 230^{o}C and Ms quad at 150^{o}C. The ionisation mode to be used is electron ionization mode at 70 Ev. Total Ion count (TIC) was used to evaluate for compound identification and quantification. The spectrum of the separated compound were compared with the database of the spectrum of known compound saved in the compared with the database of the spectrum of known compound saved in the NISTO2 Reference Spectra Library. Agilent chemstation software was used to carry out data analysis and peak area.

Fourier Transform Infrared Analysis of the produced Biofuel

The pellet technique as described by Gershon, *et al*., (1981) was used. FT-IR spectra were taken on a Kb 3000 series (Shimadzu, Kyoto, Japan) spectrophotometer using the KBr pressed disk technique, ethanol was used to clean the KBr cells. The machine calibration was tested by applying drops of nujol (liquid paraffin) solvent to a KBr cell and run its Infrared to ascertain its conformity with existing spectra. A few drops of the sample was added and 3 drops of nujol solvent were used to dissolve it in a mortar. The paste formed was pressed on the KBr cell and inserted into the machine for 10 Mpa for 3 minutes, the spectra were recorded over the spectral range between 4000 and 400 cm^{-1} with a resolution of 4 cm^{-1}.

Statistical Analysis

All the work experiments were conducted in triplicates. All data obtained is expressed as mean and standard deviation.

RESULTS

The results presented in Table 1 shows the phenotypic characteristics of *Aspergillus niger* isolated from spoiled banana and *Saccharomyces cerevisiae* isolated from 'burukutu' as well as *Mucor racemoses* isolated from spoiled bread. *Aspergillus niger* showed a black mycelium on the agar medium and presence of conidial head. *Saccharomyces cerevisiae* was identified as having creamish colonies with white buds forming cluster of cell.

Table 1: Phenotypic identification of fungi isolated from Burukutu, spoilt banana and bread

Sample	**Macroscopic**	**Microscopic**	**Organism**
Spoiled banana	White colonies with dense layer of dark brown Presence of black conidiophores	Presence of conidial heads Conidiophore stripe smooth walled Hyaline brown color	*Aspergillus niger*
Burukutu	White dense layer	White buds, forming cluster of cell.	*Saccharomyces cerevisiae*
Spoiled Bread	Colony white presences of tall and short Sporangiophores Sporangia hyaline becoming brownish to gray with age	Columella obovoid ellipsoidal Sporangiospore broadly ellipsoidal Smooth-walled grayish	*Mucor racemosus*

The results of effect of hydrolysis on reducing sugar content from banana and plantain peels as substrate are presented in Figure 1. It was observed that at 5^{th} day of hydrolysis the highest yields of reducing sugar of 59.12 and 56.62 mg/dL were obtained from banana and plantain peels respectively with water ratio of 200 mL, 15g of substrate ratio and 1.5 mL of inoculum size using *Aspergillus niger*. And 2^{nd} day of hydrolysis, lowest concentration yield of reducing sugar (16.10 mg/dL) was obtained from plantain peels with water level of 150 mL, 10 g of substrate and 1.0 mL of inoculum of *Aspergillus niger*. While 1^{st} day showed the lowest concentration yield of reducing sugar of 16.35 mg/dL obtained from banana peels with water level of 100 mL, 5 g of substrate and 0.5 mL of inoculums.

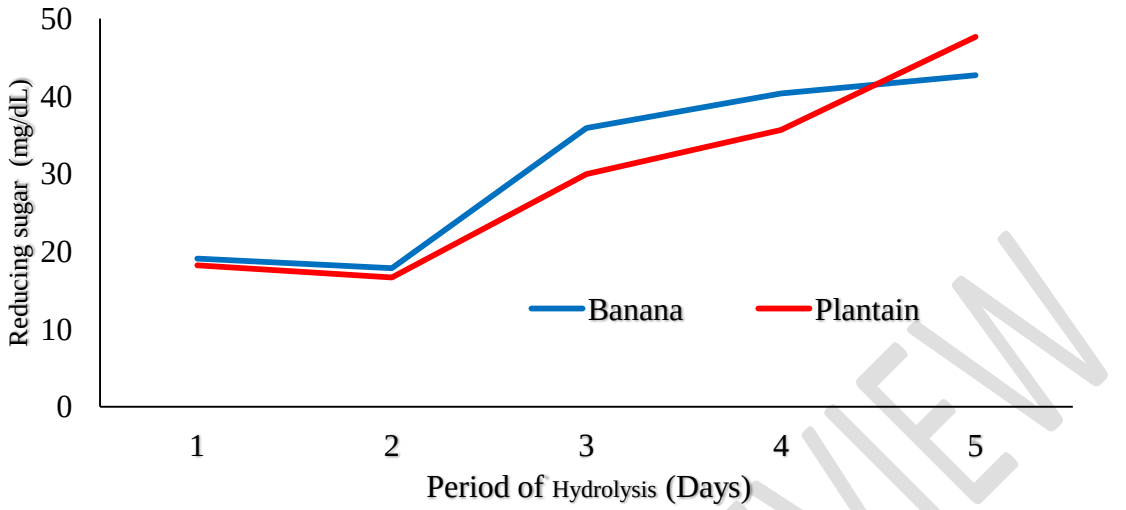

Figure 1: Effect of Hydrolysis on reducing sugar content from banana and plantain peels as substrate.

The effect of water ratio on biofuel production from banana and plantain peels using *Saccharomyces cerevisiae* indicated a decreased in biofuel concentration with increase water ratio figure 2. It was observed that the plantain produced highest ethanol at 100 mL water ratio and gradually declined toward 200 mL, while the banana peel produced highest ethanol at 150 mL.

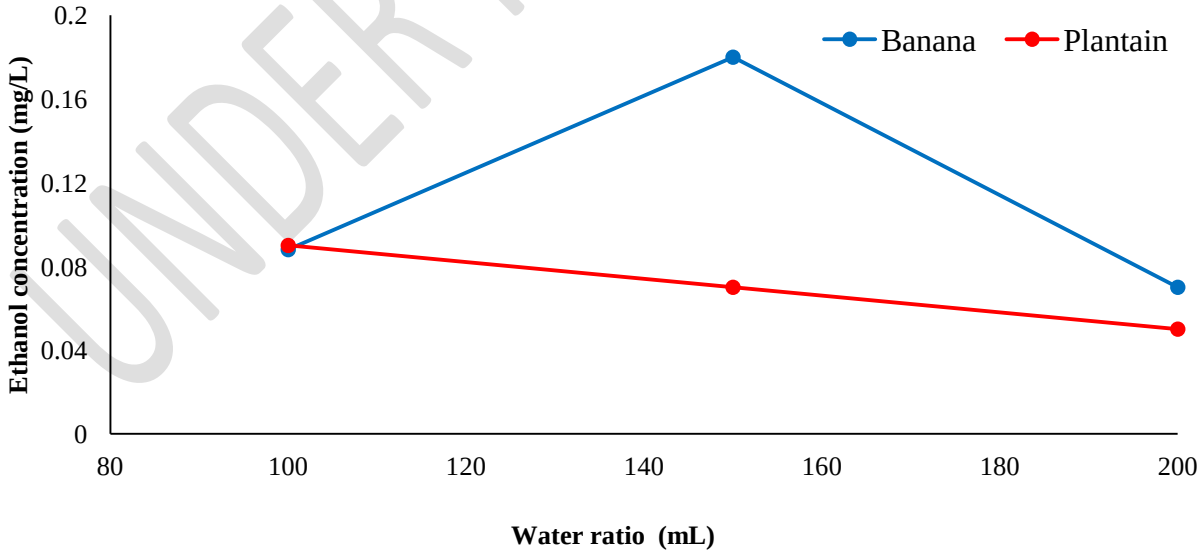

Figure 2: Effect of water ratio on biofuel yield using banana and plantain peels as substrate at the 5th days of fermentation

The result of effect of banana and plantain peels concentration on biofuel yield is presented in Figure 3. It was observed that substrate concentration increased from 5 to 15 g/L and biofuel yield increased to 0.08 mg/L.

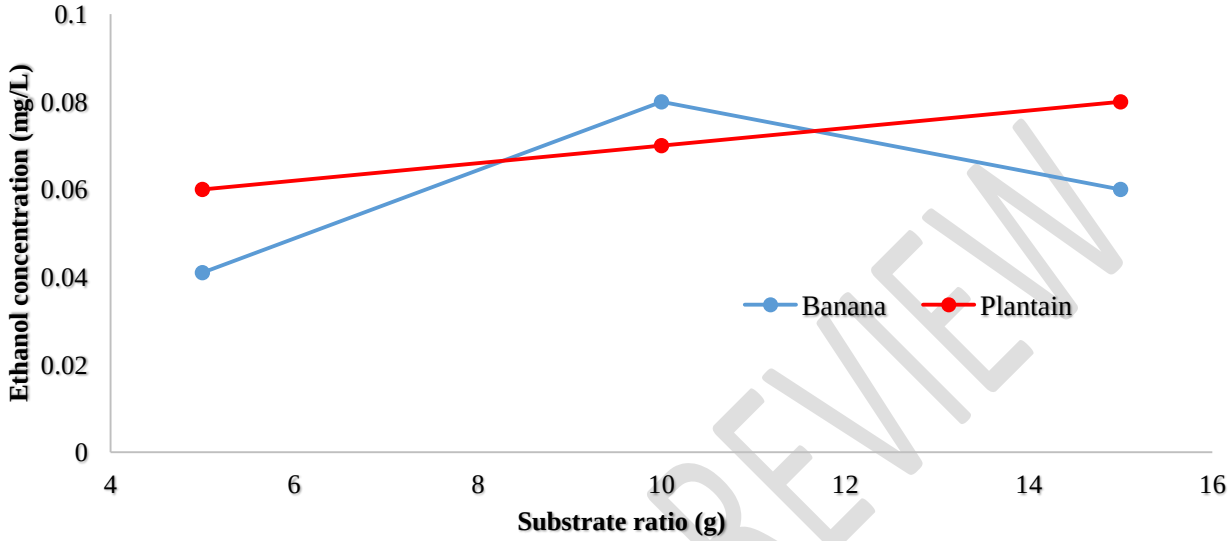

Figure 3: Effect of substrate ratio on biofuel yield using Banana and plantain peels as a substrate at the 5th days of fermentation.

The effect of inoculum size on biofuel production of banana and plantain peels using *Saccharomyces cerevisiae* is presented in Figure 4. It was observed that 0.5 mL inoculum size of *Saccharomyces cerevisiae* produced highest yield of 0.16 mg/mL ethanol on banana peels. While on plantain peels *Saccharomyces cerevisiae* produced moderate yield of 0.09 mg/mL at 1.5 mL of inoculum size.

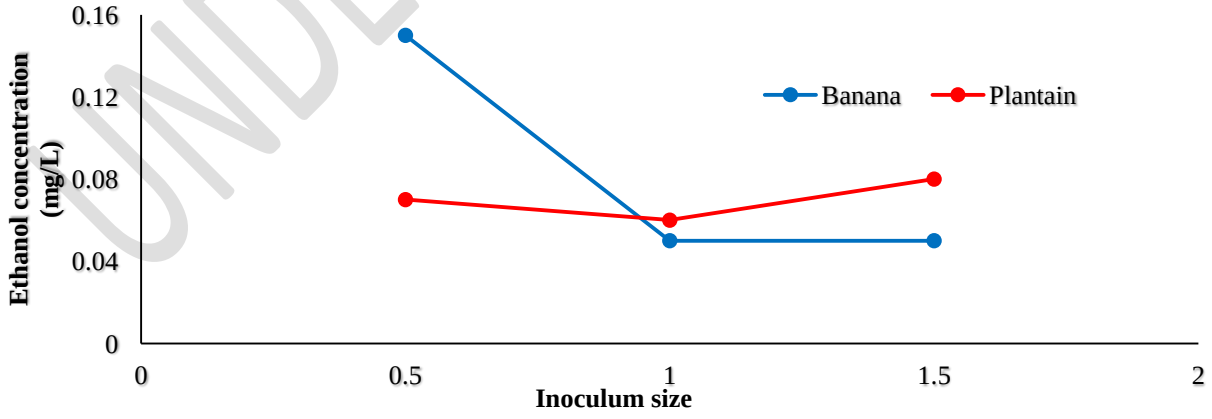

Figure 4: Effect of inoculum size on biofuel yield using banana and plantain peels as substrate at the 5th days of fermentation

The volatile organic metabolites of banana and plantain peels were hydrolysed using *A. niger* and fermented for biofuel production. Banana peels had high abundance of benzaldehyde (22.20%), which was present in the plantain peel, and the plantain peels had the biofuel '2,3-butanediol' while 9-Octadecenoic, Methyl ester (18.80%) had the highest abundance. The results is presented in Table 3.

Table 3: Volatile organic metabolite of banana and plantain peels fermented for biofuel production potential

Retention Time(min.)	Organic metabolite profile	Abundance (%)	
		Banana	Plantain
2.315	2,3-Butanediol,	-	1.66
3.019	Benzaldehyde	22.20	8.63
6.705	Caprolactam	-	1.18
14.047	4-Benzylaniline	3.85	4.30
15.431	Hexadecanoic acid, methyl ester	4.84	5.36
16.856	9-Octadecenoic acid, methyl ester, (E)-	14.52	18.80
17.057	Methyl stearate	13.95	16.42
17.186	Oleic Acid	4.66	4.54
17.366	Octadecanoic acid	7.58	8.58
18.520	Eicosanoic acid, methyl ester	1.00	0.76
19.190	9-Octadecenoic acid (Z)-	0.43	1.27
19.358	Octadecanoic acid, 2,3-dihydroxypropyl ester	0.34	2.39
19.512	Z,Z-4,16-Octadecadien-1-ol acetate	2.08	2.39
19.675	Glycidol stearate	2.30	2.46
19.741	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester	2.32	1.40
20.136	Butyl 14-methylhexadecanoate	1.24	7.72
20.892	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	8.36	12.14
21.038	Octadecanoic acid, 2,3-dihydroxypropyl ester	10.34	4.54

The result of Infrared spectroscopy for characterization of banana and plantain peels from the produced biofuel at (figure 5 and 6) shows an O-H characteristics stretch with an intense and broad band of 3500cm^{-1} to 2200cm^{-1} and 1260cm^{-1} to 1050cm^{-1} respectively corresponding to alcohol.

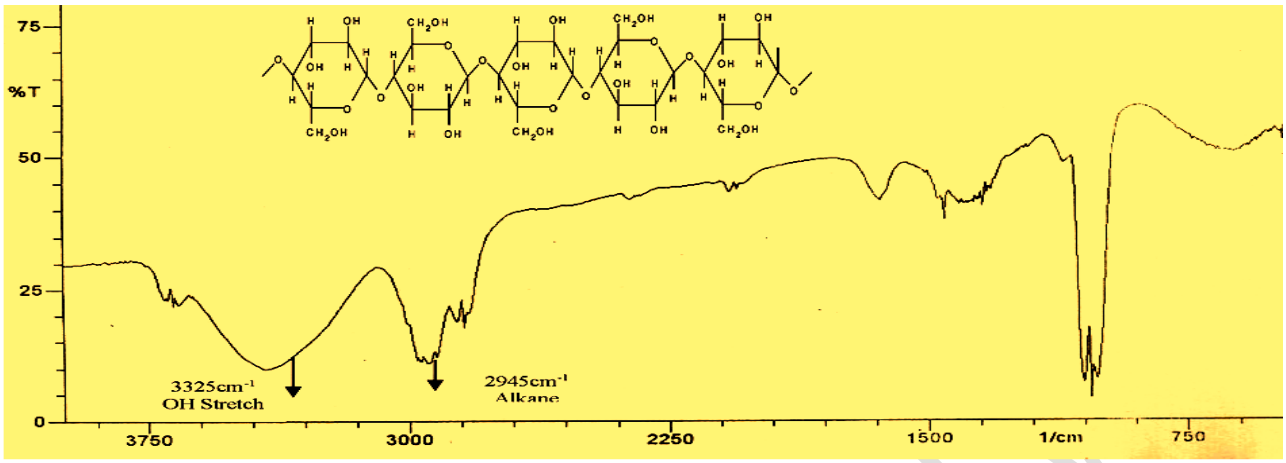

Figure 5 : FT-IR spectrum of the distillate obtained from fermented banana peels.

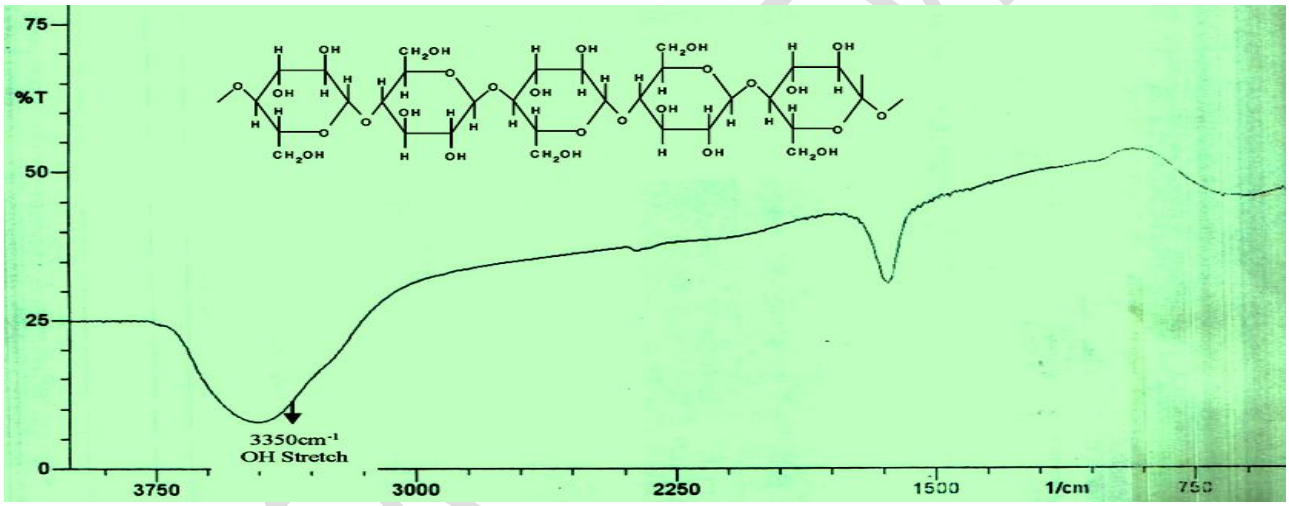

Figure 6: FT-IR spectrum of the distillate obtained from fermented plantain peels.

DISCUSSION

The results from this study indicated *Aspergillus niger, Mucor racemosus* and *Sacchromyces* cerevisiae were isolated from spoiled banana, bread and burukutu. It is not surprising the organisms are found on the samples as genus *Aspergillus* are filamentous fungi which are ubiquitous and of great importance in medical and industrial microbiology. They comprise species and strains such as *Aspergillus niger* that secrete copious amounts of cellulolytic enzymes (Acharya *et al.*, 2008). Essien *et al*, (2005) reported banana fruit peel could support microbial growth thus it could be used as a substrate for the production of variable micro fungal

biomass. The result is in conformity with Yahaya and Ado (2008) who reported the mycelial protein production of *Aspergillus niger* using banana peels. *Saccharomyces cerevisiae* was isolated from "burukutu" in this studies. *Saccharomyces cerevisae* is the organism of choice as the fermentation process biocatalyst in alcoholic beverages and fuel ethanol industry (Vallet *et al*., 1996). The organism was able to ferment glucose, fructose, Sucrose, maltose and galactose producing acid and gas. This result agree with Elijah *et al*. (2010) who reported the isolation *Saccharomyces cerevisiae* among other yeast from palm wine.

At day 5 the highest yield of reducing sugar of 59.12 and 56.62 mg/dL was obtained from banana and plantain respectively with water ratio of 200 mL, 15g of substrate ratio and 1.5 mL of inoculums size using *Aspergillus niger*. This result might be due to high lignocellulosic biomass contained in the substrate that can be converted to reducing sugar which later metabolize by yeast to ethanol, but it cannot produce cell enzymes which is required to degrade the cellulose, present in the banana peels (Essien *et al.,* 2005). *Aspergillus* spp are able to produce different kind of enzymes e.g. amylase, cellulase and protease which is responsible for degradation of polysaccharide into monosaccharide (Auta *et al.,* 2012).

At day 2 lowest concentration yield of reducing sugar (16.10 mg/dL) was obtained from plantain peels with water level of 150 mL, 10g of substrate and 1.0 mL of inoculum using *Aspergillus niger* and day 1 showed the lowest concentration yield of reducing sugar of 16.35 mg/dL was obtained from banana peels with water level of 100 mL, 5g of substrate and 0.5 mL of inoculums. It is not surprising because at the lag phase cell synthesis enzymes that could convert readily available sugar, whereby the organisms undergo cell repair by adapting to the environment. This is in agreement with the results of Laopaiboon *et al.* (2010), they reported that the hydrolysis of sugarcane baggasse (SCB) for lactic acid production using HCl is quite slow compared to when using H_2S0_4, maximum total sugar and reducing sugar concentration of 49.95 and 21.33 g/c were obtained when using 5% (v/v) of H_2S0_4. While in contrary to Itelima *et al.* (2013) the highest reducing concentration (0.94mg/cm^3). *Trichoderma reesei* released maximum reducing sugar of 22.30 mg/g in paddy straw, 25.56 mg/g in wheat straw, and 28.26 mg/g in sugarcane bagasse. *Phanerochaeta chrysosporium* recorded reducing sugars of 14.55 mg/g in paddy straw, 18.11 mg/g in wheat straw and 20.96 mg/g.

The effect of water ratio on biofuel production from banana and plantain peels sample using *Saccharomyces cerevisiae* indicated a decrease in bio ethanol concentration with increase water ratio. The decrease in ethanol concentration with increase in water ratio observed for plantain is likely due to water activity. As previously stated that water activity is the key variable to ethanol concentration for the description of some of the nonspecific inhibitory effects apparent in ethanol fermentation (Jones and Greenfield, 1986). The peak ethanol concentration observed at water ratio of 1:15 suggests that it is the peak at which the ethanol exacts the lowest water activity. Ethanol induced water activity stress has been previously reported to exact stress on yeast metabolism and cell wall integrity (Hallsworth, 1998). These findings are in conformity with the work of Epstein *et al.* (2010) who reported an ethanol volume as low as 0.06 g/mL from apple and grape juices.

The effect of banana and plantain peels concentration on biofuel yield indicated substrate concentration increase from 5 to 15 g/L, ethanol yield increased to 0.08 mg/L. The decrease in ethanol yield beyond the optimum concentration 0.05 mg/L could be as a result of product inhibition. This implies that the ethanol produced inhibits the activity of the yeast, at low substrate levels, an increase of substrate concentration normally results in an increase of the yield and reaction rate of the hydrolysis (Cheung and Anderson, 1997). However, high substrate concentration can cause substrate inhibition, which substantially lowers the rate of the hydrolysis, and the extent of substrate inhibition depends on the ratio of total substrate to total enzyme (Huang and Penner, 1991; Penner and Liaw, 1994).These findings are in conformity with the work Reddy *et.al*. (2010) that carried out an investigation on use of banana agro waste for the ethanol production. They used cellulolytic thermophilic *Clostridium thermocellum* CT2 for the biological production of ethanol. This culture was isolated from elephant droppings. They obtained the maximum ethanol yield of 0.41 g/g substrate used.

The increase in fuel yield may be due to continuous excretion of enzymes by the microorganism in the solution. The decrease in fuel yield beyond the optimum concentration could be that at the high substrate concentration, the active sites of the enzyme molecules at any given moment were virtually saturated with substrate. Thus any extra substrate has to wait until the enzyme complex has released the products before it may itself enter the active size of the enzyme (Wen, 2004).

The effect of inoculum size on biofuel production of banana and plantain peels sample using *Saccharomyces cerevisiae* indicated an increase in ethanol production. A study done by Mahamed and Reddy (1986) reported that the increasing *Saccharomyces cerevisiae* inoculums in the co-cultures *Aspergillus niger* and *Saccharomyces cerevisiae* from 4% to 12% showed an increase in the rate ethanol production from potato starch. Ocloo and Aywnor (2010) also reported that the time taken for the fermentation to be completed was affected significantly by the yeast concentration. The result obtained supported the fact that the speed of fermentation depends on the yeast concentration and the shorter the fermentation period required to achieve maximum alcohol yield (kordylas, 1990). Ueda *et al.,* (1981) reported 5days fermentation for raw cassava root starch using 15% yeast suspension. Togarepi *et al.,* (2012) reported increase production rate rapidly with the increase in the amount of yeast to the concentration of 8g/20g fruit pulp. Beyond that point the rates no longer significantly increased. At this point the substrate becomes limiting and increase the yeast amount does not increase the rate of reaction.

The FT-IR on the produced alcohol are shown on Fig. 5 have an alcohol characteristic IR absorption associated with 0-H and C-H stretching vibrations. When run as a liquid film the region 3550-3200cm^{-1} region correspond to 0-H stretching and C-H stretching region 2850-3000cm^{-1}. The spectra of the banana peels show the band at around 3325 cm-^{1}and 2945 cm^{-1} for phenol/alcohol O-H stretch and alkane C-H stretching respectively with a very intense and strong broad band. The broad O-H correspond to peak for O-H from alcohol. This might be the alcohol group of 2,3-butanediol. The C-H stretch that corresponds to alkane might represent be the body compound such as Benzealdehyde. This is likely as a result of the various vibration modes that are found in carbohydrate and Lignin (Bodirlau *et al.,* 2008). The spectra of the plantain peels indicated the presence (OH) alcohol stretching at 3350 cm^{-1} and intense strong broad. Although all samples were similar slight changes were observed possibly indicating that equivalent strategies should be employed for releasing fermentable sugar from these lignocellulosics. And also the broad O-H peak was due to the interaction (hydrogen bonding) and the water content. The samples consist of alkene, alcohol and alkenyl indicating the presence of hydrocarbons in the biofuel.

The biofuel 2,3-butanediol (2,3-BD) was detected in the distillate of the plantain biomass. 2,3-butanediol is a potential valuable fuel additive that has 27.2KJ/g heat value. The heat value of

2,3-BD is comparable to those of other liquid fuel such as ethanol which has 29.055KJ/g and methanol which has 22.081KJ/g (Flickinger,1980).The presences of 2,3-BD is not surprising as the yeast *S. cerevisiae* used for fermentation in this study has been previously shown to posses three different 2,3-BD biosynthetic pathway (Ng *et al.*, 2012).

Conclusion

This study concludes that banana and plantain peels has potential as a sustainable and low-cost biomass for the production of biofuel such as 2,3-butanediol (2,3-BD). *Aspergillus niger*, *Sacchromyces cerevisiae* and *Mucor racemusus* were Identified. A reducing sugar concentration was observed for the banana and plantain peels. The biofuel concentration was found to be highest in banana and plantain peels. The IR characterization of the sample revealed with intense strong broad band of alcohol O-H and alkane C-H stretching respectively. GC-MS result revealed the presence of benzaldehyde in all the biomass while 2,3-butanediol was only detected in the plantain peels biomass. Burukutu can be exploited for sufficient *Saccharomyces cerevisiae* for biofuel production. This study shows the potential of bioconversion of banana and plantain peels biomass for biofuel production.

REFRENCES

Acharya, P. B., Acharya, D. K. and Modi, H. A. (2008). Optimization for Cellulase Production by *Aspergillus niger* using sawdust as substrate. *African Journal of Biotechnology*, **7** (22): 4147 – 4152.

Auta, H. S., Oyeleke, S. B., Ayodele, O. B.,Bala, J.D., Abioye O.P., Ibrahim, A. D., Ijah, U.J.J and Manga, S. B.(2012).Characterization of extracellular amylase produced by *Aspergillus fumigatus* isolated from rice husk waste dumpsite. *Biosciences* **6** (6):155-159.

Bassey, N. (2010). *Oil Politics: Nigeria's Unacceptable Biofuels Policy.* Retrieved from http://234next.com/csp/cms/sites/Next/Money/5643461-183/story.csp,on August 15, 2011.

Bodirlau, R., Teaca, C. A and Spiridon, .I. (2008)"Chemical modification of beech wood; Effect on thermal stability" *Bioresources*, 3 (3):789-800.

Cheng, S.W. and Anderson, B.C.(1997). Investigation of ethanol production from municipal primary waste water. *Bioresource Technology*, **59**:81-96.

Das, H. and Singh, S. K.(2004).Useful byproduct from cellulosic wastes of agriculture and food industry. A Critical appraisal. *Critical Review food science Nutrition* **44** (2):77-89.

David E., Stephen, D., Helen, A., Rosemary, H. and Robyn, B. (2007).Descriptions of medical fungi. 2nd edition. Australia ,pp100.

Demain, A., Newcomb, M. and Wu, D. (2005). Cellulase, Clostridia, and Ethanol Microbiology. *Molecular Biology Reviews* **69** (69):124–154.

Demirbas, A. (2005). Estimating of structural composition of wood and non wood biomass samples. *Energy Sources,* **27**:761-7

Devanathan, A., Shanmugun, T., Balasubraminian and Manivannan, S. (2007). Cellulase production from coastal mangrove debris. *Trends Applied sciences Research journal,* **2**:23-27.

Domsch, K. H and Grams, W. (1970). *Fungi in agricultural soils*, Longman group limited. London, pp: 20-152.

Elijah, A. J., Ojimelukwe, P. C., Ekong, U. S. and Asamudo, N. U.(2010).Effect of *Sacoglottis gabonensis* and *Alstonia boonei* on the kinetics of *S.cerevisiae* isolated from palm wine, *African journal Biotechnology* **9 (**35):5730-5734.

Ekunsaumi, T. (2006). *Laboratory production and assay of Amylase by fungi and Bacteria*. Bio-Link Organization, UW-Washington Country.

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.

Epstein, J. L., Vieira, M., Aryal, B., Vera, N. and Solis, M.(2010) Developing biofuel in the teaching laboratory: Ethanol from various sources. *Journal Chemistry Education*,**87** (7):708-710

Flickinger, M. C.(1980). Current biological research in conversion of cellulosic carbohydrate into liquid fuels: how far have we come. *Biotechnology Bioengineering* **22**:27-48.

Gershon, J. S., Ronald, A. S., Lawrence, B. and Rose, S. B. (1981).Chemical Technicians Ready Handbook, 2nd edition, McGraw-Hillbook company, USA.

Goldemberg, J. (2008). In Proceeding of the Conference on Ecological Dimensions of Biofuels. Washigton, DC.
http://www.esa.org/biofuel/presentations/Goldemberg_Biofuelspresentation.pdf,27/04/2018

Hallsworth, J. E., (1998). Ethanol induced water stress in yeast. *Journal of Fermentation and Bioengineering*, **85** (2):125-137.

Huang, X. L., and Penner, M. H., (1991). Apparent substrate inhibition of the *Trichoderma reesei* cellulase system. *Journal of Agricultural Food Chemistry.* **39**: 2096–2100.

Itelima, J., F. Onwuliri,F., Onwuliri, E., Onyimba, I. and Oforji, S.(2013) Bio-Ethanol Production from Banana, Plantain and Pineapple Peels by Simultaneous Saccharification and Fermentation Process. *International Journal of Environmental Science and Development.*4:2.

Jaafaru, M. I. and Fagade O. E. (2007). Cellulase Production and Enzymatic Hydrolysis of Some Selected Local Lignocellulosic Substrates by a strain of *Aspergillus niger*. *Research Journal of Biological Science* **2** (1): 13 – 16.

Jones R. P. and Greenfield, P.F. (1986). Role of water activity in ethanol fermentation. *Biotechnology and Bioengineering*, **XXVII**: 29 – 40.

Kordylas, J. M. (1990). Processing and preservation of tropical and subtropical foods. Macmillan Education Limited, Houndmills pp. 105- 107.

Laopaiboon, P., Thani, A., Leelavatcharamas, V., and Laopaiboon, L. (2010). Acid hydrolysis of sugarcane bagasse for lactic acid production. *BioresourceTechnology***101**:1036–1043.

Mohamed, M. A, and Reddy, C.A. (1986) Direct fermentation of potato starch to ethanol by cocultures of *Aspergillus niger* and *Saccharomyces cerevisiae*. *Applied and Environmental Microbiology.* 1055-1059.

Mie-ling, W., Youk-meng , C., Nan-wei, S. and Hsiung, L. (2003). A rapid method for determination of ethanol in alcoholic beverages using capillary gas chromatography. *Journal food drug Analysis*,**11** (2):133-140.

Miller, G. L.(1959).Use of dinitosalicyclic acid reagent for determination of reducing. *Analytical chemistry*, 31:426.

Ng chiam,Y., Moo-young, J., Jinwon, L. and Min-kyu, O.(2012).Production of 2,3-butanediol in *Saccharomyces cerevisae* by insilico aided metabolic engineering. *Microbial cell factories*,11:68.

Ocloo, F. C. K. and Ayernor, G. S. (2010) Production of alcohol from cassava flour hydrolysate. *Journal of Brewing and Distilling*. **1** (2) :15-21.

Oniemola, P .K. and Sanusi, G. (2009). *The Nigerian Bio-Fuel Policy and Incentives* (2007): *A Need to Follow the Brazilian Pathway*. International Association for Energy Economics.

Oyeleke, S.B., Dauda, B.E., Oyewole, O.A., Okoliegbe, I.N. and Ojebode, T. 2012. Production of Bioethanol from *Cassava* and Sweet Potato Peels. *Advances in Environmental Biology,* **6** (1): 241-245.

Oyeleke, S. B. and Manga, S. B. (2008).*Essential laboratory practical in microbiology*, 1st edition. TOBEST publishers, Minna Nigeria. pp 36-37.

Patel, S. J., Onkarappa, R., and Shoba, K. S. (2007). Fungal Pretreatment Studies on Rice Husks and Bagasse. *Electronic Journal of Environmental, Agricultural, and Food Chemistry* , **6** (4):1921-1926.

Penner, M. H., and Liaw, E. T., (1994). Kinetic consequences of high ratios of substrate to enzyme saccharification systems based on Trichoderma cellulase. In: Himmel, M.E., Baker, J.O., Overend, R.P. (Eds.), Enzymatic Conversion of Biomass for Fuels Production. American Chemical Society, Washington, DC, pp. 363–371.

Pimentel D., and Patzek, T.W.(2005).“Ethanol Production Using Corn. Switch grass and wood; Biodiesel Production using Soybean and sunflower,” *Natural Resources Research*, **14** (1):65-76.

Rabah, A. B., Oyeleke, S. B., Manga, S. B. and Hassan, L. G. (2011). Microbial pre treatment of rice husk and groundnut shell for bioethanol production. *International Research Journal of Microbiology*, **2 (**8**):** 253-258.

Reddy, H. K., Srijana M., Madhusudhan, R. D. and Gopal, R., (2010)“Coculture fermentation of banana agro-waste to ethanol by cellulolytic thermophilic *Clostridium thermocellum* CT2”, *African Journal of Biotechnology* , **9** (13): 1926-1934.

Tchobanoglous, G., Theisen, H., and Vigil, S., (1993). Integrated Solid Waste Management: Engineering Principles and Management Issues. MCGraw-Hill, New York, **3**–22.

Togarepi, E., Mapiye, C., Muchanyereyi, N. and Dzomba, P. (2012) Optimization of Fermentation Parameters for Ethanol Production from *Ziziphus mauritiana* Fruit Pulp Using *Saccharomyces cerevisiae* (NA33). *International Journal of Biochemistry Research & Review* **2 (**2**)**: 60-69.

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.

Ueda, S., Zenin, C.T., Monteiro, D.A. and Park, Y.K. (1981) Production of ethanol from raw cassava starch by a non-conventional fermentation method. In: John Wiley and Sons Inc. *Biotechnology and Bioengineering*, **23**: 291-299.

Vallet, C., Said, R., Rabiller, C. and Martin, M. L. (1996). Natural abundance isotopic fractionation in the fermentation reaction: influence of the nature of the yeast. *Bioorganic Chemistry* **24**: 319-330.

Wen, Z., Liao W., and Chen S., (2004). Hydrolysis of animal manure lignocellulosic for reducing sugar production. *Bioresources Technology*, **91**:31-39

Yabaya, A. and Ado, S. A.(2008) Mycelial protein production by Production by production by *Aspergillus niger* using banana peels, *Science world journal* **3**:9-12