Global Science Research Journals

Available online at
www.globalscienceresearchjournals.org

Global Journal of Environmental Science and Technology

Full Length Research Paper Open Access

Vol.10 (3). Pp. 1-9 August, 2022

Glucose production from banana peel using *Aspergillus flavus* and *Aspergillus oryzae* ATCC 17891

A Ajiboye[1], N Magaji[1] and R Olawoyin[2*]

[1]Department of Biosciences and Biotechnology, Microbiology Unit, College of Pure and Applied Sciences, Kwara State University, Malete, Kwara State, Nigeria
[2]Department of Science Laboratory Technology, Federal Polytechnic, Offa, Kwara State, Nigeria

*Corresponding author. E-mail: bosran@yahoo.com

Received: 11-Jun-2022, Manuscript no: GJEST-22-66420, **Editor assigned:** 14-Jun-2022, PreQC no: GJEST-22-66420 (PQ); **Reviewed:** 28-Jun-2022, QC no: GJEST-22-66420, **Revised:** 10-Aug-2022, Manuscript no: GJEST-22-66420 (R); **Published:** 17-Aug-2022, DOI: 10.15651/GJEST.22.10.011.

ABSTRACT

Glucose is a sugar with a wide range of applications in food and pharmaceutical industries. It was produced in this study by submerged fermentation using fungi. *Aspergillus flavus* was isolated from banana peel, identified and compared to a typed strain of *Aspergillus oryzae* (ATCC 17891) collected from the Federal Institute of Industrial Research, Oshodi (FIIRO) Lagos. An agro based waste; banana peel (*Musa sapientum*) served as substrate. The proximate analysis of the banana peel was also determined using standard procedures. The banana peels substrate was pretreated by hydrolysis and used as substrate in a mineral salts medium in submerged fermentation. The parameters which gave the highest yields were there after combined in a single fermentation. Results of the proximate analysis of the banana peel showed carbohydrate 55.87%, crude protein 4.31%, crude fiber 7.25%, crude fat 8.17%, ash 12.75%, and moisture 11.65%. The fermentation parameters optimized to increase glucose activity include: Substrate concentration, incubation period (days), sucrose supplement, and nitrogen supplement. The amount of glucose produced by each test organism from the banana peel was determined and compared using DNSA/reducing sugar analysis. Of the two fungal isolates used, *Aspergillus flavus* had the highest glucose yield of 42.00 ± 1.13^{b} mg/ml which were observed on day 7 concentration of 50 g/l and least glucose yield of 1.50 ± 0.28^{a} mg/ml were observed on day 1 at concentration 10 g/ml while the control *Aspergillus oryzae* 17891 had the highest glucose yield of 46.60 ± 0.68^{a} mg/ml on day 5 at concentration 40 g/l and lowest glucose yield of 1.90 ± 0.28^{a} mg/ml on day 1 at concentration of 10 g/l. These result support the use of banana peels as a substrate to produce glucose when hydrolyzed by fungi instead of being thrown away and left to rot and pollute the environment.

Keywords: Glucose, Banana peel, *Aspergillus flavus*, *Aspergillus oryzae*, Fermentation

INTRODUCTION

Sugar is one of the basic needs of the Indonesian people, especially for consumption and food processing. Sugar demand in Indonesia is still dominated by sugar (sucrose). Glucose is a monosaccharide with the molecular formula $C_6H_{12}O_6$. Glucose is widely used in the food and pharmaceutical industries. Enzymatic hydrolysis produces glucose concentrations higher than the acid hydrolysis (Ayoola, et al., 2012).

Banana is a tropical fruit grown in over 122 countries worldwide. Until 2004, the culivated area of 3.8 million hectares and a total production of 56.4 million metric

tonnes of the fruit were produced ranking it fourth behind rice, corn and milk (Chai, et al., 2004; Arumugam and Manikandan, 2011). In recent times, banana peel has been utilized for various industrial applications including bio-fuel production, bio-sorbents, pulp and paper, cosmetics, energy related activities, organic fertilizer, environmental cleanup and biotechnology related processes (Gunaseelan, 2004; Bori et al., 2007). Banana plantation occupies large part of the land, but it is a contamination source because after harvest, the tree is cut down and abandoned in the fields, which foments Sigatoka (Chillet, et al., 2009). All parts of the banana plant have medicinal applications (Amit and Shailandra, 2006): the flowers in bronchitis and dysentery and on ulcers; cooked flowers are given to diabetics; the astringent plant sap in cases of hysteria, epilepsy, leprosy, fevers, hemorrhages, acute dysentery and diarrhea, and it is applied on hemorrhoids, insect and other stings and bites; young leaves are placed as poultices on burns and other skin afflictions; the astringent ashes of the unripe peel and of the leaves are taken in dysentery and diarrhea and used for treating malignant ulcers (Girish and Satish, 2008); the roots are administered in digestive disorders, dysentery and other ailments; banana seed mucilage is given in cases of diarrhea in India (Bhat et al., 2010). Antifungal and antibiotic principles are found in the peel and pulp of fully ripe bananas (Brooks, 2008). The antibiotic acts against mycobacteria (Omojasola and Jilani, 2009). A fungicide in the peel and pulp of green fruits is active against a fungus disease of tomato plants (Ponnuswamy et al., 2011). Norepinephrine, dopamine, and serotonin are also present in the ripe peel and pulp (Ratule, et al., 2007). The first two elevate blood pressure; serotonin inhibits gastric secretion and stimulates the smooth muscle of the intestines (Anhwange et al., 2009). Some of the specific diseases known to be cured by banana are:

Anaemia: High in iron, bananas are believed to stimulate the production of haemoglobin in the blood and so help in cases of anaemia (Amit and Shailandra, 2006).

Blood pressure: Banana is extremely high in potassium yet low in salt, making it the perfect food for helping to beat blood pressure (Debabandya et al., 2010).

Depression: This is because bananas contain tryptophan, a type of protein that the body converts into serotonin known to make you relax, improve your mood and generally make you feel happier (Girish and Satish, 2008).

MATERIALS AND METHODS

Sample collection and Identification bananas (*Musa sapientum*) samples were purchased from Ipata market, Ilorin, Kwara State. Nigeria. The banana sample were collected in sterile polythene bags each and labeled appropriately then immediately transported to the Microbiology laboratory (Makut, et al., 2021).

Test Organisms and Preparation of Spore Suspensions

The organisms used in this study were *Aspergillus flavus* and *Aspergillus oryzae* (ATCC 17891) was obtained from Federal Institute of Industrial Research Oshodi (FIIRO) Lagos state, Nigeria. The organisms were maintained on Potato Dextrose Agar (PDA) and stored at 4°C until use. For the preparation of the spore suspension, 10 ml of sterile water was added to 5-day old culture slants of the fungi, the surface of the culture was scratched with a sterilized loop and agitated thoroughly at 250 rpm on a shaker to suspend the spores (Omojasola and Jilani, 2009). The number of the spores were counted by using the improved Neubauer haemocytometer and adjusted to approximately 2.0×10^6 CFU/ml and 2.0×10^5 CFU/ml of *Aspergillus flavus* and *Aspergillus oryzae* ATCC 17891 respectively which were used as inoculate throughout the study.

Substrate Pretreatment

The banana fruits were washed with clean water to remove dirt; after which they were peeled. The peel was then air-dried for 7 days and then pretreated using the alkali hydrolysis method (Omojasola and Jilani, 2009). It was also further kept in hot air oven at 60°C for 2 h to reduce the moisture content. Banana peel was blended into powdered form with a Binatone blender. It is then sieved through a mesh having a pore size of about 0.5 mm and stored in an air tight sample container for further use and dry place to avoid uptake of moisture (Nandini, et al., 2014).

Proximate Analysis of Banana Peel

The proximate analysis of the banana peel was determined. The parameters analyzed were; moisture content; ash; crude protein; lipid content; total carbohydrate and crude fibre (AOAC, 2019).

Submerged Fermentation

Mineral salt medium was prepared by using 40 g of sucrose (as a carbon source), 2.5 g yeast extract (as a nitrogen source), 1g KH_2PO_4, 0.5 g $MgSO_4.7H_20$, and 0.5g KCl in 1 liter of deionized water. Aforementioned media being the high productive media was utilized by all referred scientists (Abd El-Aziz, 2013).

Ten grammes of the banana peel substrate were mixed with 90 ml of the prepared medium in 250 ml Erlenmeyer flask. These flasks were sterilized in the autoclave at 121°C for 15 minutes at 15 psi. It was then inoculated with 2.0×10^5 spores/ml for *A. flavus* and control *A. oryzae* ATCC 17891 separately. These were incubated at 28 ± 2°C on a rotary shaker at 400 rpm (Meena et al., 2010). Glucose yield was estimated for at least 24 hours intervals using reducing sugar analysis/DNSA.

Optimization for Glucose Production

Different fermentation parameters were varied in order to increase the yield efficiency of banana peels under optimal conditions for glucose production. Fermentation conditions varied were: Substrate concentration (10.0 g-50.0 g); fermentation days (1-11 days). These conditions were varied by changing one variable while keeping the others constant. Optimal conditions were later combined in a single fermentation.

Data Analysis

The data were statistically processed to estimate the mean ± standard deviation (SD) and using the two-way analysis of variance (ANOVA). All data were analyzed according to the Statistical Package for Social Sciences (SPSS) version 16.0 (SPSS Inc., Chicago, IL). A P value of <0.05 was considered to be statistically highly significant.

RESULTS

Proximate Analysis

The data from this study confirm the presence of nutrients which would serve as suitable substrate for the fermentative production of Glucose using *A. flavus* and *A. oryzae* ATCC 17891. The proximate analysis of the banana peel revealed that it contained carbohydrate 55.87%, crude protein 12.72%, crude fibre 8.37%, crude fat 8.17 %, ash 12.75 % and 11.65 % moisture. These nutrients serve as carbon, nitrogen and energy sources for glucose production (Table 1).

Table 1: Proximate composition of banana peels.

Parameters	Mean Values (%)
Moisture %	11.65 ± 0.00
Ash%	12.75 ± 0.48
Carbohydrate%	55.87 ± 0.71
Calorific value (Kj/100g)	1313.09 ± 8.09
Lipid%	8.17 ± 0.07
Crude fibre%	7.25 ± 0.09
Crude protein	4.31 ± 0.06

Values are means ± SD of proximate composition of banana peels.

Morphological Characteristics of Fungal Isolates Isolated From Banana Peels.

The morphological characteristics of fungal isolates (F_1-F_3) are presented in Table 2.

Table 2: Morphological Characterization of Fungal Isolates.

Fungal isolates	Macroscopic and microscopic description	Probable organisms
F_1	Yellowish green, large, whitish mycelia. It has aerial hypae bearing conidiophores, which are colorless, thick walled, rough and bearing vesicles.	*Aspergillus flavus*
F_2	Filled plate with whitish cotton like growth, branched rhizoid, brownish spores, whitish reverse view	*Rhizopus stolonifer*
F_3	Black spore on the surface and usually whitish underneath, large, it has a branching hypha, budding yeast cells.	*Aspergillus sp.*

Keys: F_1–F_3=Fungal Isolates.

Physiochemical Parameters

The physicochemical parameters checked for include pH, TTA, and glucose produced for *Aspergillus flavus* and *Aspergillus oryzae* ATCC 17891 during fermentation of banana peel at different substrate concentration. The result for pH ranged from 3.69 ± 0.57^b to 6.87 ±1.98^a are presented in Table 3, total titrable acid values ranged from 96.70 ± 2.12^b to 1833.80 ± 278.03^a as presented in Table 4, the result for varying substrate concentration for glucose produced was determined using reducing sugar analysis/DNSA method and the result ranged from 1.50 ± 0.14^b to 46.60 ± 0.28^a are presented in Table 5.

Table 3: pH during fermentation of banana peels to produce glucose using different substrate concentration.

Sub. Conc.(g)	Fungal isolates	Fermentation period (Days)/pH					
		1	3	5	7	9	11
10	A. O	4.76 ± 0.85[a]	4.23 ± 0.16[a]	5.21 ± 0.57[a]	4.77 ± 1.56[a]	5.96± 0.14[a]	5.36 ± 1.27[a]
	A. F	3.69 ± 0.57[b]	5.31 ± 1.56[a]	6.12 ± 1.27[b]	5.27 ± 1.56[b]	7.16 ± 1.27[b]	6.13 ± 0.93[b]
20	A. O	3.84 ± 0.57[a]	6.13 ± 2.26[a]	6.26 ± 1.58[a]	6.34 ± 0.96[a]	6.54 ± 0.85[a]	7.22 ± 1.56[a]
	A. F	5.28 ± 0.85b	5.11 ± 0.57[b]	4.29 ± 0.93[b]	5.91 ± 0.14[b]	5.77 ± 0.57[b]	5.31 ± 1.27[b]
30	A. O	4.75 ± 0.84[a]	5.32 ± 1.32[b]	4.28 ± 0.85[a]	6.03 ± 1.27[a]	4.73 ± 1.27[a]	6.45 ± 0.85[a]
	A. F	3.99 ± 0.57[b]	4.86 ± 0.84[b]	6.18 ± 1.27[b]	6.87 ± 1.98[b]	4.71 ± 0.85[b]	5.02 ± 0.85[b]
40	A. O	4.71 ± 0.85[a]	3.84 ± 0.57[b]	4.76 ± 0.70[a]	6.87 ± 1.98[a]	4.71 ± 0.85[a]	5.02 ± 0.85[a]
	A. F	3.99 ± 0.57[b]	4.86 ± 0.84[b]	5.60 ± 1.54[b]	4.36 ± 0.52[b]	5.79 ± 1.52[b]	6.19 ± 1.52[b]
50	A. O	4.96 ± 0.82[a]	4.76 ± 0.85[b]	4.00 ± 0.47[a]	4.36 ± 0.52[a]	6.23 ± 1.48[a]	6.04 ± 0.93[a]
	A. F	5.21 ± 1.52[b]	5.28 ± 0.85[b]	6.09 ± 2.36[b]	6.19 ± 1.46[b]	5.03 ± 0.41[b]	6.34 ± 1.56[b]

Values are means of duplicate reading ± Standard deviation of pH of banana peels using varying substrate concentration with values on the same column with different alphabets are significantly different at P<0.05.
Key: AF: *Aspergillus flavus*; AO: *Aspergillus oryzae* ATCC 18791.

Table 4: Total titrable acid during fermentation of banana peel to produce glucose at different substrate concentration.

Sub. Conc. (g)	Fungal Isolates	Fermentation Period (Days) / TTA					
		1	**3**	**5**	**7**	**9**	**11**
10	A.O	137.80 ± 6.51[a]	679.50 ± 4.38[a]	805.90 ± 3.25[a]	813.30 ± 1.84[a]	761.30 ± 4.38[a]	452.20 ± 0.00[a]
	A.F	96.70 ± 2.12[b]	2.222 ± 3.434[b]	727.40 ± 1.70[b]	744.40 ± 2.26[b]	712.80 ± 4.53[b]	595.00 ± 2.83[b]
20	A.O	148.30 ± 1.84[a]	869.20 ± 0.00[a]	1046.60 ± 0.00[a]	1406.10 ± 2.12[a]	949.80 ± 3.39[a]	491.40 ± 2.55[a]
	A.F	122.10 ± 0.99[b]	677.50 ± 79.90b	887.60 ± 1.97[b]	973.80 ± 2.55[b]	831.10 ± 4.38[b]	471.60 ± 0.00[b]
30	A.O	139.00 ± 0.00[a]	887.80 ± 9.05[a]	1170.50 ± 6.08[a]	1339.20 ± 0.00[a]	1050.90 ± 30.69[a]	460.80 ± 0.00[a]
	A.F	135.90 ± 2.40b	731.80 ± 3.11b	1001.35 ± 4.17[b]	1114.20 ± 2.55[b]	1025.40 ± 0.57[b]	559.90 ± 2.69[b]
40	A.O	149.80 ± 2.26[a]	917.80 ± 0.00[a]	1100.30 ± 5.79[a]	1209.40 ± 3.11[a]	982.40 ± 0.00[a]	866.30 ± 4.38[a]
	A.F	139.70 ± 2.40[b]	816.00 ± 0.00[b]	1311.30 ± 4.10[b]	1209.40 ± 3.11[b]	1090.70 ± 3.25[b]	979.80 ± 4.81[b]
50	A.O	157.20 ± 3.39a	935.30 ± 15.70[a]	1678.50 ± 8.91[a]	1833.80 ± 278.03[a]	1629.80 ± 10.47[a]	959.40 ± 2.55[a]
	A.F	158.10 ± 1.84[b]	526.63 ± 456.08[b]	1162.90 ± 1.27[b]	1472.00 ± 5.09[b]	1256.95 ± 7.42[b]	1017.00 ± 2.55[b]

Values are means of duplicate readings ± SD of TTA of banana peels using different substrate concentration and Values on the same column with different alphabets are significantly different at P < 0.05).
Key: AF: *Aspergillus flavus*; AO: *Aspergillus oryzae* ATCC 17891.

Table 5: Glucose production by *Aspergillus flavus* and *Aspergillus oryzae* atcc 17891 during fermentation of banana peels at different substrate concentration.

Sub. Conc. (g/ml)	Fungal Isolates	Fermentation Period (Days) / Glucose Content (mg/ml)					
		1	3	5	7	9	11
10	A.O	1.90 ± 0.28[a]	11.35 ± 0.35[a]	29.10 ± 0.14[a]	34.55 ± 0.49[a]	27.40 ± 0.57[a]	24.00 ± 0.28[a]
	A.F	1.50 ± 0.14[b]	5.75 ± 0.24[b]	19.25 ± 0.21[b]	32.15 ± 0.49[b]	22.30 ± 0.28[b]	12.20 ± 0.28[b]
20	A.O	2.50 ± 0.42[a]	14.55 ± 0.21[a]	34.45 ± 0.35[a]	42.45 ± 0.07[a]	38.60 ± 0.42[a]	27.00 ± 0.28[a]
	A.F	2.00 ± 0.14[b]	6.45 ± 0.35[b]	25.45 ± 0.35[b]	34.60 ± 0.28[b]	27.40 ± 0.57b	18.30 ± 0.42[b]
30	A.O	2.40 ± 0.14[a]	13.10 ± 0.28[a]	30.50 ± 0.00[a]	39.35 ± 0.21[a]	29.25 ± 0.35[a]	24.40 ± 0.42[a]
	A.F	2.45 ± 0.21[b]	7.45 ± 0.35[b]	29.35 ± 0.21[b]	39.75 ± 0.35[b]	32.55 ± 0.35[b]	20.20 ± 4.10[b]
40	A.O	2.65 ± 0.35[a]	16.40 ± 0.42[a]	46.60 ± 0.28[a]	42.05 ± 0.21[a]	36.45 ± 0.35[a]	28.85 ± 2.19[a]
	A.F	2.55 ± 0.21[b]	6.30 ± 0.21[b]	33.55 ± 0.21[b]	38.20 ± 0.28[b]	29.25 ± 0.49[b]	17.55 ± 0.35[b]
50	A.O	2.65 ± 0.07[a]	15.60 ± 0.42[a]	37.95 ± 0.35[a]	46.00 ± 0.42[a]	32.20 ± 0.42[a]	25.60 ± 2.40[a]
	A.F	2.55 ± 0.49[b]	8.00 ± 0.28[b]	32.00 ± 0.42[b]	42.00 ± 1.13[b]	36.30 ± 0.28[b]	28.60 ± 0.00[b]

Values are means ± SD of Glucose content of banana peels using different substrate concentration and Values on the same column with different alphabets are significantly different at P<0.05).
Key: AF: *Aspergillus flavus*; AO: *Aspergillus oryzae* ATCC 17891

pH, Total Titrable Acid of Banana Peel During Fermentation by Fungal Isolates at different Incubation Period (days).

The bar chart representation for pH, Total Titrable Acid During Fermentation of Banana Peels to Produce Glucose at Different Incubation Period (days) Using Fungal Isolates as shown in Figure 1 and Figure 2.

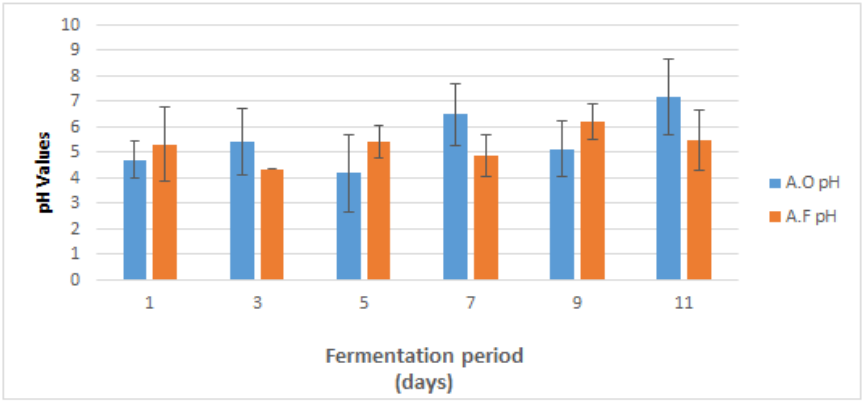

Figure 1: pH During Fermentation of Banana Peels to Produce Glucose at Different Incubation Period (days) Using Fungal Isolates.

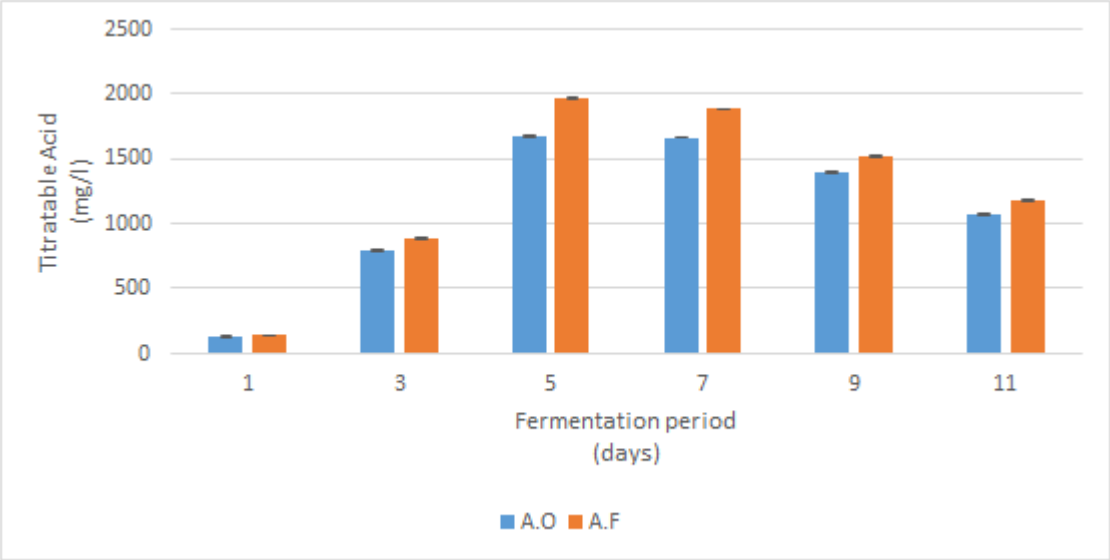

Figure 2: Total Titrable Acid during Fermentation of Banana Peels to Produce Glucose at Different Incubation Period (days).

The result for glucose produced by *Aspergillus flavus* and *Aspergillus oryzae* at different incubation period (Days) ranged from 1.70 ± 0.00[a] to 43.80 ±1.13[b] as presented in Table 6.

Table 6: Glucose production by *Aspergillus flavus* and *Aspergillus oryzae* at different incubation period (Days).

Fermentation Period (Days)	Glucose content (mg/ml)	
	A. O	A. F
1	1.70 ± 0.00[a]	2.15 ± 0.35[b]
3	13.55 ± 0.35[a]	15.60 ± 1.56[b]
5	32.05 ± 0.92[a]	43.80 ± 1.13[b]
7	40.90 ± 1.98[a]	37.10 ± 1.84[b]
9	35.15 ± 1.06[a]	35.90 ± 1.99[b]
11	29.20 ± 0.85[a]	28.55 ± 0.35[b]

Values are means of duplicate readings ± SD of glucose produced from banana peels at different Incubation period (Days).
Key: AF: *Aspergillus flavus*; AO: *Aspergillus oryzae* ATCC 17891.

DISCUSSION

Banana peel can yield glucose by the activities of cellulolytic organisms. Banana peel was used as a substrate for glucose production. Microorganisms have long been considered as harmful entities contributing towards diseases and food spoilage but also playing their role for the welfare of human being. Presently some of these microorganisms are being widely used in food industry for production of a large number of fermented food products and at the same time these are also very helpful for conversion of food industrial wastes into value added useful products such as enzymes, organic acids and glucose. (Michael, et al., 2013).

The proximate analysis of the banana peels was carried out to determine the percentage of the carbohydrate, protein, lipid, crude fiber, ash and moisture content present in the substrate. It was observed that the carbohydrate, protein and were high enough to serve as good carbon and energy sources for glucose production. The carbohydrate content of 55.87 % reported in this study exceeds the observation of Romelle et al., who reported 43.40%. This is an indication that banana peel is high in carbohydrates and provided a good carbon source for glucose production. The protein content would also serve as a good nitrogen source for microbial metabolism. Nitrogen is one of the most essential constituents of the medium for fungal fermentation and various studies have reported increased organic acid yields with high nitrogen content (Betiku et al., 2016); Omojasola and Okwechime, 2017). Banana peel contains appreciable

level of lignocellulosic materials and other components such as carbohydrates, vitamins, bioactive compounds and minerals which qualify it for various bioconversion processes (Johann et al., 2007; Dzomeku et al., 2007). The results of this study further reinforce earlier observations confirming the suitability of agro industrial residues as fermentable substrates for organic acid production (Ncube, et al., 2012; Hajian and Yusoff, 2015). Omojasola and Adeniran reported yields of 112.67 g/L and 115.67 g/l with sweet potato peel by *A. niger* and *A. terreus* respectively. El-Imam, et al. produced 48.70 g/l with Jatropha curcas seedcake with *A. terreus*. Rao et al. recorded 24.46 g/l also from Jatropha seedcake. The variation in the IA yields from the different substrates maybe due to the differences in the composition of the substrates, fermenting organisms and conditions employed in the fermentation. Generally, it was observed that *A. oryzae* produced higher yields of Glucose than *A. flavus* and this was observed in all the fermentations (Tables 3-5).

Aspergillus flavus was isolated from subjecting banana peel to submerged fermentation. *Aspergillus flavus* is found globally as a saprophyte in soils and causes disease on many important agriculture crops (Amaike and Nancy, 2011). Generally, excessive moisture conditions and high temperatures of storage grains and legumes increase the occurrence of *A. flavus* aflatoxin production. *Aspergillus flavus* is unique in that it is a thermotolerant fungus, so can survive at temperatures that other fungi cannot. *A. flavus* can contribute to the storage rots, especially when the plant material is stored at high moisture levels. *A. flavus* grows and thrives in hot and humid climates. (Hedayati, et al., 2007).

Evaluating the different fermentation parameters *i.e.* substrate concentration, incubation days for pH, total titratable acid and glucose produced of fermented banana peels to optimize the yield of glucose production. Most often, changes in fermentation conditions usually have a great influence on the production ability of a microbial strain. With the variation of substrate concentration, 50 g yielded maximum product of 42.00 g/l and 46.00 g/l by *A. flavus* and *A. oryzae* ATCC 17891 respectively on Day 7 of fermentation (Table 3).

Meena et al., (2010) also observed maximum production of Itaconic Acid at 120 h of fermentation although with much lower yields (maximum yield was 8.10 g/l) and this trend was observed when *A. niger*, *A. nidulans*, *A. flavus* (6.3, 5.6 and 4.8 g/l respectively) were used as fermenting organisms. Rafi et al., who observed highest Itaconic Acid yield of 28.88 g/l at 4 % (w/v) substrate concentration after which a decrease in yield with increase in substrate concentration was observed. This is in contrary with this work which therefore suggests that increase in substrate concentration improves the fermentation ability of the organisms (*Aspergillus flavus* and *Aspergillus oryzae* ATCC 17891.

The effect of pH is an important parameter in production of organic acid or bio-acids using fungal or any other microorganism. At pH 4.0, both isolates produced highest glucose concentrations. This is in support with Makut et al., who reported over 50 % yield of gluconic acid at pH range from 5 to 7. The best yield was at pH 6.0. However, the acid yield above and below this pH was poor (Dowdells, et al., 2010). The results confirm that banana peels is a good substrate for glucose production confirming the observations of Sharma et al., and Yi et al., about the suitability of agro-industrial as fermentable substrates.

Aspergillus flavus produced the highest TTA value at concentration 50 g/l and substrate concentration 10 g/l showed the lowest TTA while the control organism *Aspergillus oryzae* ATCC 17891 produced the highest TTA value at substrate concentration 50 g/l and lowest TTA value was at substrate concentration 10 g/l at day 7.

For Glucose Content (Reducing sugar), concentration 50 g/l showed the highest and 10 g/l showed the least value for *Aspergillus flavus* while concentration 40 g/l showed the highest value and 10 g/l showed the least value for *Aspergillus oryzae* ATCC 17891. This result is in line with Mafra, et al., who reported high titratable acidity at high substrate concentration used in the study. This acidity could be as a result of high substrate concentration used.

CONCLUSION

In conclusion, this study revealed that banana peel, which is a domestic and industrial agro waste, can serve as substrate to produce glucose when hydrolyzed by cellulolytic microorganisms, instead of being thrown away and left to rot and pollute the environment. It is also beneficial in the sense that by using cost efficient agro waste as alternate sources for higher production of acids and enzymes using *Aspergillus flavus* through submerged fermentation and *Aspergillus oryzae* ATCC 17891 a recommendable strain for industrial production of glucose. The study helps to scale up the glucose fermentation to a large-scale fermentor as grown on the optimization process.

REFERENCES

Ayoola AA, Adeeyo OA, Efeovbokhan VC, Ajileye O (2012). A comparative study on glucose production from sorghum bicolor and manihot esculenta species in Nigeria. Int. J. Sci. Technol. 2: 353-357.

Chai M, Ho YW, Liew KW, Asif JM (2004). Biotechnology and *in vitro* Mutagenesis for BananaImprovement. In Jain, SM, Swennen R (eds) Banana improvement: cellular, molecular biology, and induced mutations. Science Publishers, Enfield, USA.

Arumugam R, Manikandan M (2011). Fermentation of pretreated hydrolyzates of banana and mango fruit wastes for ethanol production. Asian. J. Biol. Sci. 2: 246-256.

Gunaseelan N (2004). Biochemical methane potential of fruits and vegetable solid waste feedstocks. Biomass. Bioenergy. 26(4): 389-399.

Amit R, Shailandra S (2006). Ethnomedicinal approach in biological and chemical investigation of phytochemicals as antimicrobials. Indian. J. Pharm. Sci. 41: 1-13.

Girish HV, Satish S (2008). Antibacterial activity of important medicinal plants on human pathogenic bacteria–a comparative analysis. World. Appl. Sci. J. 5(3): 267-271.

Bhat MS, Prabhakar A, Rama KRR, Madhu GM, Rao GH (2010). Statistical optimization and neural modeling of amylase production from banana peel using Bacillus subtilis MTCC 441. Int. J. Food. Eng. 6(4): 34-45.

Brooks AA (2008). Ethanol production potential of local yeast strains isolated from ripe banana peels. Afr. J. Biotechnol. 7(20): 3749-3752

Omojasola PF, Jilani OP (2009). Cellulose production by Trichoderma longi, Aspergillus niger and Saccharomyces cerevisae cultured on plantain peel. Res. J. Microbiol. 40: 67-74.

Ratule MT, Osman A, Saari N, Ahmad SH (2007). Microstructure of peel cell wall and selected physic-chemical characteristics of Berangan banana (*Musacv. Berangan* (AAA)) ripened at high temperature. AsPac J. Mol. Biol. Biotechnol. 15: 8-13.

Anhwange BA, Ugyeans TJ, Nyiaatagher TD (2009). Chemical composition of Musa sapientum (Banana) peels. Elec. J. Env. Agricult. Food. Chem. 8(6): 437-442.

Debabandya M, Sabyasachi M, Namrata S (2010). Banana and its by-products utilization: An overview. J. Sci. Ind. Res. 69: 323-329.

Nandini S, Nandini KE, Krishna SS (2014). Food and Agriculture Residue (FAR): A potential substrate for tannase and gallic acid production using competent microbes. J. Bioprocess. Biotech. 5(1): 1-8.

AOAC (2019) Official Methods of Analysis of the Association of Official Methods of Analysis of AOAC International. 21st Edition, AOAC, Washinghton DC.

Abd El-Aziz BA (2013). Improvement of Kojic Acid production by a mutant strain of Aspergillus flavus. J. Nat. Sci. Res. 3(4): 31-41.

Meena V, Sumanjali A, Dwarka K, Subburathinam KM, Rao KRSS (2010). Production of itaconic acid through submerged fermentation employing different species of Aspergillus. Rasayan. J. Chem. 3(1): 100-109.

Michael MD, Salleh AA, Joseph A, Tarfena A, Hashimu Z (2013). Screening and Improvement of local isolates of *Aspergillus niger* for citric acid production. Bayero. J. Pure. Appl. Sci. 6(1): 105-111.

Romelle FD, Rani AP, Manohar RS (2016). Chemical composition of some selected fruit peels. Eur. J. Food. Sci. Technol. 4: 12-21.

Betiku E, Emeko HA, Solomon B (2016). Fermentation parameter optimization of microbial oxalic acid production from cashew apple juice. Heliyon. 2(2): 82.

Omojasola PF, Okwechime PO (2017). Submerged fermentation of Jatropha seedcake in the production of itaconic acid by *Aspergillus niger* and *Aspergillus terreus*. Egypt. Acad. J. Biolog. Sci. 9(2): 1-9.

Johann FO, Heirera LJT, Couto SR (2007). Saccharification of banana agrowaste by cellulolytic enzymes. Dye pigment. 75: 32-37.

Amaike S, Keller NP (2011*). Aspergillus flavus.* Annu. Rev. Phytopathol. 49: 107–133.

Cabana H, Jones JP, Agathos S (2008). Utilization of cross-linked laccase aggregates in a perfusion basket reactor for the continuous elimination of endocrine-disrupting chemicals. Biotechnol. Bioeng. 102(6): 1582-1592.

Ricca E, Calabrò V, Curcio S, Iorio G (2009). Fructose production by chicory inulin enzymatic hydrolysis: a kinetic study and reaction mechanism. Process. Biochem. 44(4): 466-470.

El-fallal A, Dobara MA, El-sayed A, Omar N (2012). Concepts to Biotechnological Applications .Intech. 459–488.

FAO (2010) FAOSTAT: Banana Production by Countries 2010. Rome, Italy.

Fellows PJ (2016). Food Processing Technology. Wood head Publishing, Sawston, Cambridge, England.

Fogler HS (2004). Elements of Chemical Reaction Engineering Third Edition. Prentice Hall of India, New Dehli, India.

Howeler R (2006). Workshop on Partnership in Modern Science to Develop a Strong Cassava Commercial Sector in Africa and Appropriate Varieties by 2020. Bellagio,Italy, pp.2-6 .

Johnson R, Padmaja G (2013). Comparative Studies on the Production of Glucose and High Fructose Syrupfrom Tuber Starches. Int. Res. J. Biol. Sci. 10: 68–75.

Miller GL (1959). Use of dinitrosalicylic acid reagent for determination of reducing sugar. Anal. Chem. 31(3): 426-428.

Morales S, Alvarez H, Sanchez C (2008). Dynamic models for the production of glucose syrups from cassava starch. Food. Bioproducts. Process. 86(1): 25-30.

Narasimha G, Sridevi A, Viswanath B, Chandra MS, Rajasekhar RB (2006). Nutrient effects on production of cellulolytic enzymes by Aspergillus niger. Afr. J. Biotechnol. 5(5): 472-476.

Schieber A, Stintzing C, Carle R (2001). By products of plant food processing as a source of functional compounds recent

development. Trend. Food. Sci. Technol. 12(11): 401-413.
Sivakumar S (2014). Isolation of cellulolytic fungi and their degradation on cellulolytic agricultural wastes. J. Acad. Ind. Res. 2: 458.

Widsten P, Kandelbauer A (2008). Laccase applications in the forest products industry: A review. Enzyme Microb. Technol. 42(4): 293-307.

Widiasa IN, Susanto H (2009). Ultrafiltration fouling of amylose solution: Behavior, characterization and mechanism. J. Food. Eng. 95(3): 423-431.