Utilization of Lignocellulosic Waste (Plantain Peel) and Subsequent Generation of Organic Acids of Industrial Importance by *Streptomyces albus* Strain DOB KF977551

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Introduction

The world economy is currently faced with unprecedented decline and uncertainty. A major feasible option for rescuing the situation is the use of agro wastes generated from activities such as cultivation, harvesting and processing (Parveen *et al*., 2012; Pleissner and Venus, 2016). The demand for plantain is on the increase because of the nutritional health benefits attached to its consumption. The increased demand has led to improved cultivation techniques and sophisticated processing by agro-allied industries; hence, plantain peel is abundantly generated as wastes in the tropical Africa and could be considered as an ideal substrate for microbial process for the production of value- added products. Historically, organic acids are known for their use as additives and preservatives in the food, pharmaceutical and cosmetic industries (Suresh, 2013). One of the major factors in the production of industrially important acids is the raw materials such as corn and cassava, which are commonly used before now, but could lead to food crisis. Moreover, the pre-treatments such as gelatinization, liquefaction and enzymatic saccharification to glucose and subsequent conversion of glucose to organic acids make it uneconomical (Amit *et al.* 2014).

Biological production offers with significant advantages compare with chemical synthesis because it allows the use of cheap raw agro-industrial materials (tagged as "wastes") mostly generated in large quantities yearly which results in environmental pollution and public health problems. Focus is on direct fermentation and conversion of wastes to organic acids by bacteria which possess the enzymatic capabilities without the need for pre-treatment stage of saccharification. This has warranted studies on the ability of a tropical estuarine *Streptomyces* strain to utilize plantain peel as substrate for the production of organic acids of importance.

Aim

The focus of this work is to provide evidence for the direct bacterial production of industrially important acids from plantain wastes to replace sugars and costly nitrogenous materials with the goal to keep the cost of raw material low.

Materials and methods

Streptomyces albus strain DOB KF977551 (inocula) was isolated from a tropical estuary in Lagos, Nigeria. Identification was based on cultural and biochemical characteristics, electron microscopy and 16S rDNA gene sequencing as described previously (Buraimoh *et al*., 2015). Growth study was performed under aerobic batch (submerged) fermentation using 1ml of the organism as the inoculum in Erlenmeyer flasks (250 ml) containing mineral salts medium (100 ml, pH 7.0) which was supplemented with 1.0 g (w/v) substrate (washed, dried

grounded plantain peel) as sole carbon source. Incubation was carried out at 30 ^{o}C on a rotary shaker (150 rpm) for 21 days. Growth was evaluated at intervals (3 days) by the intensity of turbidity (O.D $_{600nm}$) in mineral salts medium, while the metabolic products were determined using GC-FID (Hewlett Packard (HP) 5890 series II ,California, USA) with an OV-3 glass column pack. Column temperature was 200 ^{o}C while the injector and detector temperatures were 200 ^{o}C and 270 ^{o}C respectively with N_2 carrier gas and H_2 at a flow rate of 22 ml/min and temperature/ramping rate of 5^{o}C/min. After extraction, the analytes (1ml) each, including the uninoculated control was injected into the GC-FID to detect the by-products of fermentation.

Results and discussion

Increase in the optical density (up to 2.20 nm) showed that the organism utilized the plantain peel as a growth substrate. The pH dropped from 7.2 to 6.08; and thereafter, fluctuated between 6.08 and 6.87 throughout the period of the experiment (Table 1). The diversity and quantities (mg/L) of organic acids detected in the growth medium of *Streptomyces albus* strain DOB are shown in table 2. The results of the GC-FID (Fig.1) showed that acetic, lactic, oxalic, $_{n}$valeric, isovaleric, cis -aconitic acid, nbutyric acid, trans –aconitic and iso-butyric acids were the by- products of fermentation of plantain peels by this strain. Although full utilization of plantain waste has been reported to be hampered due to recovery challenges facing submerged state fermentation, however, Vijayaraghavan *et al*. (2011) are of the opinion that if properly harnessed, the whole process of bioconversion is sustainable because microorganisms such as bacteria can produce valuable enzymes from wastes thereby offsetting the costs associated with the pre-treatment techniques.

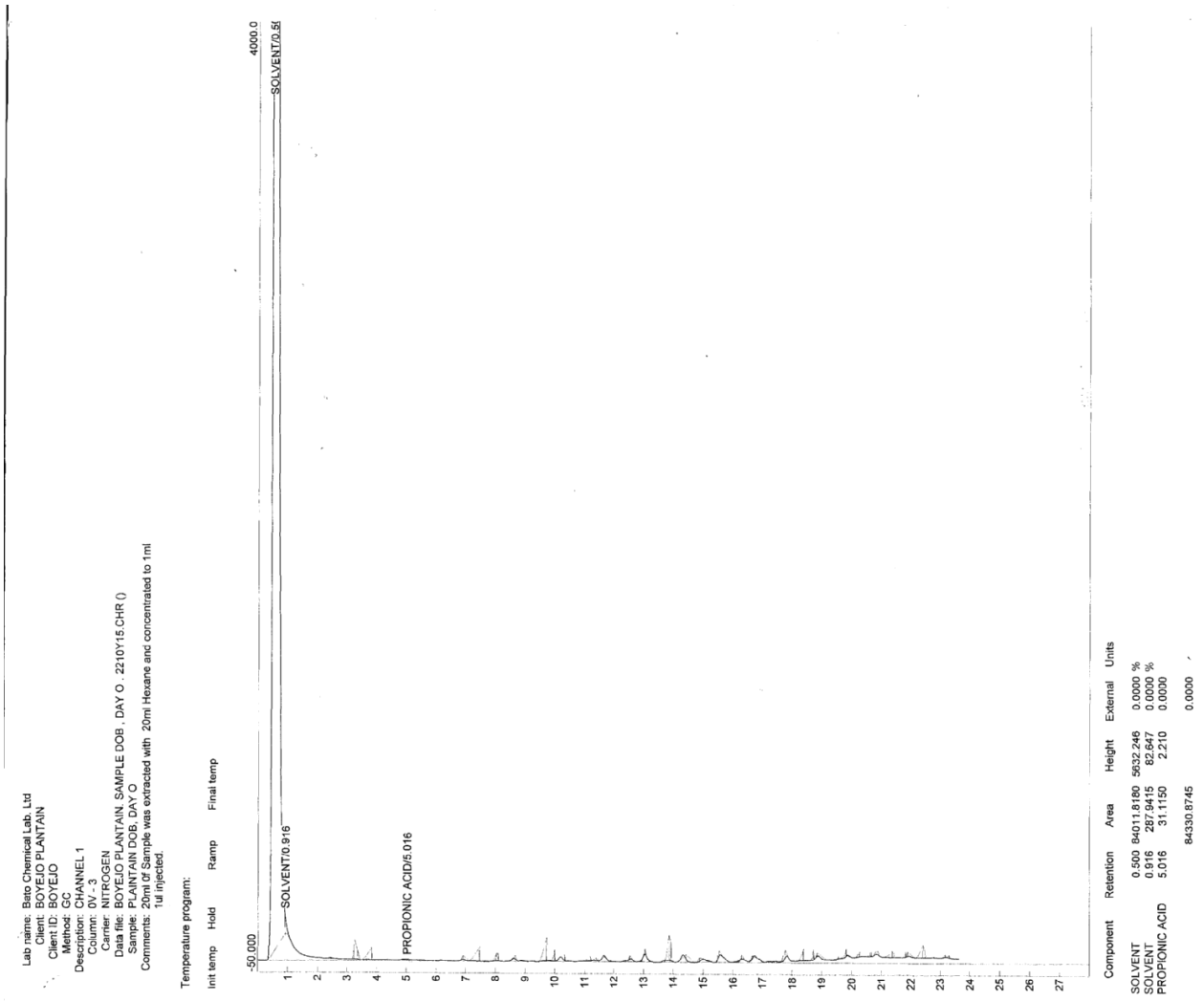
Table 1: Optical density and pH levels of the growth medium of *Streptomyces albus* strain DOB KF977551 on plantain peel

DAYS	O.D (nm)	pH
O	1.05	7.2
3	1.03	6.08
6	1.11	6.54
9	1.07	6.41
12	2.20	6.48
15	1.13	6.53
18	1.07	6.64
21	1.11	6.87

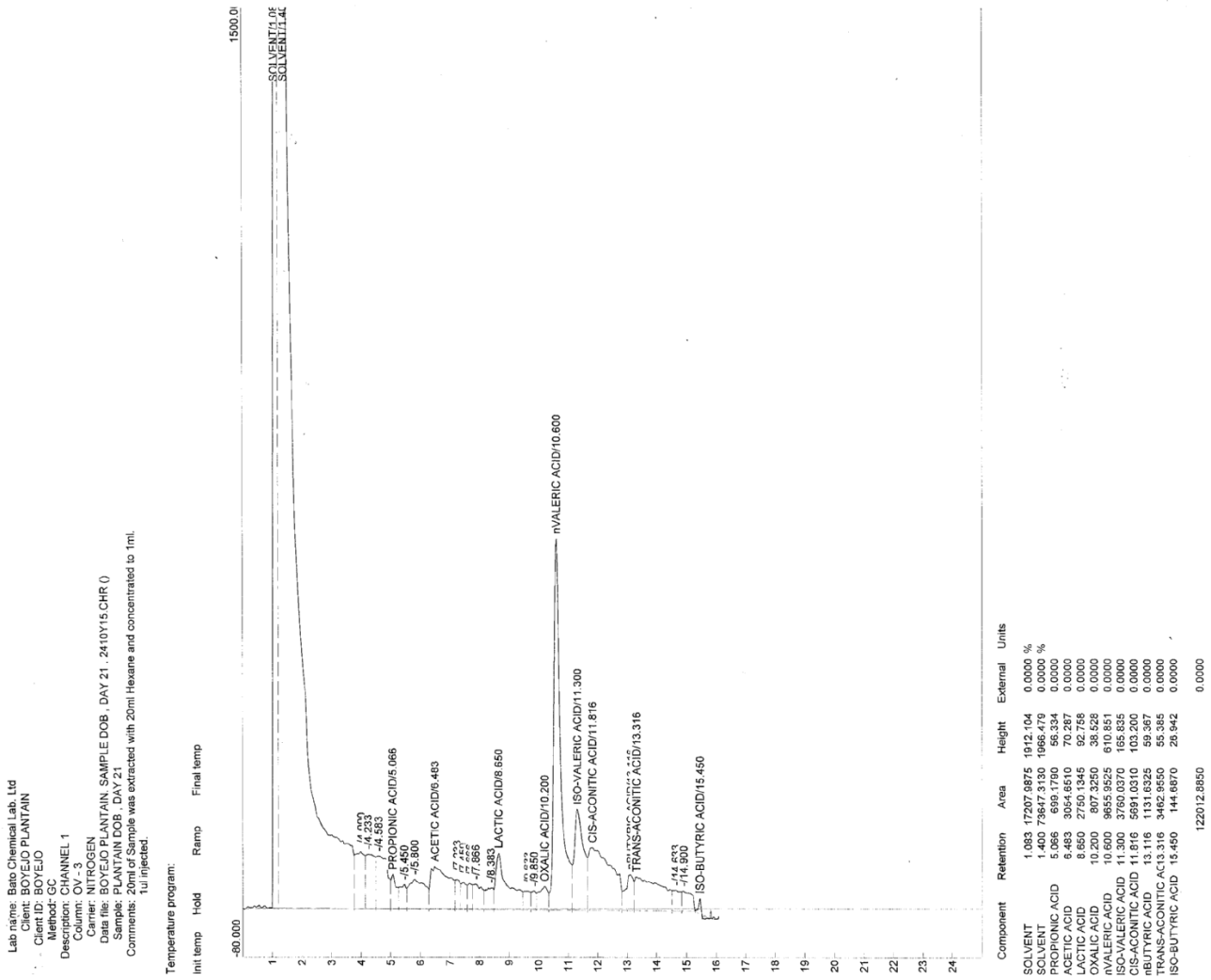
TABLE 2: Diversity and quantities (mg/L) of organic acids detected in the growth medium of *Streptomyces albus* strain DOB KF977551 using plantain peel as the sole carbon source

METABOLITES	DAY 0	DAY 9	DAY 21
Propionic acid	0.03	0.06	0.65
Acetic acid	0	0.94	2.86
Lactic acid	0	0.70	2.57
Oxalic acid	0	0.16	0.76
nVALERIC	0	6.24	9.04
Iso valeric	0	0.94	3.52
Cis aconitic acid	0	0.42	5.33
nButyric acid	0	0.31	4.93

Trans aconitic	0	0.86	3.24
Iso-butyric acid	0	0.13	0.13



A



B

Fig.1: Gas chromatographic profiles for the generation of diverse biochemicals from the medium containing plantain peel as the sole carbon and energy source during aerated batch culture of *Streptomyces albus* strain DOB KF977551 by day 0 (A) and by day 21

Summary of findings

1. *Streptomyces albus* strain DOB efficiently utilized plantain waste for growth
2. Various acids of industrial importance were generated from plantain waste
3. The highest O.D of 2.20 nm was achieved by day 12 at pH 6.48

Conclusions

The outcome of this work suggests the efficient utilization of plantain peel by *Streptomyces albus* strain DOB, for the biological production of organic acids of industrial importance without the need for costly pre-treatment step. Moreover, it simultaneously removes these "wastes" from the environment (bioremediation). Plantain peel appears to be an ideal substrate for microbial process for the production of organic acids. Further work will focus on optimization, scale-up and kinetic modelling of the processes.

References

1. Amit, V., Abhijeet G., Nimisha, T. (2014). Organic acids production from *Lactococcus lactis* and *Leuconostoc mesenteroides* using a novel citrus and potato waste medium. J. Innv. Biol. 1(4): 175 – 180.
2. Buraimoh, O.M., Ilori, M.O., Amund, O.O., Michel Jr, F.C. and Grewal, S.K. (2015). Assessment of bacterial degradation of lignocellulosic residues (sawdust) in a tropical estuarine microcosm using improvised floating raft equipment. Int. Biod. Biodegr. 104: 186-193.
3. Parveen, J., Olorunnisola, K. S. and Zahangir, A. (2012). Bio-Valorization Potential of Banana Peels (*Musa sapientum*): An Overview. *Asian J. of Biotechnol. 4: 1-14.*
4. Pleissner, D., and Venus, J. (2016). Utilization of protein-rich residues in biotechnological processes. *Appl. Microbiol. Biotechnol*. 10 (5), 2133-2140, http://link.springer.com/article/10.1007/s00253-015-7278-6
5. Suresh, K., Jayasuni, J.S., Gokul, C.N., Anu, V. (2013). Citric acid production from agronomic waste using Aspergillus niger isolated from decayed fruit. J. of Chem. Biol. and Physical Sci. 3:1572-1576 Pleissner, D., and Venus, J. (2016). Utilization of protein-rich residues in biotechnological processes. *Appl. Microbiol. Biotechnol*. 10 (5), 2133-2140, http://link.springer.com/article/10.1007/s00253-015-7278-6
6. Vijayaraghavan P., Remya, C.S. and S.G. Prakash. (2011). Production of α-Amylase by *Rhizopus microsporus* using Agricultural By-products in Solid State Fermentation. *Research J. of Microbiol. 6: 366-375.*

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