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ASSESSMENT OF THE NUTRITIONAL COMPOSITIONS OF TWO VARIETIES OF PLANTAIN AND THEIR ASSOCIATED FUNGAL PATHOGENS

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Abstract

Studies on the nutrient quality and post-harvest fungal pathogens of two varieties of Musa paradisiaca : false hron (long variety) and cardaba (short variety) were carried out in the Department of Plant Science and Biotechnology, Rivers State University within a period of two months (February to March, 2021). Proximate analysis showed that the long variety had higher values of moisture (58.0±0.01%), lipid (1.70±0.00%), fibre (1.61±04%) and protein (3.50±0.02%) while the short variety had higher contents of ash, (3.5±0.00%) and carbohydrate (34.40±0.03%). Mineral assessment revealed the presence of calcium, iron, magnesium, phosphorus, potassium and sodium. However, higher concentration of calcium (39±0.02mg/100g) was recorded for the long variety. Higher values of potassium (205±0.04mg/100g) and sodium (34±0.01mg/100g) were observed for the short variety. Nevertheless, both varieties had equal contents of iron (4.0±0.00mg/100g), magnesium (36±0.00mg/100g) and potassium (300±0.00mg/100g). Determination of vitamins revealed only the presence of thiamine in both varieties while no values were seen for vitamins A, C and naicin. Phytochemical screening showed the availability of phytate, saponin, polyphenol and flavonoid in both varieties. Three fungal organisms (Saccharomyces cerevisiae, Rhizopus stolonifer and Aspergillus flavus) were isolated and found to be responsible for the spoilage of M. paradisiaca. However, S. cerevisiae and A. flavus only occurred in the long variety at incidence of 60% and 40% respectively. R. stolonifer and S. cerevisiae were associated with the spoilage of the short variety at 30% and 70% incidence respectively. Generally, both varieties possess appreciable nutrient and phytochemicals and as such should be included into daily diet.

Keywords: *Musa paradisiaca,* variety, nutrient and fungal pathogens

INTRODUCTION

Musa paradisiaca commonly known as plantain is a member of the Musaceae family and is distributed across all regions of the world (OECD, 2009). The plant is monoceous and can grow up to 16m in height with elliptic leaves. The plant undergoes two major phases which include the vegetative phase (production of leaves) and the reproductive phase (production of inflorescence) (Karamura and Karamura, 1995). According to Roy, (1990) plantain can be classified into three based on morphology (French, false horn and horn plantains). Roy, (1990) and OECD, (2009) further showed that the false horn type represents the long finger variety and the cardaba the short finger variety.

Plantain can be cultivated in a variety of soils with high content of organic matter. While lack of light intensity can lead to prolonged plant cycle, temperature determine the rate of growth and time for maturity (Oduje, Oboh, Ayodele and Stephen, 2015; Waskar and Roy, 1996). *M. paradisiaca* is mostly propagated vegetatively by the use of suckers and micropropagation technique as majority of consumed plantain are

vegetatively parthenocarpic (Mary and Sathiamoorthy, 2003).

Plantain are very crucial in the society as it serve as a source of food and income for farmers (Roy, 1990). The fruits of the plant are cherished because they are blessed with abundant nutrient components including mositure, fibre, ash, lipid, carbohydrate, protein, calcium, magnesium, sodium, potassium, phosphorus, iron as well as vitamins (Okareh, Adeolu and Adepoju, 2015; Oduje *et al*., 2015). *M. paradisiaca* possesses phytochemical components that have been used pharmaceutically to serve as antimicrobial, antidiabetic and anticancer regulators due to the presence of oxalate, flavonoid, tannin, glycosides, polyphenol and many others (Lavanya, Abi, and Vani, 2016; Sirajudin, Ahmed, Chowdhum, Kamarudin, Khan, Uddin and Musa, 2014; Chuku, 2009).

Plantain also faces the challenge of pests and diseases whose activities of these organisms do not only affect the yield and quality of produce but also their marketability and income of growers and traders (Jones, 2002; Ploetz, Thomas and Slabaugh, 2003; Gold, Pinese and Peña, 2002).

Several diseases such as Sigatoka leaf spot, Fusarium wilt, moko disease and Xanthomonas wilt caused by *Mycosphaerella* app, *Fusarium oxysporum*, *Pseudomonas solanacearum* and *Xanthomonas vasicola* pv. Musacearum (Manzo-Sánchez, Guzmán-González, Rodríguez-García, James and Orozco-Santos, 2005; Marín, Romero, Guzmán and Sutton, 2003; Ploetz, 2006; Eyres, Hammond and Mackie, 2005; Fegan and Prior, 2006; Biruma, Pillay, Tripathi, Blomme, Abele, Mwangi, Bandyopadhyay, Muchunguzi, Kassim, Nyine, Turyagyenda and Eden-Green, 2007; Aritua, Parkinson, Thwaites, Heeney, Jones, Tushemereirwe, Crozier, Reeder, Stead and Smith, 2008). Plantain also suffer damages from several nematodes including the *Radopholus similis* (burrowing nematode), *Pratylenchus coffeae* and *P. goodeyi* (root-lesion nematodes) and *Meloidogyne incognita* and *M. javanica* (root-knot nematodes) (Sarah, Pinochet and Stanton, 1996; Moens, Araya, Swennen and De Waele, 2006; Bridge, Fogain and Speijer, 1997).

However, there is dearth of information on the nutrient quality and associated mycoflora of the long and short finger plantain varieties in Port Harcourt. Hence, this research was embarked.

MATERIALS AND METHODS

Sample Collection

Two varieties of *M. paradisiaca*, False horn (Long finger variety) and Cardaba (short finger variety) as described by Roy, (1990) and OECD, (2009) respectively were bought from fruit garden market Port Harcourt, Rivers State. They were immediately transported to the Department of Plant Science and Biotechnology, Rivers State University for further studies.

Determination of nutrient components of fruits of *M. paradisiaca*

Healthy fruit samples of *M. paradisiaca* were sent to the Food Science and Technology Laboratory for the determination of nutrient composition. The methods of AOAC, (2005) was used for the analysis.

Preparation of media

Sterilization of conical flask, slides, Petri dishes and all the equipment needed for the experiment was carried out in the laboratory. The glass wares were sterilized in the oven at 120^{o}C for an hour after washing with soap, while other equipment were surface sterilized with 70% ethanol to reduce microbial contamination (Agrios, 2005). Inoculating loops and scalpels were sterilized by dipping for 20 seconds in 70% ethanol and heated to red hot. The mycological medium used was Sabouraud Dextrose Agar prepared in a conical flask using the standard method. The mouth of the flask was plugged with non-absorbent cotton wool and wrapped with aluminium foil. The conical flask containing the mycological medium was autoclaved at 121^{o}C and pressure of 1.1kg cm-3 for 15 minutes. The molten agar was allowed to cool to about 40 ^{o} C and dispensed into Petri

dishes at 15mls per plate and allowed to further cool and solidify.

Isolation of fungi from partially rotted *M. paradisiaca*

The direct plating method of Mehrotra and Aggarwal, (2003) was adopted were 0.5cm of the samples showing visible signs of spoilage by moulds was cut from the healthy portions of the fruits up to the points where rot had established and inoculated onto Sabouraud Dextrose Agar in Petri dishes onto which ampicillin was added to hinder the growth of bacteria in triplicate. The inoculated plates were incubated for 5 days at ambient temperature of 25^{o} C ± 3^{o} C (Chuku, 2009). The entire set up was observed for 7 days to ensure full grown organisms. Pure culture of isolates was obtained after a series of isolations**.**

Identification of fungi from *M. paradisiaca*

Microscopic examination of fungal isolates was carried out by the needle mount method (Cheesebrough, 2000). The fungal spores were properly teased apart to ensure proper visibility. The well spread spores were stained with cotton blue-in-lacto phenol and examined microscopically using both the low and high power objective. The fungi were identified based on their spore and colonial morphology, mycelia structure and other associated structures using the keys of (Barnett and Hunter, 1998).

Determination of percentage incidence

The percentage incidence of fungal occurrence was determined by the formular stated below (Chuku, Agbagwa and Worlu, 2019):

$$\frac{X}{Y} \times \frac{100}{1} = \% \text{ incidence}$$

Where:

X= total number of each organism in a variety

Y= total number of all identified organism in a variety

Statistical analysis

Data obtained were subjected to mean and standard deviation analysis with the aid of SPSS software version 22.

RESULTS AND DISCUSSION

Table 1: Proximate composition of both varieties of plantain (%)

Parameters	Long variety	Short variety
Moisture	58.0±0.01	56.0±0.00
Ash	3.20±0.00	3.50±0.00
Lipid	1.70±0.00	0.5±0.01
Fibre	1.61±0.04	1.50±0.00
Carbohydrate	32.90±0.02	34.40±0.03
Protein	3.50±0.02	2.90±0.01

Table 2: Mineral composition of both varieties of plantain (mg/100g)

Parameters	Long variety	Short variety
Calcium	39.00±0.02	32.00±0.00
Iron	4.00±0.00	4.00±0.00
Magnesium	36.00±0.00	36.00±0.00

Phosphorus	204.00±0.01	205.00±0.04
Potassium	300.00±0.00	300.00±0.00
Sodium	33.00±0.00	34.00±0.01

Table 3: Vitamin composition of both varieties of plantain (mg/100g)

Parameters	Long variety	Short variety
Vitamin C	0.00	0.00
Vitamin A	0.00	0.00
Thiamine	0.005±0.00	0.005±0.00
Naicin	0.00	0.00

Table 4: Phytochemical composition of both varieties of plantain (mg/100g)

Parameters	Long variety	Short variety
Phytate	0.002±0.00	0.001±0.00
Oxalate	0.00	0.00
Saponin	0.001±0.03	0.00
Tannin	0.00	0.00
Polyphenol	6.7±0.00	6.80±0.01
Flavonoid	12.06±0.02	12.05±0.00

Table 5: Fungal isolates from both varieties of plantain and their percentage incidences

Fungal isolates	Long variety (%)	Short variety (%)
Aspergillus flavus	40	-
Rhizopus stolonifer	-	30
Saccharomyces cerevisiae	60	70

The proximate composition result presented in Table 1 reveals the presence of moisture, ash, lipid, fibre, carbohydrate and protein in both varieties of *M. paradisiaca*. However, higher moisture content (58.0±0.01), lipid (1.70+0.00), fibre (1.61±0.04) and protein (3.50±0.02) were observed for the long variety while higher concentration of ash (3.5±0.00) and carbohydrate (34.40±0.03) were recorded for the short variety. The findings of the present study has shown that both varieties of *M. paradisiaca* contained appreciable amounts of moisture, ash, lipid, fibre, carbohydrate and protein. However, the long variety had higher values for proximate composition than the short variety. Several other authors also showed similar values for proximate parameters in plantain as well as other Musa species (Nelson, Ploetz and Kepler, 2006).

The result of the present study is higher than the proximate values reported by Zakpaa, Mak-Mensah and Adubofour, (2010) for the flour of plantain. Although, they also reported higher carbohydrate content (91.162). The report of Zakpaa *et al* was also supported by the findings of Okareh *et al*. (2015) as they also reported lower values for proximate composition for the leaf, fruit stalk and ripe peel of plantain. The report of Hapsari and Lestari, (2016) on the proximate composition of the short variety of *M. paradisiaca* (Cardaba) were lower than those reported in this study.

Oduje *et al*., (2015) reported higher proximate values for composition of the peels of ripe and unripe plantain than those recorded in this study. Nevertheless, the result of the current study is in line with the report of Yarkwan and Uvir, (2015) for fresh *M. paradisiaca*. The importance of proximate composition in the day to day living of man cannot be overemphasized as they do not only provide energy (carbohydrate) but also amino acids (protein) (Roy, 1990).

The result of mineral composition of both varieties of plantain shown in Table 2 revealed that higher values of phosphorus (205±0.04) and sodium (34±0.01) were recorded for the short variety. Although, higher values of calcium (39±0.02) was observed for the long variety. Both varieties recorded equal values of 4±0.00, 36±0.00 and 300±0.00 for iron, magnesium and potassium respectively. Result for the mineral contents of the present study has shown that both varieties of plantain possessed several mineral components. Both types recorded equal values of iron, magnesium and potassium. However, the short variety had more mineral contents than the long variety. Literatures have shown the relevance of plantain in terms of mineral composition (Tchango, Bikoi, Achard, Escalant and Ngalani, 1999).

The mineral composition of the current study are in line with those reported in plantain by Yarkwan and Uvir, (2015). However, the values they reported were lower than mineral values in the present study. Oduje *et al*., (2015) also reported lower mineral contents of the peels of unripe, ripe and over ripe plantain compared to their equivalents presented in this study. Furthermore, the report of Egbuonu, Nneji and Ukasoanya, (2017) for the peels and leaves of *M. paradisiaca* are lower than those of the current study. On the other hand, the mineral contents of the current study disagrees with the findings of Okareh *et al*., (2015) as they reported higher mineral values for the ripe peels, fruit stalk and leaf flours of plantain. Minerals are vital components for efficient metabolic processes as well as other biosynthesis (OECD, 2009).

Results of the vitamin contents of the current study have shown that both varieties of plantain had minute quantity of vitamins as there were no vitamins A, C and naicin. Although, only thiamine was found and recorded. Earlier studies have shown the presence of vitamins in Musa species. However, very few were able to show the availability of the assessed vitamin parameters of this study (Hapsari and Lestari, 2016). The thiamine concentration recorded in this study is lower than that reported by Egbuonu *et al.*, (2017) for the peels and leaves of M. *paradisiaca*. More so, they also recorded the availability of vitamins C, riboflavin and naicin. Nevertheless, the vitamin A content of the present study agrees with their findings as they also reported 0.00 value for both the peels and leaves of plantain. Vitamins are crucial as it assist the body immune system (Nelson, 2006).

The result of phytochemicals composition of both varieties of *M. paradisiaca* presented in Table 4 showed that higher values of phytate (0.002±0.00), saponin (0.001±0.03) and flavonoid (12.06±0.02) were recorded for the long variety whereas higher value of polyphenol (6.80±0.01) was recorded for the short variety. Nevertheless, both varieties recorded no values for tannin and oxalate. It was also observed that the short variety did not record any saponin content. The present study reveals the availability of several phytochemicals in both varieties of plantain. Researches have shown the availability of different phytochemicals in *M. paradisiaca* as well as other sister members of the Musaceae family (Lakshmi, Agarwal and Mahdi , 2015). The phytochemical result of the present study on the absence of tannin and saponin (short variety) are in line with the report of Yarkwan and Uvir, (2015) as they reported similar situation for fresh, sun dried and oven dried plantain. Nevertheless, the findings of the current study disagrees with the report of Oduje *et al*., (2015) as they reported the availability of saponin and tannin for ripe and unripe peels of plantain. Phytochemicals are of great relevance as studies have shown their ability to proffer antifungal, anticancer, antibacterial and antidiabetic activities (Lavanya *et al*., 2016; Sirajudin *et al*., 2014).

The result of fungal isolates presented in Table 5 revealed a total of three fungal organisms (*Saccharomyces cerevisiae, Rhizopus stolonifer* and *Aspergillus flavus*) to be associated with the spoilage of *M. paradisiaca*. *S. cerevisiae* and *A. flavus* were only recorded for the long variety with respective incidence of 60% and 40%. *R. stolonifer* and *S. cerevisiae* were the organisms found in the short variety with 30% and 70% incidence respectively. The present study has revealed three fungal organisms to be associated with plantain. Although, *S. cerevisiae* occurred in both varieties while *R. stolonifer* and *A. flavus* were only seen in the short and long varieties respectively. Several literatures have implicated fungi as well as other pathogenic organisms on Musa species (Marin *et al*., 2003; Aritua *et al*., 2008; Moens, Araya, Swennen and De Waele, 2006). The *A. flavus* isolate of the current study agrees with the report of Ogunyemi *et al*., (2015) as they also implicated *A. flavus* as well as other *Aspergillus* species to be responsible for the spoilage of plantain. Sani and Kasim, (2019) also reported the menace of *Aspergillus* species on banana. The findings of the present study further agrees with the report of Chuku, (2009) as *Aspergillus* species, *R. stolonifer* and yeast were all implicated to cause spoilage of plantain at the different stages of ripening. The activities of these spoilage organisms do not affect plant quality but also their appearance and marketability (Mendez-Casitillo, Prieto-Correa and Jimenez-Junca, 2017; Seiyaboh and Izah, 2018).

CONCLUSION

The present study has confirmed the findings of early researchers about *M. paradisiaca* being endowed with several nutrients including proximate, mineral, vitamin and phytochemical contents. However, plantain also faces the challenge of fungal diseases as three fungal organisms were isolated to be responsible for its spoilage. Proper hygienic measures should be adopted during its handling and storage to avoid contamination.

REFERENCES

Agrios, G. N. (2005). *Plant pathology,* 5th edition. Elsevier Academic Press, USA 383-557.

AOAC, (2005). Official methods of analysis of AOAC international. 18th edition. Association of official analytical chemists, Washington, D.C., USA.

Aritua V., Parkinson N , Thwaites R., Heeney J. V., Jones D. R., Tushemereirwe W., Crozier J., Reeder R., Stead D. E. and Smith J. (2008). Characterization of the *Xanthomonas* sp. causing wilt of enset and banana and its proposed reclassification as a strain of *X. vasicola*. *Plant Pathology,* 57: 170-177.

Barnett, H. L. and Hunter, B. B. (1998). *Illustrated genera of imperfect fungi*, 4th edition. American Phytopathological Society Press, St. Paul Minnesota, 218.

Biruma M., Pillay M., Tripathi L., Blomme G., Abele S., Mwangi M., Bandyopadhyay R., Muchunguzi P., Kassim S., Nyine M., Turyagyenda L. and Eden-Green S. (2007). Banana *Xanthomonas* wilt: A review of the disease, management strategies and future research directions. *African Journal of Biotechnology* 6: 953-962.

Bridge J., Fogain R. and Speijer P. (1997). The Root Lesion Nematodes of Banana. Musa Pest Fact Sheet No. 2. INIBAP, Montpellier, France. 4 pp.

Cheesebrough, M. (2000). *Distinct laboratory practice in tropical countries* part 2. Cambridge University Press London, 143-156.

Chuku, E. C. (2009). Fungi responsible for the spoilage of plantain (*Musa paradisiaca*) at various ripening stage. *Acta Agronomical Nigeriana*, 9(1&2), 35-45.

Chuku, E. C., Agbagwa, S. S. and Worlu, C. (2019). Nutrient quality and associated spoilage fungi of English pear (*Pyrus communis* L.). *International Journal of Agriculture, Environment & Bioresearch*, 4(6), 317-325.

Egbuonu A. C. C., Nneji W. O. and Ukasoanya A. C. (2017). Comparative evaluation of some nutrient contents and antifungal properties of ground *Musa paradisiaca* (Plantain) peels and leaves. *British J. Appl. Sci. & Tech.,* 19(1): 1-8.

Eyres, N., Hammond N. and Mackie A. (2005). Moko Disease *Ralstonia* solanacearum (Race 2, Biovar 1). Government of Western Australia, Department of Agriculture and Food, Factsheet Note 175. 2 pp.

Fegan, M., and P. Prior. (2006). Diverse members of the *Ralstonia solanacearum* species complex cause bacterial wilts of banana. *Australasian Plant Pathology*, 35: 93-101.

Gold, C.S., Pinese B. and Peña J. E. (2002). Pests of banana. Pp. 13-56 in J.E. Peña, J.L. Sharp and M. Wysocki, eds., Tropical Fruit Pests and Pollinators: Biology, Economic Importance, Natural Enemies and Control. CABI Publishing, Wallingford, UK.

Hapsari, L. and Lestari, A. D. (2016). Fruit characteristics and nutrient values of four Indonesian banana cultivars (*Musa* species) at different genomic groups. *AGRIVITA J. Agric. Sci.*, 38(3): 303-311.

Jones, D.R. (2002). *Diseases of Banana, Abacá and Enset*. CABI Publishing, Wallingford, UK. 544 pp.

Karamura, E.B., and D.A. Karamura. (1995). Banana morphology – part II: The aerial shoot. Pp. 190-205 in S. Gowen, ed., Bananas and Plantains. Chapman & Hall, London, UK.

Lakshmi V., Agarwal S. K. and Mahdi A. A. (2015). An overview of *Musa paradisiaca* Linn. *Natural Products*, 11(4): 105-109.

Lavanya K., Abi B. G. and Vani G. (2016). *Musa paradisiaca*: A review on phytochemistry and pharmacology. *World J. Pharm. & Med. Res*., 2(6): 163-173.

Manzo-Sánchez, G., Guzmán-González S., Rodríguez-García C. M., James A. and Orozco-Santos M. (2005). Biología de Mycosphaerella fijiensis Morelet y su interacción con Musa spp. *Revista Mexicana de Fitopatología* 23: 87-96.

Marín, D.H., Romero R. A., Guzmán M. and Sutton T. B. (2003). Black Sigatoka: An increasing threat to banana cultivation. *Plant Disease*, 87: 208-222.

Mary, A.E., and S. Sathiamoorthy. (2003). Effect of packing treatments on green life and peel-split of banana cv. Rasthali (AAB). *Indian Journal of Agricultural Research*, 37: 72-75.

Mehrotra, R. S. and Aggarwal, A. (2003). Pythopathological techniques in plant pathology: In *Plant pathology* 2nd edition. Tata McGraw-Hill publishing company limited, 821.

Mendez-Casitillo L., Prieto-Correa E. and Jimenez-Junca C. (2017). Identification of fungi isolated from banana rachis and characterization of their surface activity. *Letters in Appl. Micro.*, 64: 246-251.

Moens T., Araya M., Swennen R. and De Waele D. (2006). Reproduction and pathogenicity of *Helicotylenchus multicinctus*, *Meloidogyne incognita* and *Pratylenchus coffeae* and their interaction with *Radopholus similis* on Musa. *Nematology*, 8: 45-58.

Nelson S. C., Ploetz R. C. and Kepler A. K. (2006). Musa species (banana and plantain). http//:www.traditionaltree.org. Retrieved on 26th March, 2021.

Oduje A. A., Oboh A., Ayodele A. J. and Stephen A. A. (2015). Assessment of the nutritional, antinutritional and antioxidant capacity of unripe, ripe an over ripe plantain (*Musa paradisiaca*) peels. *Int. J. Adv. Res*., 3(2): 63-72.

OECD, (2009). Consensus document on the biology of bananas and plantains (*Musa* Spp.). http://www.oecd.org/biotrack. Retrieved on the 20th March, 2021.

Ogunyemi A. K., Buraimoh O. M., Ogundele M. T., Adigun J. A., Olumuyiwa E. O., Amud O. O., Okpuzor J., Odetunde S. K., Ehinmore I. O. and Avungbeto M. O. (2015). Potentials of microorganisms associated with plantain peels in the Lagos metropolis for biodegradation and bioconservation. *Ife J. Sci.*, 17(3): 657-666.

Okareh O. T., Adeolu A. T. and Adepoju O. T. (2015). Proximate and mineral composition of plantain (*Musa paradisiaca*) wastes flour; a potential nutrient source in the formulation of animal feeds. *Afri. J. Food Sci. and Tech.*, 6(2): 53-57.

Ploetz, R.C. (2006). Fusarium wilt of banana is caused by several pathogens referred to as *Fusarium oxysporum* f. sp. cubense. *Phytopathology*, 96: 653-656.

Ploetz, R.C., Thomas J. E. and Slabaugh W. R. (2003). Diseases of banana and plantain. Pp. 73-134 in R.C. Ploetz, ed., Diseases of Tropical Fruit Crops. CABI Publishing, Wallingford, UK.

Roy, S. (1990). Plantain cultivation under the West African conditions. IITA Ibadan, Nigeria, pp22.

Sani, M. A. and Jason, M. (2019). Isolation and identification of fungi associated with post harvest deterioration of banana (*Musa paradisiaca* L.). *PhOL*, 2: 347-354.

Sarah J.L., Pinochet J. and Stanton J. (1996). The burrowing nematode of bananas, *Radopholus similis* Cobb, 1913. Musa Pest Fact Sheet No. 1. INIBAP, Montpellier, France. 2 pp.

Seiyaboh, E. I. and Izah, S. C. (2018). Enumeration of microbial density in plantain (*Musa paradisiaca*) chips sold in Yenagoa metropolis, Nigeria. *Int. J. Res. Studies Micro. & Biotech*., 4(2): 45-48.

Sirajudin Z. N. M., Ahmed U. Q., Chowdhum A. J. A., Kamarudin E., Khan A. V., Uddin A. H. and Musa N. (2014). Antimicrobial activity of banana (*Musa paradisiaca*) peels against food borne pathogenic Microbes. *J. Pure & Appl. Micro.*, 8(5): 3627-3639.

Tchango J. T., Bikoi A., Achard R., Escalant J. V. and Ngalani J. A. (1999). Plantain: post harvest operations. FAOUN, pp 58.

Waskar, D.P., and S.K. Roy. (1996). Methods adopted for extending the shelf life of banana fruit – a review. *Agricultural Reviews Karnal*, 17: 132-138.

Yarkwan, B and Uvir, R. H. (2015). Effects of drying methods on the nutritional composition of unripe plantain flour. *Food Sci. and Quality Mgt.*, 41: 5-10.

Zakpaa H. D., Mak-Mensah E. E. and Adubofour J. (2010). Production and characterization of flour produced from ripe plantain (*Musa sapientum* L. var. paradisiaca; French horn) grown in Ghana. *J. Agric. Biotech. And Sus. Dev*., 2(6): 92-99.