British Journal of Applied Science & Technology
19(1): 1-8, 2017; Article no.BJAST.28393
ISSN: 2231-0843, NLM ID: 101664541

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Comparative Evaluation of Some Nutrient Contents and Antifungal Properties of Ground *Musa paradisiaca* (Plantain) Peels and Leaves

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Authors' contributions

This work was carried out in collaboration between all authors. Author ACCE designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors WON and CAU managed the literature searches and carried out the experiments under supervision of author ACCE. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2017/28393
Editor(s):
(1) Harshadrai M. Rawel, Institute of Nutritional Science, University of Potsdam, Germany.
Reviewers:
(1) Simone Carradori, University of Chieti, Italy.
(2) Catherine F. Hizon, Cagayan State University, Philippines.
Complete Peer review History: http://www.sciencedomain.org/review-history/17796

Original Research Article

Received 17th July 2016
Accepted 3rd August 2016
Published 11th February 2017

ABSTRACT

Musa paradisiaca (plantain) fruit peels and the plant leaves may have some nutrients and antifungal properties. Thus, the study determined and compared some nutrients (minerals and vitamins) in the ground plantain peels and leaves and the antifungal property of the aqueous and ethanol extracts (at concentration of 100 mg/ml) of the ground plantain peels and leaves, using standard methods. In either sample, vitamin A was not detected. The difference (±5.28 mg/100 g) in the highest of the detected vitamins, vitamin C in the samples, was statistically significant ($p<0.05$) whereas the difference (±0.01 mg/100 g) in the least detected vitamins, vitamin B_2, was not significant ($p>0.05$). Out of the determined minerals (mg/100 g), the highest concentration was potassium (40.00 ± 0.08) in the plantain leaves followed by phosphorous (36.00 ± 1.65) in the plantain peels while the least was magnesium (1.80 ± 0.05) in the leaves followed by iron (5.60 ± 0.06) in the peels. The ethanol and aqueous extracts of the peels and leaves showed activity (inhibition zone diameter measured in

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millimeter, mm) against *Candida albicans,* however, the activity of the ethanol extract of the leaves (15.67±0.58) was higher ($p<0.05$) than that of the ethanol extract of the peels and the aqueous extract of the peels and leaves. The difference in activity against *C. albicans* between the samples extracts in terms of either the same or the different extracting solvent was significant ($p<0.05$) but the overall difference between the samples compared to the extracting solvents (±0.67) was the same hence non-significant ($p>0.05$). A similar trend was recorded for the activity of the ethanol and aqueous extracts of the peels and leaves against *P. notatum*. Thus, the plantain peels and leaves could be alternative source for vitamin C. The extracts (aqueous and ethanol) had activity against *C. albicans* and *P. notatum* hence may be useful in managing such pathogen-induced ailments. Overall negligible difference in activity against either *C. albicans or P. notatum* in terms of samples and the extracting solvents was suggested and this may be an underlying useful trend for comparing the overall antimicrobial activity of different samples and solvents, hence warrants a follow up.

Keywords: Antifungal; Penicillum notatum; Candida albicans; minerals; vitamins.

1. INTRODUCTION

Generally, nutrient, including mineral and vitamin, content and antifungal activity determination of plants and plant parts provide basic information for discovering and developing new sources for foods and drugs. This follows the increasing human health challenges and food shortages [1] compounded by adverse effects of foods and food condiments [2,3] and the increasing drug and even multiple drug resistance by disease causing microbes [4,5].

Musa paradisiaca is a mono herbaceous perennial crop that is in the family *Musaceae*, genus *Musa* and species *paradisiaca* [6]. It is a tropical crop and is an important staple food in Africa [7] including Nigeria [8]. The plant is tall with a sturdy pseudo stem and large broad leaves arranged spirally at the top [9]. The leaves have large blades with a pronounced central midrib and obvious veins [9]. Each pseudo stem produces a group of flowers from which the fruits develop in a hanging cluster. *Musa paradisiaca* is also known as ogede, agbagba and apanda in Yoruba, and as ayaba in Hausa [10]. In Igbo language, the various names are used to differentiate plantain as a whole plant and as the unripe or ripe fruits. For instance, in Ojoto and environs, the whole plant is known as *ojioko* and the unripe fruit is known as *jioko* while the ripe fruit is known as *ogade/ogede*. Literally, *jioko* means 'yam pod' or 'yam pod in a bunch' probably because plantain and yam are essentially consumed similarly boiled, roasted, pounded and fried [9].

Plantain fruits are available in Nigeria throughout the season and are employed in the folkloristic management of diseases due to its anti-ulcerogenic, antimicrobial and analgesic properties [11]. Fruits generally contain bioactive compounds, for instance, *Citrus limonum* (lemon) contain esculetin reported to improve markers of health functions in rats [12]. Many recipes are made from plantain fruits. The unripe fruits are processed into flour and thickened into paste by stirring in boiling water. The ripe or unripe mature fruits are consumed boiled, steamed, pounded, roasted or fried into chips while the overripe plantains are fried with palm oil [8]. Thus, the demand for plantain fruit in Nigeria is high. This could result to abundant waste generation in the form of plantain peels that are essentially discarded as waste, thereby constituting a menace to the environment. In addition, plantain leaves are spatially used and not as food, hence are essentially discarded on harvesting the plantain fruits.

Plantain is rich in phytonutrients hence has nutritional value [13,14]. The peels could be good sources of bioactive compounds but as major waste products of various fruits are essentially discarded. Plantain leaves may have nutritional and medicinal properties but were in most cases utilized for neither purpose. Discarding the peels and leaves could contribute to environmental waste burden with potential public health implications [15,16]. Generally, plantain fruit is considered nutritious. Meanwhile, important bioactive compounds and activities could be inherent in these seeming food wastes. For instance, the leaves and peels of watermelon have nutritive and antimicrobial properties [17,18,15]. Possible roles of bioactive compounds in improving and managing even metabolic diseases have been suggested [19,20]. It is interesting to ascertain if the peels and leaves contained important nutrients as

nutrient content and antifungal activity determination are basic steps to developing novel nutraceuticals. These warranted this study designed to determine the nutritive and antifungal properties of plantain (*Musa paradisiaca*) fruit peels and plant leaves. The possible contribution of these samples to food supply could be high [21]. The study objectives include the determination of some minerals (sodium, potassium, magnesium and calcium) and vitamins (vitamin A, C, B_1, B_2 and B_3) contents in the ground fruit peels and plant leaves flour and the determination of the anti-fungal activity of the aqueous and ethanol extracts of the samples against two fungi (*Candida albicans* and *Penicillum notatum*).

2. MATERIALS AND METHODS

2.1 Chemicals and Reagents

The solvent, ethanol and other chemicals used, including those used in the preparation of reagents, were of analytical grade and product of British Drug House Laboratory, England. This study was conducted between May and August, 2015 at the Department of Biochemistry, Michael Okpara University of Agriculture Umudike, Nigeria.

2.2 Collection and Identification of Plant Materials

A mature but unripe plantain bunch was purchased (and harvested, with the epicarp/peel still green, along with the green leaves) at Ndioro, a town near Michael Okpara University of Agriculture, Umudike Nigeria. It was identified as giant/elephant plantain specie of *Musa paradisiaca* by Dr. Garuba Omosun, an Associate Professor at the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike, Nigeria. The whole of the leaves, including the mid rib, was used in the study.

2.3 Samples Preparation

The plantain fruits were thoroughly washed with clean water. The peels were removed and chopped into bits using a home choice European knife. The leaves were separately chopped into bits. The samples (peels and leaves) were separately placed on a foil and weighed with a Satorious Digital Weighing Balance, Model BP210S, Germany before and after sun drying for four days to obtain the wet weight and dry weight respectively. The respective dry weight sample was separately ground into powder using Arthur Thomas Laboratory Mill Crypto model, USA, covered separately in a labeled white nylon and kept in the desiccator pending use.

2.4 Sample Extraction

The aqueous and ethanol extracts respectively of the *Musa paradisiaca* peels and leaves were separately obtained as described previously [22]. However, 10 g of the respective ground sample, weighed using Sartoruis Digital Weighing Balance, was immersed in 100 ml instead of 200 ml of the respective extraction solvent (ethanol or water) contained in a conical flask. The solution was shaken intermittently for 24 hours and thereafter filtered using Whatman no. 1 filter paper into a clean beaker. The respective solvent was recovered from the filtrate using a Soxhlet apparatus and the filtrate finally evaporated to dryness using a steam bath set at 100℃.

2.5 Nutritive (Minerals and Vitamins) Content Determination

Vitamins A, B_1 (thiamine), B_2 and B_3 (niacin) were variously determined by the spectrophotometric method described earlier [23,24] whereas vitamin C (ascorbic acid) was determined by the method described by Okwu and Josiah [25]. Mineral content *viz:* potassium, sodium, calcium and magnesium were determined by the spectrophotometric method described by James [26], using Jenway Digital Spectrophotometer, Model 6320D, manufactured by Jenway Equipment Company, France.

2.6 Tested Fungal Species

The fungal species used for the antifungal test, *Candida albicans and Penicillum notatum,* were clinical isolates provided by the Central Laboratory of National Root Crop Research Institute Umudike Abia state, Nigeria. Generally, the choice of *C. albicans* and *P. notatum* in the study of anti-fungal activity was that they represent common and opportunistic fungal pathogens that cause varied infections in animals, including humans.

2.7 Antifungal Activity Test

The disc agar diffusion method was used to determine the antifungal activity of the extracts

as reported earlier [22]. Incubation was at 37℃ for 24 hours under aerobic condition. The antifungal activity was determined by measuring the diameter (in millimetres, mm) of the zone of inhibition formed around the discs. The antifungal activity test was performed in triplicate and the mean zone of inhibition calculated.

2.8 Statistical Analysis

The data obtained by triplicate determinations were subjected to analysis of variance (ANOVA) using SPSS 16.0 for Windows. Difference at a p value < 0.05 was regarded as statistically significant. Results were expressed as mean± standard deviation (SD).

3. RESULTS AND DISCUSSION

Results as shown in Table 1, showed that vitamin A was not detected in either sample. The vitamins content of the plantain peels and leaves respectively for ascorbic acid, vitamin C (mg/100 g) (9.98±1.01, 15.26±0.01) was highest while the least was riboflavin, vitamin B_2 (mg/100 g) (0.07±1.02, 0.06±0.87). The difference between the ascorbic acid content in the samples (±5.28) was statistically significant ($p<0.05$) while that for riboflavin, vitamin B_2 (±0.01) was non-significant ($p>0.05$).

Out of the determined minerals (mg/100 g), the highest concentration was potassium (40.00 ± 0.08) in the plantain leaves followed by phosphorous (36.00 ± 1.65) in the plantain peels while the least was magnesium (1.80 ± 0.05) in the leaves followed by iron (5.60 ± 0.06) in the peels (Table 2). The observation, aside the difference in the riboflavin content of the peels and leaves, was significant ($p<0.05$).

As shown on Table 3, the ethanol and aqueous extracts of the peels and leaves showed activity (mm) against the *C. albicans*. However, the activity of the ethanol extract of the leaves (15.67±0.58) was higher ($p<0.05$) than that of the ethanol extract of the peels and the aqueous extract of the peels and leaves. The difference between the ethanol extract of the peels and leaves (±3.00) and between the aqueous extract of the peels and leaves (±2.33) was significant ($p<0.05$). Also, the difference between the ethanol extract and aqueous extract of the peels (3.00) and between the ethanol extract and aqueous extract of the leaves (3.67) was significant ($p<0.05$). However, the overall difference between the samples compared to the extracting solvents (±0.67) was the same, hence non-significant ($p>0.05$).

As shown on Table 4, the ethanol and aqueous extracts of the peels and leaves showed activity (mm) against the *P. notatum*. However, the activity of the ethanol extract of the leaves (14.33±1.52) was higher ($p<0.05$) than that of the ethanol extract of the peels and the aqueous extract of the peels and leaves. The difference between the ethanol extract of the peels and

Table 1. Some vitamins composition of *Musa paradisiaca* (plantain) peels and leaves

Vitamins	Peels	Leaves	Difference
Ascorbic acid (Vitamin C) (mg/100 g)	9.98 ± 1.01	15.26 ± 0.01	± 5.28*
Niacin (Vitamin B_3) (mg/100 g)	0.49 ± 0.03	0.30 ± 0.01	±0.19^{ns}
Riboflavin (Vitamin B_2) (mg/100 g)	0.07 ± 1.02	0.06 ± 0.87	±0.01 $^{ns-}$
Thiamine (Vitamin B_1) (mg/100 g)	0.16 ± 0.04	1.23 ± 0.07	±1.07*
Retinal (Vitamin A) (IU)	0.00	0.00	0.00

*Result = Value ± SD of duplicate determinations. Different superscript in a row or column means that the difference is significant (p<0.05), ns = difference is not significant (p > 0.05). * = difference is significant (p < 0.05)*

Table 2. Some minerals composition of *Musa paradisiaca* (plantain) peels and leaves

Minerals	Peels (mg/100 g)	Leaves (mg/100 g)	Difference (mg/100 g)
Calcium	10.00 ± 0.95	13.50 ± 0.02	±3.50*
Magnesium	7.60 ± 0.55	1.80 ± 0.05	±5.80*
Sodium	16.20 ± 1.35	28.00 ± 0.03	±11.80*
Potassium	23.50 ± 1.54	40.00 ± 0.08	±16.50*
Phosphorus	36.00 ± 1.65	15.20 ± 2.89	±20.80*
Iron	5.60 ± 0.06	14.00 ± 0.14	±8.40*

*Result = Value ± SD of triplicate determinations. Different superscript in a row or column means that the difference is significant (p<0.05), ns = difference is not significant (p > 0.05). * = difference is significant (p < 0.05)*

Table 3. Anti-fungal activity (inhibition zone diameter, IZD (mm) at a concentration of 100 mg/ml of the ethanol and water extracts of *Musa paradisiaca* (plantain) peels and leaves against C. *albicans*

According to extracting solvents	Bacterial species	According to study samples		Difference (mm) between the peels and leaves extracts	Difference (mm) between the extracting solvents
		Plantain peels	Plantain leaves		
Ethanol extract (100 mg/ml)	*C. albicans* (IZD, mm)	12.67 ± 0.45	15.67 ± 0.58	±3.00*	
Water extract (100 mg/ml)	*C. albicans (IZD, mm)*	9.67 ± 0.58	12.00 ± 1.00	±2.33*	
Difference between the activity of the extracting solvents against *C. albicans* (mm)		±3.00*	±3.67*	±0.67^{ns}	±0.67^{ns}

*Result = Mean ± SD of triplicate determinations. * = Difference is significant (p<0.05), ns = Difference is not significant (p>0.05)*

Table 4. Anti-fungal activity (inhibition zone diameter, IZD (mm) at a concentration of 100 mg/ml of the ethanol and water extracts of *Musa paradisiaca* (plantain) peels and leaves *P. notatum*

According to extracting solvents	Bacterial species	According to study samples		Difference (mm) between the peels and leaves extracts	Difference (mm) between the extracting solvents
		Plantain peels	Plantain leaves		
Ethanol extract (100 mg/ml)	*P. notatum (IZD, mm)*	10.67 ± 1.24	14.33 ± 1.52	±3.66*	
Water extract (100 mg/ml)	*P. notatum (IZD, mm)*	6.33 ± 0.58	9.33 ± 0.58	±3.00*	
Difference in activity between the extracting solvents against *P. notatum* (mm)		±4.34*	±5.00*	±0.66^{ns}	±0.66^{ns}

*Result = Mean ± SD of triplicate determinations. * = Difference is significant (p<0.05), ns = Difference is not significant (p>0.05)*

leaves (±3.66) and between the aqueous extract of the peels and leaves (±3.00) was significant (p<0.05). Also, the difference between the ethanol extract and aqueous extract of the peels (4.34) and between the ethanol extract and aqueous extract of the leaves (5.00) was in either case significant (p<0.05). However, the overall difference between the samples compared to the extracting solvents (±0.66) was the same, hence non-significant (p>0.05).

The present study investigated some nutritive and antifungal properties of the *Musa paradisiaca* (plantain) peels and leaves. Prior studies [27,28] confirmed the presence of vitamins and minerals in the fruits, fruit peels and leaves. In the present study, out of the determined minerals (mg/100 g), the highest concentration was potassium in the plantain leaves followed by phosphorous in the plantain peels while the least was magnesium in the leaves followed by iron in the peels. This suggests the distribution of these minerals in the plantain peels and leaves. The sodium content in the peels and leaves did not compare with the value for *Vitex mombassae* (96.08 ± 0.28) and *Maenua angolensis* (96.11 ± 0.76) as reported by Emmanuel et al. [29]. The content of calcium and phosphorous in the peels and leaves was lower than the range (110.00 – 180.00 mg/100 g) but the iron content in the samples compared with the range (10.50 – 14.00 mg/100 g) in plantain bract [30]. The potassium content in the samples was higher than 0.95 mg/100 g in edible portion of plantain [31]. Generally, minerals in adequate amount ensure normal physiological functions [32,33], hence the detection at the recorded concentration of these minerals, notably potassium and phosphorous, in the samples is nutritionally and physiologically noteworthy.

The highest vitamin in either sample was vitamin C while the content in the leaves was statistically higher ($p<0.05$) than that in the peels by 5.28 mg/100 g. The least determined and detected vitamin was vitamin B_2 but the difference between the content in the samples (±0.01) was non-significant ($p>0.05$), hence negligible. Vitamin A was not detected in either sample, suggesting that the plantain peels and leaves could not be a source for vitamin A. Generally, vitamins play important roles in the regulation of normal metabolism and as an antioxidant [34] but may be required in small amounts [35], hence the comparatively lower content of the B vitamins (B_1, B_2 and B_3) in the samples could still be useful. The vitamin C composition in the peels and in the leaves compared with the value reported for *Terculia africana* [29], but lower than the values reported for *Citrus lemon* [36]. The result implies appreciable quantity of vitamin C in the peels and leaves, though higher in the peels than in the leaves. The absence of vitamin A in the samples has a negative nutritional implication as vitamin A (retinol) is quite essential in the eye physiology and function.

The activity of the ethanol and aqueous extracts of the peels and leaves against the *C. albicans* was higher ($p<0.05$) in the leaves (15.67±0.58) than that of the ethanol extract of the peels and the aqueous extract of the peels and leaves. The result indicated that the peels and leaves extracts of the solvents showed antifungal activity against the tested fungus and that the ethanol may be preferred solvent to water in extracting the active phytochemicals in the samples [35]. The significant difference in the activity of the extracting solvents when compared between samples (peels and leaves) and within samples (peels versus peels or leaves versus leaves) was in either case the same hence non-significant on further matrix analysis (Table 3) suggesting overall negligible difference in the observed activity against *C. albicans* in terms of the samples and the extracting solvents. Similar trend was recorded on comparison of the activity of the ethanol and aqueous extracts of the peels and leaves against *P. notatum* (Table 4) and in earlier study [9] which may be pointing to an underlying trend that may be useful in comparing the overall antimicrobial activity of different samples and solvents, warranting a follow up. Furthermore, the minimum inhibitory concentration (MIC) values for the extracts need to be determined in further studies.

4. CONCLUSION

The plantain peels and leaves could be alternative source for vitamin C. The extracts (aqueous and ethanol) had activity against *C. albicans* and *P. notatum* hence may be useful in managing such pathogen-induced ailments. Overall negligible difference in activity against either *C. albicans or P. notatum* in terms of samples and the extracting solvents was suggested and this may be an underlying useful trend for comparing the overall antimicrobial activity of different samples and solvents, hence warrants a follow up.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/17796