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Full Length Research Paper

Assessment of phytochemical and mineral composition of unripe and ripe plantain (*Musa paradisiaca*) peels

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Plantain (*Musa paradisiaca*) fruit constitutes a staple food widely consumed predominantly in Africa. The peel, a major by-product, of plantain fruit is largely viewed to be of little or no significance and consequently discarded, thereby constituting a threat to the environment. It is on account of the foregoing that this study was designed to investigate the phytochemical and mineral components of both the unripe and ripe plantain peels, and possibly suggest ways for its proper utilization. This study was conducted using standard phytochemical assay procedures and the atomic absorption spectrophotometric methods. The result of the phytochemical screening showed the presence of alkaloids (3.53 ± 0.64 and 3.4 ± 0.38 g/100 g), flavonoids (0.16 ± 0.05 and 0.13 ± 0.02 g/100 g), tannins (2.18 ± 0.63 and 3.22 ± 0.82 g/100 g) and terpenoids (1.88 ± 0.24 and 1.83 ± 0.19 g/100 g) in unripe and ripe plantain peels, respectively. More so, for both the unripe and ripe plantain peels, considerable levels of Ca (176.30 ± 8.77 and 176.42 ± 8.94 mg/100 g), Na (47.37 ± 5.82 and 47.34 ± 5.72 mg/100 g), K (787.70 ± 6.20 and 787.73 ± 6.29 mg/100 g), Mg (81.60 ± 0.12 and 81.31 ± 0.31 mg/100 g), and Fe (40.95 ± 15.61 and 26.25 ± 14.80 mg/100 g) were detected in the peel samples investigated, respectively, with the unripe plantain however possessing a significantly higher level of Fe. The amount of Pb (0.4 ± 0.02 mg/100 g) and (0.023 ± 0.01 mg/100 g) for unripe and ripe, respectively, were significantly low ($P < 0.05$) to engender any deleterious consequences. This study therefore demonstrates that, the often undervalued plantain peels contain a substantial amount of mineral elements, phytochemicals and an infinitesimal level of toxicants. The peels, as a result, could be further processed and utilized as nutraceuticals in food and animal feeds.

Key words: Mineral elements, phytochemicals, plantain peels.

INTRODUCTION

In developing countries, the management of waste is a major difficulty faced by agro-based industries. In Nigeria, for example, plant biomasses are often incinerated in the open air regardless of the environmental implications (Babayemi et al., 2010). According to Tchobanoglous et al. (1993), the public are exposed to serious health hazards resulting from poor and inefficient solid waste disposal. These include but not limited to environmental pollution and increase in insect vectors of disease. Tchobanoglous et al. (1993) expressed further that, the

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failure to remediate and utilize these materials ultimately leads to superfluous build-up of waste and natural resource depletion.

M. paradisiaca is an important staple food crop in Central and West Africa. The estimates of the Food and Agriculture Organization indicate that Nigeria produces about 2.11 million metric tons annually, and this contributes considerably to the diet of the local population (FAO, 2005). Plantain belongs to the genus *Musa* and can be consumed in both the unripe and ripe stages.

Wolfe et al. (2003) opined that the main by-product derived during the processing of fruits is the peels; and, in myriad instances these peels have proven a good source of dietary fibres, caroteinoids, polyphenols and other bioactive compounds which are beneficial to human health. The work of Wolfe et al. (2003) preceded that of Ajasin et al. (2006) where it was chronicled that, plantain peels are of substantial nutritional value because it possess about 16% crude fibre, 12% crude protein and 1300 Kcal/kg on the basis of dry matter. Ajasin et al. (2006) further observed that whilst the quantity of starch decreased from 50 to 35%, the amount of total sugar increased from 3.0 to 31.6% in the peel during ripening. Even so, plantain peel is considered a rich source of hemicellulose (13%) and cellulose (10%) than its pulp which contains 1.3 and 1.4% for hemicellulose and cellulose, respectively (Agama-Acevedo et al., 2015).

Plants generally contain some biologically active naturally occurring chemicals also referred to as “secondary metabolites” (Zenk, 1996). It is yet well documented in the literature that, some of these bioactive substances in plants essentially serve as medicinal herbs (Soetan, 2008). Consequent upon this, several research works have been conducted to assess the phytochemical and mineral content of various parts of diverse plants to, among other things, unearth viable therapeutic alternatives to synthetic drugs. These phytochemicals include: alkaloids, flavonoids, saponins, tannins etc. Soetan (2008) advanced that some of these phytochemicals are applied as pharmacologically active agents and in nutrition.

Because of harsh weather conditions, appreciable amount of plantains are lost during post-harvest period due to accelerated ripening by warm weather. This therefore makes it imperative to bring out a way of making use of the ripe plantain peel. Additionally, it is equally on record that apart from the use of unripe plantain peel in soap making and possibly animal feeds, the usefulness of the ripe plantain peel, by contrast, has not been effectively maximized (Onyegbado et al., 2002). The foregoing observation is indeed unfortunate in this era of nutraceuticals and functional foods.

Also, besides the obvious use of these peels, most literature research studies lay little or no stress on the chemical composition of these peels, how they can be harnessed and bio-converted into useful materials. For this reason, this work sought to find out the phytochemical and mineral composition of unripe and ripe plantain peels separately and comparatively in an attempt to promote its bioconversion into value added products.

MATERIALS AND METHODS

Chemicals

Concentrated sulphuric acid, Acetone, Sodium hydroxide, Boric acid, Ethanol, Concentrated HCL, Folin-Ciocalteau’s reagent were products of Sigma Aldrich, St. Louis, MO, USA. All other chemicals, including the distilled water utilized, were of analytical grade.

Plant collection and extract preparation

The plantain samples (unripe and ripe) utilized for this research were purchased from Sabon Gari market, Kano, Nigeria. And the botanical identification and verification were carried out at the Department of Botany, Bayero University, Kano.

The unripe and ripe peels of plantain were subsequently removed. The peels were then collected, grouped and properly washed under running tap water to rid them of any contaminants. They were further rinsed with distilled water. Thereafter, these peels were sliced into small pieces (0.5 to 1.0 mm) and immediately air dried at 25°C for 240 h. The dried peels were ground into powder and passed through 0.1 mm mesh size sieve. The free-flowing powder samples were then packed into screwed bottles and labeled appropriately.

5 g of each powdered samples was consequently soaked in 500 ml solvent, distilled water and ethanol, as the case may be. The mixture was left to stand for about 48 h during which it was shaken intermittently. It was then filtered and the extract evaporated under reduced pressure at 40°C, whilst final solvent elimination was actualized with the aid of water bath.

Phytochemical screening

Phytochemical evaluation of peel samples was conducted on the aqueous, ethanolic and dried powder specimens according to standard procedures (Earl and Warren, 1961; Felgis, 1975; Sofowora, 1979 and 1993).

Mineral composition determination

Mineral elements were determined after 1 g of the ashed peel samples were subjected to wet oxidation using perchloric acid and nitric acid in accordance with the method of Osborn and Voogt (1978). The estimates of sodium and potassium in the digested samples were obtained using flame photometer (Model 52-A, Perkin Elmer, Waltham, MA, USA) in line with the procedure of Bonire et al. (1990).

The atomic absorption spectrophotometer (Analyst 200, Perkin Elmer, Waltham, MA, USA) was used to analyze the concentration of calcium, copper, magnesium, lead, zinc and iron according to the method of Bamhard (1985). The absorption of these mineral elements was compared with their respective standard absorption.

Statistical analysis

All analysis was conducted in triplicates. The results obtained therein were used for the statistical analysis using the statistical

Table 1. Qualitative screening of phytochemicals in aqueous and ethanolic extract of unripe and ripe plantain peels.

Phytochemicals	Aqueous extract		Ethanolic extract	
	Unripe peels	Ripe peels	Unripe peels	Ripe peels
Alkaloids	-	-	+	+
Flavonoids	-	-	+	+
Tannins	+	+	+	+
Saponins	+	+	-	-
Anthraquinones	-	-	-	-
Cardiac glycosides	-	-	-	-
Terpenoids	-	-	+	+

+: Present, −: Absent.

Table 2. Quantitative estimate of phytochemicals present in ethanolic extract of unripe and ripe plantain peel (g / 100 g).

Phytochemicals	Ethanolic extract	
	Unripe peels	Ripe peels
Alkaloids	3.53 ± 0.64^{a}	3.47 ± 0.38^{a}
Flavonoids	0.16 ± 0.05^{a}	0.13 ± 0.02^{a}
Tannins	2.18 ± 0.63^{a}	3.22 ± 0.82^{b}
Terpenoids	1.88 ± 0.24^{a}	1.83 ± 0.19^{a}

The results represent the mean of three determinations ± standard deviation. Data on the same row with different superscripts are significantly different (P < 0.05).

package for social sciences (SPSS), version 20 (SPSS Inc., Chicago, IL, USA). Descriptive statistics and student t-test were used to analyze results.

RESULTS AND DISCUSSION

The objective of this study was to assess the phytochemical profile and mineral composition of unripe and ripe plantain peels separately and comparatively. The qualitative phytochemical evaluation was conducted in solvent extracts of unripe and ripe *M. paradisiaca* peel using distilled water and ethanol (Table 1), whilst only ethanolic dried powder specimen was subjected to quantitative screening (Table 2). The ashed peel samples were equally investigated for mineral element composition (Table 3).

According to Ighodaro et al. (2009), the medicinal properties of plants are largely informed by the bioactive compounds inherent in them. In this study, it was observed that phytochemicals like saponins and tannins were present in both the aqueous and ethanolic extracts of unripe and ripe plantain peels (Table 1). Surprisingly however, alkaloids, flavonoids and terpenoids were exclusively detected in only the ethanolic extract of the samples investigated (Table 1). It is notwithstanding plausible to rationalize that, the exclusive discovery of alkaloids, flavonoids and terpenoids in only the ethanolic peel extract could be attributed to the different polarities of the solvents used for extraction.

Beyond that, the composition of these phytochemicals does not however seem to have been quantitatively influenced by ripening which is often marked by chemical changes. Besides the concentration of tannins that was found to be significantly higher (P < 0.05) in ripe plantain peels, no significant difference (P > 0.05) was observed in the level of alkaloids, flavonoids and saponins in the unripe and ripe plantain peels investigated (Table 2). Middleton and Kandaswami (1992) had advanced that phytochemicals induce myriad biological and pharmacological activities. Soforowa (1993) further corroborated Middleton and Kandaswami's hypothesis by stating that alkaloids, flavonoid and tannins possess enormous medicinal properties. According to Koleva et al. (2002), flavonoids inhibit free radical generation by interfering with biochemical pathways leading to ROS production. And hence are considered potent antioxidants.

Ojo et al. (2006) reported that, saponins possess antimicrobial properties and could function as precursors of several steroidal substances with diverse physiological roles. The discovery of saponins in the peels extract of plantain also renders it ideal for utilization in the preparation of medicinal soap given that saponin could function as a forming agent. This essentially could assist

Table 3. Mineral composition of unripe and ripe plantain peels (mg / 100 g).

Mineral element	Samples	
	Unripe peels	Ripe peels
Sodium	47.37 ± 5.82[a]	47.34± 5.72[a]
Calcium	176.30 ± 8.77[a]	176.42 ± 8.94[a]
Magnesium	81.60 ± 0.12[a]	81.31 ± 0.31[a]
Zinc	2.51 ± 0.48[a]	3.01 ± 0.57[b]
Iron	40.95 ± 15.61[a]	26.25 ± 14.80[b]
Potassium	787.70 ± 6.20[a]	787.73 ± 6.29[a]
Copper	1.19 ± 0.01[a]	1.01 ± 0.01[a]
Lead	0.4 ± 0.02[a]	0.23 ± 0.01[b]

The results represent the mean of three determinations ± standard deviation. Data on the same row with different superscripts are significantly different (P < 0.05).

in reducing the utilization of synthetic forming agents in medicinal soaps (Wijetunge and Perera, 2016). In a paper by Asquith and Butler (1986), it was posited that tannins confer anti-hemorrhagic and anti-diarrhoeic properties. These observations, taken together, presuppose that the unripe and ripe plantain peels contain invaluable therapeutic potential yet to be optimized.

Refreshingly, plantain peels seem to be a promising source of nutrients for animal feeds production (Babatunde, 1992). Calles et al. (2000) reported that in the diet of growing pig, meals made from ripe plantain peel replaced about 31% of maize without any adverse condition on growth performance. This could possibly be linked to the disease preventive nay protective effect of the putative non-nutritive chemicals present in this peel.

It has been revealed by this research that plantain peels are high in potassium, sodium and calcium, and hence could be considered a vital source of these elements for both plants and animals nutrition. In quantitative terms, a relatively high level of calcium, magnesium, potassium and sodium were discovered in both peels (Table 3). There was nonetheless any significant difference (P>0.05) in the content of these mineral elements. In one twist however, unripe plantain peels demonstrated a significantly higher (P<0.05) level of iron and lead (Table 3). While it is true that these findings are consistent with the observations of Ighodaro (2012), it is even yet promising that the levels obtained were in conformity with WHO recommendations.

O'Connell (2011) posited that calcium is an essential part of intracellular processes that take place inside insulin responsive tissues like the adipose tissue and skeletal muscle. Changes in calcium flux can result in deleterious consequences on insulin secretion, a calcium dependent process. Therefore, the considerable level of calcium in the peels of unripe and ripe plantain in this study hints the significance of these peels to diabetics.

Chen et al. (2010) linked the incidence of hypertension to the intake of diet with higher Na to K ratio. Interestingly, the relatively higher amount of K to Na observed in this work could serve a comparative advantage on grounds of Chen's observation. Alternative revelation from this investigation is that, K is the predominant mineral element in plantain peels.

Combustion is the primary process for directly utilizing biomass energy with consequent production of ash as by-product. The ash of plantain peels possesses an enormous quality that qualifies it for wide range of applications in agriculture (Onyegbado et al., 2002). According to Israel and Akpan (2016), ashes from these peels could be utilized in the production of NPK fertilizer. The plantain peel nay biomass is combusted in hot fire to produce a white ash and Potassium oxide is extracted from the ash thereof. This procedure is more economical than obtaining KOH from the market. The potash obtained from plantain peels is utilized for local production of soap and is equally a potential chemical for biodiesel production, hence making plantain peels a potential renewable energy source (Enontiemonria et al., 2016; Betiku and Sheriff, 2014).

Pyruvate kinase utilizes magnesium as a cofactor. Beyond this, magnesium also regulates glucose transport across cell membrane (O'Connell, 2011). With the discovery of no significant loss of magnesium in the samples studied, the usefulness of these peel samples is even yet established. The role of zinc in the control of insulin production by pancreatic tissues and the use of glucose by fat and muscle cells was comprehensively elucidated by Eleazu et al. (2013). Observation from this study reveals a significantly higher level of zinc in the ripe plantain peel. This revelation is, however, confounding as Okorie et al. (2015) reported diametrically opposite results.

Copper is a trace element found in living organisms and crucial not just in redox chemistry, but also in growth and development. Today, this element is being explored as a therapy for several conditions, including neurodegenerative disorders like Alzheimer and Parkinson disease (Tisato et al., 2010).

Exposure to heavy metals like lead, mercury, cadmium and arsenic yet remains a huge threat to human health (Jarup, 2003). Lead is obviously toxic to kidneys, heart, intestines, bone, nervous and reproductive systems. It specifically impairs nervous system development and thus toxic to children, resulting in permanent behavior and learning disorders (Jarup, 2003). Most importantly, the detection of considerable level of iron in unripe plantain peel tends to be a significant discovery in this study. Chen et al. (2010) contended that iron is an important component of hemoglobin and it is critical in the production of energy and normal function of the immune system.

Conclusion

This study has revealed that unripe and ripe plantain peels are rich source of minerals and phytochemicals. In this regard, their disposal or disuse must abate; because they could be nutritionally studied and well processed as a good source of nutrients, and even further, for biogas production. The presence of phytochemicals also demonstrates its potential to serve as nutraceuticals and a medicinally vital material in animal health.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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