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RESEARCH ARTICLE

Assessment of the Nutritional, Anti nutritional and Antioxidant capacity of Uripe, ripe, and over ripe Plantain (*Musa paradisiaca*) Peels

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Abstract

Plantain (*Musa paradisiaca*) peels are the major by-product of plantain fruits, constituting about 40% of the fruits but are presently underutilized. This study was carried out to investigate the nutrient, antinutrients contents and antioxidant capacity, of the unripe (UPP), ripe (RPP), and over-ripe (OPP) plantain peels. The plantain pulps were removed from the fruits, leaving the peels only. The peels where thoroughly washed, cut into small pieces, air dried and grounded into powder. Thereafter, the mineral analysis, proximate food analysi, antinutrients contents and antioxidant capacity of the peels were all assessed. The results showed the availability of minerals, the UPP had the highest values of Na (162 mg/g), K (235 mg/g), Ca (100 mg/g), Mg (76 mg/g), P (360 mg/g) and Fe (5.6 mg/g), and OPP had the least values of the minerals. Carbohydrate, crude protein, crude fibre, fat, ash, and moisture contents of the peels ranged from 52.26 - 62.53, 4.21 - 7.89, 0.51 – 0.74, 2.9 -5.23, 12.50 - 17.24 and 13.28 – 20.38 respectively, with the UPPs having the highest contents. Furthermore, the composition for tannins, saponins, phytate, and oxalate ranged from 2.84 – 5.39, 3.27 – 7.73, 9.88 – 11.12 and 0.36 – 0.81 mg/g respectively. For the antioxidant capacity, the UPP extract had the highest values for the total phenolic content (8.94mg.GAE/g), highest for total flavonoid (1.0mg.QUE/g), and same in the Vitamin C content (11.72mg/100g). All the plantain peel extracts were able to scavenge the free radical from ABTS (2, 2^1- azino-bis (3-ethylbenzthiazoline-6-sulphonic acid). These results reveal that plantain peels thrown away as waste contains an appreciable amount of nutrient, vitamin, mineral elements and low level of toxicants. Plantain peels (UPP, RPP and OPP) can be further processed to remove or reduce drastically the anti-nutrients and used as nutraceuticals in food, animal feeds, and pharmaceutical industry.

INTRODUCTION

Plantain (*Musa paradisiaca L.*) is a tropical fruit that constitute a staple food crop in Central and West Africa. Over 2.11 million metric tons of plantains are produced in Nigeria annually which contributes substantially to the nutrition of subtropical local populations (FAO, 2005). In Nigeria, plantain is called "Ogede" in the Yoruba language (Olorunda and Adelusola, 1997). Different varieties of plantain are consumed by the households in Nigeria but the most preferred (plantain) varieties are the false horn type (locally known as 'Agbagba'). In Nigeria and other parts of Africa and in many other places in the world, plantain (*Musa paradisiaca*) serves as a major staple food and is particularly desired for the variability in the stages of ripeness and in cooking methods (Oladele and Khokhar, 2011). The peels are known to constitute a menace to the society thereby adding to the worse problem of environmental pollution particularly in places where ruminants (sheep and goat) are not allowed to roam about

(Omole et al.,2008). Plantain is employed in the folklore management of diseases such as ulcer, wound healing and many others due to its anti-ulcerogenic, antimicrobial, anti urolithiatic activities, analgesic properties (Kumar et al., 2012).

Peels are the major by-products obtained during the processing of various fruits and these were shown to be a very good source of polyphenols, caroteinoids, dietary fibres, and other bioactive compounds which possess various beneficial effects on human health (Wolfe, et al., 2003). During postharvest period, much of plantain is lost due to harsh weather conditions, especially in the tropics. This is because of the warm weather that accelerates the ripening process before it gets to the market. Therefore, it is of utmost importance to find a way of utilizing the ripe and over ripe plantain peels also, not only the unripe (green)plantain peel which has been used in various ways, majorly, for soap making (Onyegbado et al., 2004), animal feeds (Babatunde, 1992), and biogas production (Betiku and Ajala, 2014).

Elmadfa and Meyer (2010) stated that, "adequate nutritional analysis is the basis for developing and implementing effective intervention programmes to improve the nutrition at the population level". Aduku (1993) and Ajasin et al. (2004) observed that plantain peels have some nutritional values as it contains about 12% crude protein, 16% crude fibre, and 1300kcal/kg energy on dry matter basis. It is well known that plants generally contain antinutrients acquired from fertilizer and pesticides and several naturally-occurring chemicals (Igile, 1996). Some of these naturally occurring chemicals are known as ''secondary metabolites'' and they have been shown to be highly biologically active (Zenk, 1991). They are phytochemicals which includes; saponins, tannins, flavonoids, alkaloids, trypsin (protease) inhibitors, oxalates, phytates, haemagluttinins (lectins), cyanogenic glycosides, cardiac glycosides, coumarins and gossypol. Most of these secondary metabolites elicit very harmful biological responses, while some are widely applied in nutrition and as pharmacologically-active agents (Soetan, 2008).

The anti-nutritional factors (ANFS) may be defined as those substances generated in natural food stuffs by the normal metabolism of species and by different mechanisms (e.g. inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of feed) which exert effects contrary to optimum nutrition (Kumar, 1992). Being an ANF is not an intrinsic characteristic of a compound but depends upon the digestive process of the ingesting animal (Kumar, 1992). For example, trypsin inhibitors, which are ANFs for monogastric animals, do not exert adverse effects in ruminants because they are degraded in the rumen (Makkar, 2003). The biological effects of all these chemicals are diverse, and complex. Therefore, several considerations justify the continued surveillance, knowledge and future research on antinutritional factors/toxic substances naturally present in plants used as foods and feedstuffs and ways of reducing them to safe level of consumption. Most of the toxic and antinutrient effects of these compounds in plants could be removed by several processing methods such as soaking, germination, boiling, autoclaving, fermentation, genetic manipulation and other processing methods (Soetan, 2008). Recent epidemiological and controlled-case studies reported that many anti-nutrients that present in a low level give beneficial effects for prevention of diseases like coronary diseases and cancers (Pandey, Rizvi, 2010). Due to this, they can be considered as anti-nutritional factors with negative effects or non-nutritive compounds with positive effects on health (Habtamu and Negusse, 2014). Natural polyphenols exert their beneficial health effects by their antioxidant activity, these compounds are capable of removing free radicals, chelate metal catalysts, activate antioxidant enzymes, reduce α-tocopherol radicals, and inhibit oxidases (Amic et al. 2003; Alia et al. 2003).

In this era of functional foods and nutraceuticals, it is necessary to take into consideration, the nutritional, antinutritional composition, and antioxidant capacity, of the unripe, ripe and over ripe plantain peels. Little has been done using these three basic plantain peels. Most literature research works are on the use of all the plantain peels with no emphasis on the chemical composition and contribution of each of the different plantain peels comparatively. Therefore this study sought to investigate the nutritional and anti-nutritional composition of the unripe, ripe, and over ripe plantain peels, individually and comparatively.

2. MATERIALS AND METHODS

2.1 Plant material

Plantain were freshly harvested at harvest maturity (September) and identified by the Crop production department in Federal University of Technology, Akure. The unripe plantain (green) peel was removed with a sharp clean knife and the pulp removed gently. To obtain the ripe peel, some of the unripe plantains were kept to ripen at room temperature and the ripe peel (yellow) was removed as described by (Ajila et al., 2007a). Furthermore, some of the ripe plantain peels were kept to ripen more, at room temperature as to ensure over ripeness of the plantain (brown). The fresh peels thus obtained were used for analysis.

2.2 Chemicals

0.1N HCL (standard), concentrated Sulphuric acid, Sodium hydroxide solution 40% w/w, Potassium sulphate, Copper sulphate, Boric acid, Acetone 80%, concentrated HCl, Folin- Ciocalteau's reagent, Sodium carbonate, Aluminium Chloride and Potassium acetate were obtained from Sigma Fine Chemicals, St. Louis, MO, USA. All other chemicals and solvents were of analytical grade and, the water used is glass distilled.

2.3 Preparation of Plantain peels

The unripe plantain peels (UPP), ripe plantain peels (RPP), and over ripe plantain peels (OPP), were collected and washed properly, to avoid any contaminants'. The plantain peels were grouped as collected. Each group were cleaned, rinsed with distilled water, and manually sliced thinly (0.5-1.0mm thick). The sliced part was immediately air-dried; the dried products were pulverized and passed through a 100-mesh sieve, producing a free-flowing powder.

2.4 Aqueous extraction

1g of each sample was soaked in 100 ml of distilled water for about 24 hours. The mixture was filtered and air dried. The air dried samples were kept in -20ºC until usage for further analysis. All analyses were performed in triplicate, and results were averaged.

2.5 Proximate composition determination

Proximate composition (moisture, ash, protein, fat, crude fibre and) of the 6 treatments was determined using standard analytical methods AOAC (1998), Preet and Punia (2002) and official and standard method of Saldanha, (1995). The moisture content of the sample was determined gravimetrically by drying 5 g of the sample in a crucible to a constant weight at 120°C. The ash content of the sample was determined gravimetrically by ashing 2 g of each sample in a clean pre-weighed crucible in a furnace at 550°C for 24 hours. The protein content was determined using Kjeldahl method of nitrogen (N) analysis. Approximately 2g of each sample was digested with concentrated H 2SO 4 using K 2 SO 4 catalyst. The ammonia in the digested sample was then distilled into a standard boric acid and titrated with 0.1 M HCl. The crude protein of the sample was obtained using the formula: crude protein =titre value x 1.4 x 50 x 100 x 65/(1000 x 10 x 1)N2. The crude fibre was determined using an acid alkaline hydrolysis involving boiling 2g of the sample with 0.1 M H 2SO 4 and 0.1 M NaOH in a beaker. The content of the beaker was filtered through a Büchner funnel, dried and ashed at 550°C. The total fat content of each sample was determined gravimetrically by Soxhlet solvent extraction technique and the residue was dried to a constant weight and calculated as % of ether extract = (wt of extract/wt of sample) x 100. Carbohydrate content was determined as the difference: 100 – (moisture + ash + protein + fat + crude fibre).

2.6 Mineral composition determination

Sodium, potassium, calcium, magnesium, zinc and iron were determined with an automatic Atomic Absorption Spectrophotometer (Unicam Model 929, Unicam Cambridge, England). Total phosphorus was determined spectrophotometrically after incubation with Molybdo-vanadate solution (AOAC, 1998).

2.7 Phytochemical screening

Phytochemical screening of the seeds for saponins, tannins, cardiac glycosides, alkaloids, anthraquinones and flavonoids was carried out according to standard methods (Sofowora, 1993; Trease and Evans, 1989). The anti-nutrients were also determined using the same method.

2.8 Determination of the Total Antioxidant capacity

2.8.1 Determination of total phenol content

The total phenol content was determined according to the method of Singleton et al. (1999). Briefly, appropriate dilutions of the extracts were oxidized with 2.5 ml 10% Folin-Ciocalteau's reagent (v/v) and neutralized by 2.0 ml of 7.5% sodium carbonate. The reaction mixture was incubated for 40 min. at 45 °C and the absorbance was measured at 765nm in the spectrophotometer. The total phenol content was subsequently calculated as gallic acid equivalent.

2.8.2 Determination of total flavonoid content

The total flavonoid content of both extracts were determined using a slightly modified method reported by Meda et al. (2005), briefly 0.5 ml of appropriately diluted sample was mixed with 0.5 ml methanol, 50 µl 10% AlCl3 , 50 µl 1 M Potassium acetate and 1.4 ml water, and allowed to incubate at room temperature for 30 min. The absorbance of the reaction mixture was subsequently measured at 415nm; the total flavonoid content was subsequently calculated. The non-flavonoid polyphenols were taken as the difference between the total phenol and total flavonoid content.

2.8.3 Determination of Vitamin C

Vitamin C content of the samples was determined using the method of Benderitter et al. (1998). Briefly, 75 μL DNPH (2 g dinitrophenyl hydrazine, 230mg thiourea, and CuSO4 ·5H2O in 100mL of H 2SO4) was added to 500 μL reaction mixture (300 μL of appropriate dilution of the extracts with 100 μL of 13.3% trichloroacetic acid (TCA)) and water. The reaction mixture was subsequently incubated for 3 hours at 37∘C, then 0.5mL of 65% H 2SO4 (v/v) was added to the medium, and the absorbance was measured at 520nm using spectrophotometer. The vitamin C content of extracts was subsequently calculated using ascorbic acid as standard.

2.8.4 Determination of (2, 21- azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) ABTS radical scavenging ability

The ABTS• (2, 21- azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) scavenging ability of both extracts, were determined according to the method described by Re et al. (1999). The ABTS• was generated by reacting an (7 mmol/L) ABTS aqueous solution with K2S2O8 (2.45 mmol/L, final concentration) in the dark for 16 h and adjusting the Abs734nm to 0.700 with ethanol. 0.2 mL of appropriate dilution of the extract was added to 2.0 mL ABTS• solution and the absorbance were measured at 734 nm after 15 min. Trolox was used as standard and trolox equivalent antioxidant capacity was subsequently calculated.

3. Results and discussion

3.1 Proximate composition of the plantain peels

The moisture content is very essential for life maintenance and analysis of it is one of the most widely used measurements which determine the way the food will be processed and its shelf life. Moisture has been used as a measure of stability and susceptibility to microbial contamination (Davey, 1989). From table 1, the unripe plantain peel (UPP) had the highest percentage of moisture content, (20.38 ± 1.20%), with the over ripe plantain peel (OPP) with the least (13.28 ± 0.07%). But the moisture content of the least plantain peel (over ripe plantain peels) was higher than the (average of 7.4%) pollen pellets as observed by Almeida-Muradian et al. (2005). This decrease in moisture content in the plantain peels, from Unripe plantain peel > ripe plantain peels >over ripe plantain peels, might have been as a result of moisture loss as the plantain ripens. The ash composition of food samples is very important in determining mineral contents. In our study, high ash content was recorded in (table 1) by UPP (17.24 ± 0.065), suggesting that as the plantain ripens, more of the minerals move into the plantain pulp. The ash content of the plantain peels was higher than the ash content reported by Nurhanan and Wan Ishak, (2013); mature silk corn (5.51%), and immature silk corn (5.28%). Protein is needed for normal body growth, repairs and maintenance. A relatively high amount of protein is therefore required for functional foods and nutraceuticals, because they are used basically for supplementation. In this study there was a significant ($P<0.05$) decrease in the protein level in plantain peels (Table 1). The highest percentage of crude protein was found in the unripe plantain peel (0.74±0.01), while the least was the over ripe plantain peel (4.21 ±0.02). These values compare favourably with the crude protein values reported for Zanthxylum zanthoxyloides (8.74%) (Nnamani et al, 2009). Carbohydrate level in the unripe plantain peels (62.53±1.35) was significantly ($P<0.05$) higher than both the RPP and OPP, (58.82±1.20 and 56.26±1.20 respectively). This also might be an indication of increase in in the level of carbohydrate in the pulp. It could also be possible that a decrease in the protein level in the plantain peels may have resulted in the increase in carbohydrate. This is further confirmed in Table 1 in which significant negative relationship was noted between crude protein and crude carbohydrate. The crude fiber content of unripe plantain peels (0.74±0.01) was higher than both plantain peels with the over ripe plantain peels with the least crude fiber content (0.51±0.015).Which is lower than the relatively high crude fiber content (7.09 ± 0.11) of Moringa oleifera leaves (Ogbe and John, 2012) and 6.5% of bitter leaves (Akindahunsi and Salawu,2005). Crude fiber is the part of food that is not digested by human but the normal functioning of the intestinal tract depends upon the presence of adequate fiber. It increases stool bulk and decreases the time that waste materials spend in the gastrointestinal tract. Fiber helps in the maintenance of human health and has been known to reduce cholesterol level of the body (Bello et al., 2008). A low fiber diet has been associated with heart disease, cancer of the colon and rectum, varicose veins, phlebitis, obesity, appendicitis, diabetes and even constipation (Saldanha 1995, Lajide et al., 2008). Hence, all the three plantain peels cannot be recommended as veritable source of crude fiber, even when compared with 8.43 ± 0.028 of Lophira lanceolata seeds(Lohlum et al.,2010) and 7.00% of Corchorus olitorius (Akindahunsi and Salawu, 2005). The crude lipid content obtained for the plantain peels was in this decreasing order unripe plantain peels (5.23 ± 0.045%) > ripe plantain peels (3.80± 0.35%) > over ripe plantain peels (2.90 ± 0.03%). Lipid provides very good sources of energy and aids in transport of fat soluble vitamins, insulates and protects internal tissues and contributes to important cell processes (Pamela et al., 2005). More so, it is good to add lipid (fat) to most of our diets, because many body functions depend on lipids.

3.2 Mineral Composition of the plantain peels

Minerals are considered to be essential in human nutrition and generally, minerals from plant sources are less-bioavailable than those from animal sources (Lopez et al., 2002). From table 2, the mineral contents of all the plantain peels with the unripe plantain peel, with the highest values of Na (162 mg/g), K(235 mg/g), Ca (100 mg/g), Mg (76 mg/g), P (360 mg/g) and Fe(5.6 mg/g), and the over ripe peels had the least of values of the minerals. The values obtained for the over ripe plantain peels was comparatively a little higher in some of the mineral content than Aneilema aequinoctiale (Ukpabio et al., 2013). They generally help in maintenance of acid-base balance, response of nerves to physiological stimulation and blood clotting (Hanif et al., 2006).Calcium and phosphorus are associated with each other for growth and maintenance of bones, teeth and muscles (Clarke, 2008). Magnesium is a component of chlorophyll and it is an important content in connection with Ischemic heart disease and calcium metabolism in bones (Bergman et al., 2009). Zinc is involved in normal functioning of immune system and is associated with protein metabolism (Hambidge, Krebs., 2007). Iron is an essential trace element for haemoglobin formation, normal functioning of central nervous system and in the oxidation of carbohydrate, protein and fats (Murray et al. 2000). In animals, a Calcium/Phosphorus ratio above 2.0 helps to increase the absorption of calcium in the small intestine. Food is considered "good" if the ratio Ca/P > 1 and "poor" if < 0.05 (Nieman et al., 1992), while recommended Sodium/Potassium, Na/K is 0.60. From table 3, the Na/K is 0.64 for the OPP, 1.37 for the Ripe plantain peel and 0.69 for the UPP. All of the plantain peels are more than the recommended value of 0.6, which might indicate a good source of nutraceuticals. For unripe plantain peels the Ca/P is 0.43, ripe plantain peels is 0.40 and for over ripe is 0.28, though all the figures are less than 1, but they are greater than 0.05, the recommended value for poor.

Table 1- Mineral composition of unripe, ripe and over ripe plantain (*musa paradisiaca*) peel

SAMPLE	Na	K	Ca	Mg	P	Fe
	(mg/g)	(mg/g)	(mg/g)	(mg/g)	(mg/g)	(mg/g)
OPP	58 ± 0.75	97 ± 1.05	59 ± 0.65	27 ± 0.08	136 ± 1.15	1.6± 0.03
RPP	140 ± 1.06	102 ± 1.25	86 ± 0.7	51 ± 0.55	214 ± 1.18	3.2 ± 0.02
UPP	162 ± 1.35	235 ± 1.54	100 ± 0.95	76 ± 0.55	360 ± 1.65	5.6 ± 0.06

The result represents the mean of three readings ± standard deviation

3.3 Bioavailability of Minerals

The bioavailability of a mineral or trace element is defined as the fraction of the ingested nutrient that is absorbed and subsequently utilised for normal physiological functions (Susan and Hurrell, 1996). It is more than the quantity or percentage of minerals found in a particular food, it's the availability for physiological functions, which is relative to the age, sex, stage of growth, pregnancy, lactation and diet type. The Ferguson et al (1988) was used for the calculation of mineral bioavailability, the mineral content/ Phytate ratio gives the available mineral. As shown in table 3, the UPP has the highest bioavailability of minerals; Na (16.40), K (23.79), Ca (10.12), Mg (7.69), P (36.43) and Fe (0.57), with the least recorded by the OPP. This is good compared with the Ca/Phytate ratio as reported by Oboh et al. (2005)

3.3 Qualitative and quantitative phytochemical contents of the plantain peels

Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties. They are natural bioactive compounds found in plant food, leaves or other parts of plants that interplay with nutrients and dietary fiber to protect them. Recent research demonstrate that they can protect humans against diseases as well as, in risk reduction for a variety of chronic or inflammatory conditions (Middleton et al., 2000).The presence of phytochemicals in the plantain peels suggests possible medicinal applications. They are known to exhibit both medicinal activities as well as physiological activities (AOAC, 1998). Saponins, tannins, flavonoid, steroids,

terpenoid and cardiac glycosides were detected in all of the three plantain peels (Table 4) while anthraquinones, phlobatanin and alkaloids were not detected in all three plantain peels. Saponins are glycosides, which include steroid saponins and triterpenoid saponins (Dei et al., 2007). According to Harborne (1984), saponins have anti-hyper cholesterol, anti- inflammatory, cardiac depressant property and also appear to kill or inhibit cancer cells without killing the normal cells in the process (Okwu, 2001). Phlobatannins inhibit the growth of many microorganisms like fungi, yeast, bacteria and viruses (Asquith and Butter, 1986). These compounds were also detected in A. hispida and A. racemosa (Hufford et al., 1993). Steroidal compounds observed in all the three plantain peels are of importance and interest in pharmacy due to their relationship with such compounds as sex hormones they also promote immune functions in the skin and also reduce inflammation (Iniaghe et al., 2009). Anti-nutrients such as tannins, saponins, phytate, and oxalate were observed to be significantly low in all the plantain peels (mg/100g), as shown in Table 5. The unripe plantain peel has the highest content of tannins, saponins, and oxalate, 5.39± 0.02, 7.73 ± 0.03, and 0.81 ± 0.07mg/g, respectively and while the over ripe plantain peel has the highest content of phytate (11.12 ± 0.05mg/g).

Table 2 – Mineral bioavailability

SAMPLE	Na	K	Ca	Mg	P	Fe
	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g
OPP	5.21	8.72	5.30	2.42	12.23	0.14
RPP	15.45	11.25	9.06	5.62	23.62	0.35
UPP	16.40	23.79	10.12	7.69	36.43	0.57

Table 3- Proximate Analysis of unripe, ripe and over ripe plantain (*Musa paradisiaca*) peel

SAMPLE	MOISTURE	ASH	FAT	CRUDE-FIBRE	CRUDE-PROTEIN	CARBO-HYDRATE
	%	%	%	%	%	%
UPP	20.38 ± 1.20	17.24±0.065	5.23±0.045	0.74±0.01	7.89±0.02	62.53±1.35
RPP	14.29 ±0.07	13.33±0.065	3.80±0.35	0.62±0.01	5.72±0.03	58.82±1.20
OPP	13.28 ±0.07	12.50±0.045	2.90±0.03	0.51±0.015	4.21±0.02	56.26±1.20

The result represents the mean of three readings ± standard deviation

Table 4- Qualitative Phytochemical Screening of unripe, ripe and over ripe plantain (*musa paradisiaca*) peel

Phytochemical screening	R	S	U
ALKALOID	-	-	-
SAPONIN	+	+	+
TANNIN	+	+	+
FLAVONOD	+	+	+
STERIOD	+	+	+
TERPENOID	+	+	+
PHLOBATANIN	-	-	-
ANTRAQUINONE	-	-	-
CARDIAC GLYCOSIDES			
LEGAL TEST	+	+	+
SALKOWSKI TEST	+	+	+
LIEBERMAN TEST	+	+	+
KELLER KILIANI TEST	+	+	+

Table 5 - Quantitative phytochemical screening unripe, ripe and over ripe plantain (musa paradisiaca) peel

SAMPLE	Tannin mg/g	Saponin mg/g	Phytate mg/g	Oxalate mg/g
UPP	5.39 ± 0.02	7.73 ± 0.03	9.88 ± 0.05	0.81 ± 0.07
RPP	4.24 ± 0.01	5.99 ± 0.02	9.064 ± 0.04	0.495 ± 0.03
OPP	2.84 ± 0.03	3.27 ± 0.01	11.12 ± 0.05	0.36 ± 0.02

The result represents the mean of three readings ± standard deviation

3.4 Total antioxidant capacity of plantain peels

From table 6, it can be deduced that the UPP has the highest content of total phenol (8.99mg.GAE/g), total flavonoid (1.0mg/QUE/g), and Vitamin C (11.72mg/100g), with the OPP extract with the least content of total phenol (6.15mg.GAE/g), total flavonoid (0.621mg/QUE/g), and Vitamin C (4.87mg/100g). The phenolic distribution in the plantain peels as shown in table 6 agrees with the phenolic distribution in plant foods such as fruits (Chu et al. 2002), vegetables (Sun et al.2002), peppers (Oboh and Rocha 2007a, b). Phenolics are capable of scavenging free radicals, chelate metal catalysts, activate antioxidant enzymes, reduce α-tocopherol radicals, and inhibit oxidases (Alia et al. 2003; Amic et al. 2003). The prevention of the chain initiation step by scavenging various reactive species such as free radicals is considered to be an important antioxidant mode of action (Dastmalchi et al. 2007). The free radical scavenging ability of the three plantain extracts was further studied using a moderately stable nitrogen-centred radical species – ABTS (2, 2'-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid) radical (Re et al. 1999).

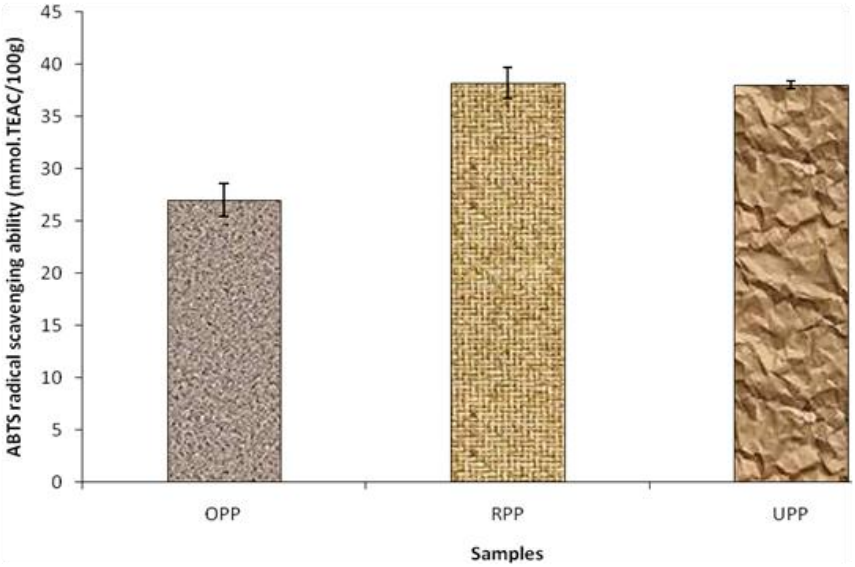

Fig. 1 - ABTS (2, 2'-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid) of aqueous extract from plantain peels, Values represent means of triplicate (*n*=3).
Key :
OPP – Over ripe Plantain Peel
RPP - Ripe Plantain Peel
UPP- Unripe Plantain Peel
TEAC – Trolox equivalent antioxidant capacity

The ABTS* scavenging ability reported as trolox equivalent antioxidant capacity (TEAC) is presented in Fig. 1. The Unripe and ripe plantain peel extract scavenged the free radicals much more better than the overripe plantain peel extract. However, the trend in the ABTS* scavenging ability reported as agrees with the total anti-oxidant activity in table 6. This also agrees with the findings of Adefegha et al. (2012) (A. danielli and A. melegueta); Ademiluyi et al. (2010) (fermented and unfermented Soy dadawa beans); and Oboh et al. (2010) (Grape fruit and Shaddock peels).

4. Conclusions

From the nutritional, antinutritional and total antioxidant analysis of the plantain peel (40% of the total plantain fruit), it will be a matter of underutilisation, if plantain peels are thrown away as by products from processing industries. The Unripe, Ripe and Over ripe plantain peels nutritionally analysed can be processed properly and eaten as food. With the presence of phytochemicals, it has the potential to act as nutraceuticals in animal health, pharmaceuticals and can be medicinally vital.

Conflict of interest statement
The authors declare no conflict of interest exists

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