

Antioxidant potential, phenolic profile and nutrient composition of flesh and peels from Nigerian white and purple skinned sweet potato (*Ipomea batatas L.*)

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ABSTRACT

Sweet potato is an important food crop in many part of the world that provides essential nutrients and also contains useful phytochemicals with chemopreventive potentials. Although sweet potato peels, which may contain some nutrients and phytochemicals are usually discarded before consumption of the tubers. Therefore, this present investigation seeks to compare the nutraceutical potentials of peels and flesh from white and purple skinned sweet potato. The evaluated antioxidant indices (DPPH radical scavenging capacity, ABTS radical scavenging capacity, reducing power, total phenol, total flavonoid and inhibitory action against lipid oxidation) were higher in peels of the studied potato compared to the flesh. The HPLC-DAD analysis revealed presence of some phenolic compounds (gallic acid, catechin, chlorogenic acid, caffeic acid, caffeic acid derivative, ellagic acid, epicatechin, rutin, isoquercitrin, quercitrin), with higher level of each identified compounds in the peels. The result of the proximate indices (%) revealed a higher value of carbohydrate in the flesh and a higher value of fat, protein and ash in peels of the evaluated sweet potato. The result also showed a higher amount of some of the evaluated minerals (Zn, Fe, Cu, Ca, Mg, Mn) and amylose-amylopectin ratio (white skinned sweet potato: 11.94, purple skinned sweet potato: 13.67) in peels. The result of this investigation showed that that leaving the potato skin intact during processing will enhance the nutraceutical potentials which could be explored in the management of free radical mediated disorders.

Keywords: Antioxidants, Phenolic compounds, Nutrient composition, Sweet Potato Peels, Sweet potato Flesh

INTRODUCTION

The effects of free radicals such as superoxide, peroxides, oxide and hydroxide ions on human tissues have been reported to cause many pathological disorders, including cardiovascular diseases, cancer, cataracts, neurological dysfunctions, deficiencies in immune response, age-related problems, among others (Diaz *et al.*, 1997). Antioxidants are secondary metabolites in food and have been reported to possess properties that eliminate the oxidative stress in animal tissues. Synthetic antioxidant such as butylated hydroxytoluene, tannic acid and propyl gallate has been reported to be harmful to human health (Pourmorad *et al.*, 2006). Natural antioxidant compounds in plants are capable of terminating a free radical-mediated oxidative reaction and have beneficial activities in protecting the

human body from such diseases (Havsteen, 2002). This has therefore led to the wide screening of plants for antioxidant potentials. Studies have suggested that antioxidants occur naturally in many fresh foods particularly fresh fruits, whole grains, vegetables including sweet potato (*Ipomoea batatas*) and great interest have been placed in screening and ranking plant materials and food commodities for total antioxidant activity.

Sweet potato (*Ipomoea batatas L.*) is an important food crop in many parts of the world, being cultivated in more than 100 countries. It is an easy-to-grow crop with good adaptability in diverse environmental conditions which has high yielding ability and high energy content (Ravindran *et al.*, 1995). Sweet potato is among the most under-exploited of the developing world's major crops (Walker and Crissman, 1996), it belongs to the family *convolvulaceae* and is highly nutritious, easily digestible (Akpapunam and Abiante, 1991). One way of minimizing post-harvest losses and increasing the utilization of sweet potato is through processing it into flour, which is a more stable intermediate product. The flour can be used as a starting material for production of juice, bread, candy, noodles, snacks, fufu (dough), and alcohol (Eleazu and Ironua, 2013). Sweet potato cultivars are known to be rich in dietary fiber, minerals, vitamins and antioxidants, including anthocyanins, phenolic acids, beta-carotene and tocopherol (Bengtssona *et al.*, 2008; Kim *et al.*, 2007; Van Jaarsveld *et al.*, 2006; Yildirim *et al.*, 2011).

Sweet potato phenolics were found to inhibit the growth of human colon, leukemia and stomach cancer cells (Kurata *et al.*, 2007), to inhibit growth of viruses and fungi *in vitro* (Peterson *et al.*, 2005) and to ameliorate diabetes in humans (Ludvik *et al.*, 2008). It has been reported that white, orange and purple-fleshed sweet potato cultivars have antioxidant and radical scavenging activities (Furata *et al.*, 1998; Cevallos-Casal and Cisneros-Zevallos, 2004). The use of beta-carotene-rich orange-fleshed sweet potato has helped to improve the vitamin A deficiency (Low and Van Jaarsveld, 2008). Purple-fleshed sweet potato tubers were reported to have anti-mutagenic activity (Yoshimoto *et al.*, 1999). Several studies reveal the potential chemopreventive properties of sweet potato phenolic extracts (Shimozono *et al.*, 1996; Rabah *et al.*, 2004) with the claim that it is valuable for anaemia, hypertension and diabetes (Ludvik *et al.*, 2004). The purple-flesh varieties are sources of anthocyanins, concentrated in the starchy core and more concentrated in the outer skin than the inner cortex (Bae *et al.*, 2006).

Although, the outer skin of sweet potato is usually discarded before consumption in many parts of the world and reports had shown that the skin contain a number of additional nutrient and phytochemicals (Bae *et al.*, 2006; Lister and Munro, 2000). Therefore, the present study is carried out to compare the nutritional potentials, antioxidant activities and the phenolic constituents of flesh and peels from white and purple skinned sweet potato commonly consumed in the Southwestern part of Nigeria.

MATERIALS AND METHODS

2.1 Collection and Identification of Samples

The two varieties of sweet potato (white and purple skinned) were bought from the King's market, Akure, Ondo State, Nigeria and were identified and authenticated in the Department of Crop, Soil and Pest Management, School of Agriculture and Agricultural Technology, Federal University of Technology, Akure, Ondo State, Nigeria. The sweet potato samples were washed and the peels separated from the flesh. Both peels and flesh were sliced and steamed at 100°C for 15 minutes to prevent browning of the flesh. After cooling, the sliced samples were air-dried, milled into fine powder and stored in a sealable bag prior to analysis. The chemicals were analytically graded, while the water used was glass distilled water.

2.2 Extraction of Sample for Antioxidant Assay and Phenolic Identification

Finely grinded powdered samples of the sweet potato (3g) were extracted with 30ml acidified methanol (1% conc. HCl in methanol) in three phases as follows: 10ml solvent was added to the flour sample in a conical flask and completely covered with aluminum foil. The sample was stirred (magnetic stirrer) for 2hrs, centrifuged in a 40ml plastic centrifuged tube at 1900rpm for 10 minutes (25°C) and decanted. Keeping the supernatant, the residue was then extracted again in 10ml of the solvent for 20minutes, centrifuged and decanted keeping the supernatant and this process was repeated the third time. The supernatant was then combined and stored in a glass bottle covered with aluminum foil and kept in refrigerator prior to analysis.

2.3 Nutrient Composition

2.3.1 Proximate Analysis

Proximate composition (moisture, proteins, fat, carbohydrates and ash) of the sweet potato peels and flesh were determined by the standard methods (AOAC, 1990). The crude protein content ($N \times 6.25$) of the samples was estimated by the macro-Kjeldahl method; the crude fat was determined by extracting a known weight of powdered sample with petroleum ether, using a Soxhlet apparatus; the ash content was determined by incineration at 600 ± 15 °C. Total carbohydrates were calculated by difference.

2.3.2 Mineral Analysis

Five grams (5g) of the sample was ashed in an electric furnace at 550°C for 24 hours. The resulting ash was cooled in desiccators and weighed. The ash was dissolved with 2ml of concentrated HCl and few drops of concentrated HNO_3 were added. The solution was placed in boiling water bath and evaporated almost to dryness. The content was then transferred to 100ml volumetric flask and diluted to volume with de-ionized water. Appropriate dilution was made for each element before analysis. The mineral analysis carried out on the sample were calcium, magnesium, potassium, sodium, manganese, zinc, copper and iron contents were quantified using Buck Atomic absorption spectrophotometer model 210A (AOAC, 1990).

2.3.3 Starch and Free Sugar determination

The method described by (Dubois *et al.*, 1956) was used. This involves weighing 0.020g finely ground sample into centrifuge tubes and wetted with 1ml of ethanol. 2ml of distilled water was added, followed by 10ml hot ethanol. The mixture was vortexed and centrifuged at 2000rpm for ten minutes. The supernatant was collected and used for free sugar analysis, while the residue was used for starch analysis. To the residue was added 7.5ml of perchloric acid and allowed to hydrolyze for 1 hour. It was then diluted to 25ml with distilled water and filtered through Whatman No 2 filter paper. From the filtrate 0.05ml was taken, made up to 1ml with distilled water, vortexed and ready for color development as described for standard glucose curve preparation. The supernatant was made up to 20ml with distilled water, an aliquot of 0.2ml was taken and 0.5ml (5% phenol) and 2.5ml concentrated sulphuric acid was subsequently added. The sample was allowed to cool and the absorbance read on a UV/Visible at 490nm wavelength.

2.3.4 Amylose Determination

The amylose content was determined by the method described by (Juliano, 1971). 0.1g of flour sample or standard was weighed into a centrifuge tube. To this, 1ml of 95% ethanol and 9ml 1N NaOH were carefully added, the test was covered and the content was mixed very well on a vortex mixer. Thereafter, the samples were heated for 10 minutes in a boiling water bath to gelatinize the starch, and then allowed to cool to room temperature. 10 times dilution of the extract was made by taking 1ml of the extract and make up to 10ml with 9ml of distilled water. An aliquot of 0.5ml was taken from the diluents for analysis. 0.1ml of Acetic acid solution and 0.2ml of iodine solution were added to the diluents and the volume was made up to 10ml with 9.2ml of distilled water. The test mixture was left for 20mins for color development after which it was vortexed and the absorbance was read at 620nm.

2.4 Antioxidant Indices

2.4.1 Total Phenolic Content

The total phenolic content of the extracts was determined by the Folin-Ciocalteu assay as described by (Waterman and Mole 1994). The hydro-alcoholic extract (0.25 ml), was placed in a 25 ml volumetric flask and 5 ml distilled water was added. Folin-Ciocalteu's phenol reagent (1.25 ml) was added and mixed. After 2 min, 3.75 ml 20% (w/v) sodium carbonate solution was added. The contents were mixed and distilled water was added to volume and mixed. The mixture was left to stand for 2 hr after addition of the sodium carbonate for which the absorbance of the mixture was measured at 760 nm using a Lambda EZ150 spectrophotometer (Perkin Elmer, USA). The standard used was tannic acid and the results which were determined in triplicates were expressed as mg tannic acid equivalents per gram of the sample.

2.4.2 Total Flavonoid Content

The total flavonoid content of the extract was determined using a slightly modified method as described by Meda *et al.* (Meda *et al.*, 2005). Briefly, 0.5mL of appropriately diluted sample was mixed with 0.5mL methanol, 50µL of 10% AlCl_3 , 50µL of 1mol L^{-1} potassium acetate and 1.4mL water, and allowed to incubate at room temperature for

30 min. Thereafter, the absorbance of each reaction mixture was subsequently measured at 415 nm. The total flavonoid was calculated using quercetin as standard by making use of a seven point standard curve (0-40 µg/ml or 0-100 µg/ml), the total flavonoids content of samples was determined in triplicates and the results were expressed as mg quercetin equivalent per gram of the sample.

2.4.3 Reducing Power

The reducing power of the extracts was determined by assessing the ability of each extract to reduce FeCl₃ solution as described by (Oyaizu, 1986). Briefly, appropriate dilution of each extract (2.5 ml) was mixed with 2.5 ml 200 mM sodium phosphate buffer (pH 6.6) and 2.5 ml 1% potassium ferricyanide. Each mixture was incubated at 50°C for 20 min and then 2.5 ml 10% trichloroacetic acid was added. This mixture was centrifuged at 353 x g for 10 min. 5ml of the supernatant was mixed with an equal volume of water and 1 ml of 0.1% ferric chloride. The absorbance was measured at 700 nm. The ferric reducing antioxidant power was determined in triplicate and expressed as mg ascorbic acid equivalent/g of the sample.

2.4.4 DPPH antiradical assay

The DPPH assay was done according to the method of (Brand-Williams *et al.* 1995), with some modifications. The stock solution was prepared by dissolving 24 mg DPPH with 100mL methanol and then stored at -20°C prior analysis. The working solution was obtained by mixing 10mL stock solution with 45mL methanol to obtain an absorbance of 1.1 units at 515 nm using the spectrophotometer. Phenol extracts (300µl) were allowed to react with 2700µl of the DPPH solution for 6 h in the dark. Then the absorbance was taken at 515 nm. Results which were determined in triplicates were expressed in µmol Trolox Equivalent/g sample. Additional dilution would be needed if the DPPH value measured was over the linear range of the standard curve.

2.4.5 ABTS antiradical assay

Antioxidant activity of the extracts was determined using the 2, 2'-azinobis-(3- ethylbenzothiazoline-6-sulfonic acid) ABTS antiradical assay (Awika *et al.*, 2003). The ABTS^{•+} (mother solution) was prepared by mixing equal volumes of 8mM ABTS and 3mM potassium persulphate (K₂S₂O₈) (both prepared using distilled water) in a volumetric flask, which was wrapped with foil and allowed to react for a minimum of 12 hr in a dark place. The working solution was prepared by mixing 5 ml of the mother solution with 145 ml phosphate buffer (pH 7.4). A range of trolox (6-hydroxy-2, 5, 7, 8-tetramethylchroman-carboxylic acid) standard solutions (100–1000 µM) were prepared in acidified methanol. The working solution (2.9 ml) was added to the methanolic extracts (0.1 ml) or Trolox standard (0.1 ml) in a test tube and mixed with a vortex. The test tubes were allowed to stand for exactly 30 min. The absorbance of the standards and samples were measured at 734 nm with a Lambda EZ150 spectrophotometer. The results which were determined in triplicates were expressed as µmol Trolox equivalents/g sample, on dry weight basis.

2.5 Quantification of Phenolic compounds by HPLC-DAD in Purple and White Skinned Sweet Potato

Reverse phase chromatographic analyses were carried out under gradient conditions using C₁₈ column (4.6 mm x 150 mm) packed with 5µm diameter particles; the mobile phase was water containing 2% acetic acid (A) and methanol (B), and the composition gradient was: 5% of B until 2 min and changed to obtain 25%, 40%, 50%, 60%, 70% and 100% B at 10, 20, 30, 40, 50 and 60 min, respectively, following the method described by Boligon *et al.* (2012). with slight modifications. Purple skin sweet potato, purple flesh sweet potato, white skin sweet potato and white flesh sweet potato were analyzed at a concentration of 20 mg/mL. The presence compounds was investigated, namely, gallic acid, caffeic acid, caffeic acid derivative, chlorogenic acid, ellagic acid, catechin, epicatechin, kaempferol, quercetin, isoquercitrin, quercitrin and rutin. Identification of these compounds was performed by comparing their retention time and UV absorption spectrum with those of the commercial standards. The flow rate was 0.7 ml/min, injection volume 40 µl and the wavelength were 254 nm for gallic acid, 280 nm catechin and epicatechin, 327 nm for caffeic, caffeic derivative, ellagic and chlorogenic acids, and 365 nm for quercetin, isoquercitrin, quercitrin, rutin and kaempferol. The samples and mobile phase were filtered through 0.45 µm membrane filter (Millipore) and then degassed by ultrasonic bath prior to use. Stock solutions of standards references were prepared in the HPLC mobile phase at a concentration range of 0.020 – 0.200 mg/ml for quercetin, isoquercitrin, quercitrin, rutin, kaempferol, epicatechin and catechin; and 0.050 – 0.250 mg/ml for gallic, chlorogenic, caffeic and ellagic acids. The chromatography peaks were confirmed by comparing its retention time with those of reference standards and by DAD spectra (200 to 500 nm). All chromatography operations were carried

out at ambient temperature and in triplicate. The limit of detection (LOD) and limit of quantification (LOQ) were calculated based on the standard deviation of the responses and the slope using three independent analytical curves, as defined by (Boligon *et al.* 2012). LOD and LOQ were calculated as 3.3 and $10 \sigma/S$, respectively, where σ is the standard deviation of the response and S is the slope of the calibration curve.

2.6 Determination of Lipid Oxidation Assay

Egg homogenate (0.5ml, 10% v/v) and 0.1ml of the methanolic extract were added to a test tube made up to 1ml with distilled water as described by (Maisuthisakul *et al.*, 2007) with slight modification, 0.05 ml FeSO_4 (0.07M) was added to induce lipid peroxidation and incubated for 30mins. Then 1.5ml of 20% acetic acid (pH adjusted to 3.5 with NaOH) and 1.5ml of 0.8% (w/v) TBA in 1.1% sodium deodecyl sulphate and 20% TCA were added and the resulting mixtures were vortexed and then heated at 95°C for 60min. After cooling, 5.0 ml of butan-1-ol was added to each tube and centrifuge at 300 rpm for 10min. The absorbance of the organic layer was measure at 532nm. The percentage inhibition of lipid peroxide formation by the extract was calculated.

2.7 Statistical Analysis

All experiments were performed in triplicates. Analysis at every time point from each experiment was carried out in triplicate. Means, standard errors and standard deviations were calculated from replicates within the experiments and analyzed using Microsoft Excel XP.

RESULTS AND DISCUSSION

Research has demonstrated that nutrition plays a crucial role in the prevention of chronic diseases, as most of the existing chronic diseases can be related to diet. Today, consumers are more aware of health benefits of antioxidants from fruits and vegetables than ever in addition to their nutritional benefits from minerals and vitamins. Phytochemicals and secondary metabolites like phenolics are produced by plants to protect it from abiotic and biotic stresses, but they are also beneficial to humans under disease induced oxidative stress (Shetty *et al.*, 2008). In addition to endogenous antioxidant defense systems, consumption of dietary and plant-derived antioxidants appears to be a suitable alternative. The medicinal plants are rich sources of natural antioxidants; higher intake of foods with functional attributes including high level of antioxidants in functional foods is one strategy that is gaining importance (Brown and Rice, 1998).

Table 1: Antioxidant Indices of White and Purple Skin Sweet Potato Flesh and Peel

Sample	DPPH ($\mu\text{mol TE/g}$)	ABTS ($\mu\text{mol TE/g}$)	Reducing Power (mgAAE/g)	Total Phenol (mgTAE/g)	Total flavonoid (mgQE/g)	Lipid Oxidation (% Inhibition)
WPSP	0.26 ± 0.00^b	$8.75 \times 10^{-6} \pm 0.00^c$	0.10 ± 0.00^c	51.32 ± 0.80^c	1711.70 ± 7.70^d	55.11 ± 0.46^c
WFSP	0.23 ± 0.00^a	$7.06 \times 10^{-6} \pm 0.00^a$	0.01 ± 0.00^a	9.86 ± 2.99^a	579.63 ± 9.80^b	4.84 ± 0.81^a
PPSP	1.12 ± 0.01^c	$8.99 \times 10^{-6} \pm 0.00^d$	0.32 ± 0.00^d	133.92 ± 2.24^d	1682.10 ± 7.48^c	61.83 ± 1.23^d
PFSP	0.24 ± 0.01^a	$7.23 \times 10^{-6} \pm 0.00^b$	0.02 ± 0.00^b	10.41 ± 2.61^a	96.91 ± 1.07^a	51.07 ± 0.47^b

Means \pm SD followed by different letter in a column are significantly different ($p < 0.05$) by Tukey Test.
Abbreviation: TE= Trolox Equivalent; AAE= Ascorbic Acid Equivalent; TAE= Tannic Acid Equivalent; QE= Quercetin Equivalent

The result of the antioxidant indices of peels and flesh from white and purple skinned sweet potato is as shown on Table 1. The result revealed a high antioxidant potential and inhibitory action against lipid oxidation by peels of purple and white skinned sweet potato with higher activity in the purple peels compared with the peel of white skinned sweet potato and that the antioxidant indices of purple flesh is higher than that of the white flesh obtained from white skinned sweet potato. This is in agreement with the report of (Furata *et al.*, 1998), who tested the radical scavenging activity of sweet potato cultivars with varying fleshed color and concluded that the radical scavenging activities of sweet potato increases in varieties that are pigmented on the outer layer. The result further showed that purple peels ranked higher in all the evaluated antioxidant and radical scavenging activities compared with flesh

from both white and purple skinned sweet potato and white peels respectively. This is also consistent with the reports that high antioxidant is associated with anthocyanin levels that are typically found in the peel of potatoes, and its content is higher in cultivars that consist of brighter peel colors (Zhang *et al.*, 2009). The observed high antioxidant activities in the peels is also in agreement with the report of (Mokbel and Hashinaga, 2005) who reported a higher antioxidant activity in the peels of banana fruits, with the claim that polyphenols are concentrated on the outermost part of fruits.

Figure 1(a-d): HPLC-DAD Phenolic Chromatogram of (a) Purple Peel (b) Purple Flesh (c) White Peel (d) White flesh Sweet Potato. 1: Gallic acid; 2: Catechin; 3: Chlorogenic acid; 4: Caffeic acid; 5: Caffeic; 6: Ellagic acid; 7: Epicatechin; 8: rutin; 9: Isoquercitrin; 10: Quercitrin; 11: Quercetin and 12: Kaempferol

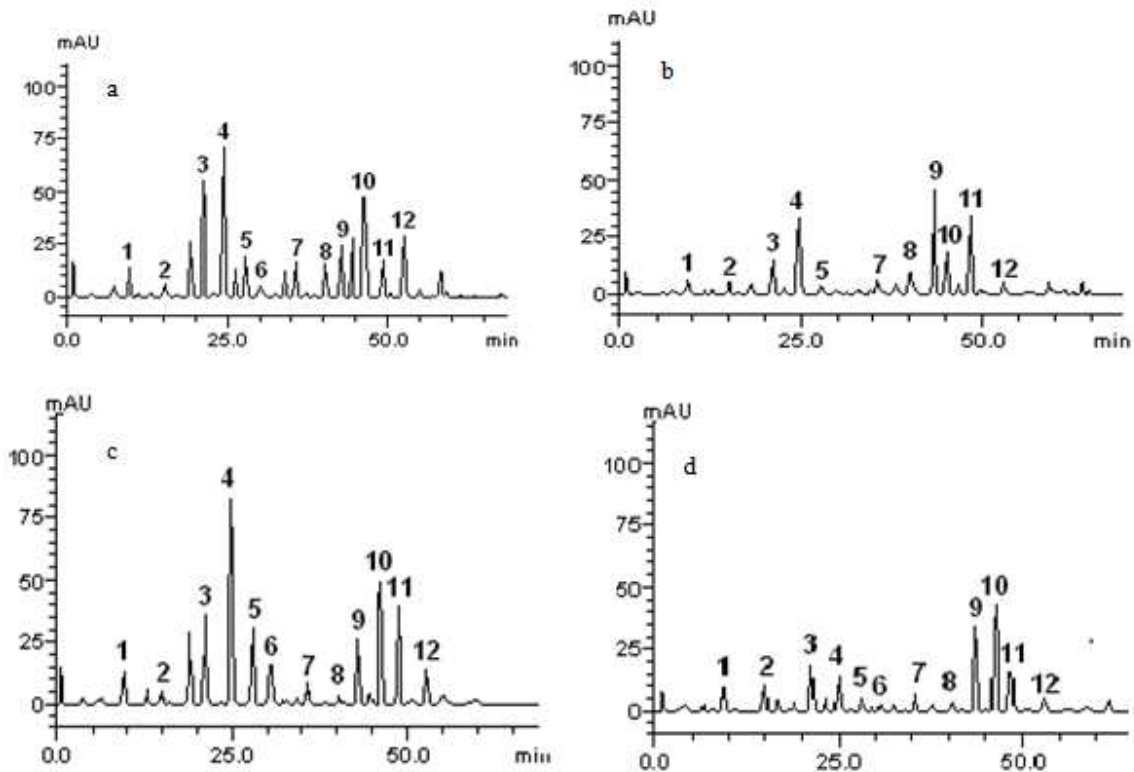


Figure 1(a-d)

Table 2: Phenolic Composition of Purple skin, purple flesh, white skin and white flesh sweet potato extracts

Compounds	Purple skin	Purple flesh	White skin	White flesh	LOD	LOQ
	%	%				
Gallic acid	$0.65 \pm 0.01\text{a}$	$0.17 \pm 0.01\text{a}$	$0.61 \pm 0.02\text{a}$	$0.32 \pm 0.03\text{a}$	0.038	0.125
Catechin	$0.17 \pm 0.01\text{b}$	$0.15 \pm 0.02\text{a}$	$0.19 \pm 0.01\text{b}$	$0.37 \pm 0.01\text{b}$	0.025	0.081
Chlorogenic acid	$2.25 \pm 0.03\text{c}$	$0.63 \pm 0.01\text{b}$	$1.46 \pm 0.03\text{c}$	$0.64 \pm 0.01\text{c}$	0.016	0.049
Caffeic acid	$2.97 \pm 0.01\text{d}$	$1.38 \pm 0.01\text{c}$	$3.08 \pm 0.01\text{d}$	$0.40 \pm 0.02\text{b}$	0.009	0.030
Caffeic derivative ^a	$0.73 \pm 0.02\text{a}$	$0.11 \pm 0.03\text{a}$	$1.42 \pm 0.01\text{c}$	$0.18 \pm 0.01\text{d}$	-	-
Ellagic acid	$0.18 \pm 0.01\text{b}$	-	$0.75 \pm 0.03\text{a}$	$0.09 \pm 0.01\text{e}$	0.043	0.139
Epicatechin	$0.70 \pm 0.01\text{a}$	$0.19 \pm 0.01\text{a}$	$0.30 \pm 0.01\text{e}$	$0.21 \pm 0.02\text{d}$	0.014	0.046
Rutin	$0.68 \pm 0.02\text{a}$	$0.34 \pm 0.02\text{d}$	$0.17 \pm 0.01\text{b}$	$0.11 \pm 0.03\text{e}$	0.031	0.103
Isoquercitrin	$1.09 \pm 0.03\text{e}$	$1.86 \pm 0.01\text{e}$	$1.39 \pm 0.02\text{c}$	$1.48 \pm 0.01\text{f}$	0.040	0.132
Quercitrin	$1.94 \pm 0.01\text{f}$	$0.72 \pm 0.03\text{b}$	$1.85 \pm 0.03\text{f}$	$1.79 \pm 0.03\text{g}$	0.007	0.023

Results are expressed as mean \pm standard deviations (SD) of three determinations. Averages followed by different letters differ by Tukey test at $p < 0.01$. LOD: Limit of detection; LOQ: Limit of quantification ^a Quantified was caffeic acid.

Table 3: Proximate Composition (%) of Purple Peels, White Peels, Purple and White Flesh

Sample	Moisture	Ash	Crude fibre	Fat	Protein	Carbohydrate
WPSP	12.80±0.70 ^c	5.40±0.09 ^d	7.67±0.29 ^c	21.85±1.91 ^b	8.40±0.12 ^d	43.88±2.73 ^a
WFSP	13.55±0.27 ^c	1.47±0.03 ^a	2.52±0.23 ^a	12.17±0.53 ^a	4.96±0.10 ^a	65.10±0.28 ^b
PPSP	9.56±0.10 ^a	3.16±0.28 ^c	8.92±0.14 ^d	23.17±1.11 ^b	7.94±0.10 ^c	47.27±0.89 ^a
PFSP	11.21±0.25 ^b	1.98±0.01 ^b	3.33±0.14 ^b	11.77±0.64 ^a	6.54±0.10 ^b	65.17±0.93 ^b

Means ± SD followed by different letter in a column are significantly different ($p < 0.05$) by Tukey Test.
 WPSP- White Peel Sweet Potato; WFSP- White Flesh Sweet Potato; PPSP- Purple Skin Sweet Potato and
 PFSP- Purple Skin Sweet Potato

Table 4: Mineral Analysis (mg/g) of Purple peel, purple flesh, white peel and white flesh of Sweet Potato Sample

Sample	Zinc	Iron	Copper	Potassium	Sodium	Calcium	Magnesium	Manganese
WPSP	0.028±0.004 ^c	0.493±0.05 ^d	0.029±0.005 ^d	66.76±1.3 ^b	36.89±0.2 ^a	1.06±0.049 ^c	0.487±0.01 ^b	0.017±0.002 ^b
WFSP	0.019±0.003 ^a	0.055±0.004 ^a	0.0043±0.0001 ^a	188.92±2.50 ^c	134.97±8.80 ^c	0.541±0.02 ^a	0.246±0.03 ^a	0.0035±0.0001 ^a
PPSP	0.075±0.002 ^d	0.410±0.01 ^c	0.0094±0.001 ^c	55.72±1.50 ^a	383.10±1.99 ^b	1.34.30±0.04 ^d	0.497±0.04 ^c	0.15±0.03 ^c
PFSP	0.023±0.02 ^b	0.084±0.005 ^b	0.006±0.0004 ^b	216.5±0.33 ^d	137.93±1.14 ^d	0.689±0.04 ^b	0.295±0.03 ^b	0.016±0.01 ^b

Means ± SE followed by different letter in a column are significantly different ($p < 0.05$) by Turkey Test

The result of the HPLC-DAD analyses of purple peel, purple flesh, white peel and white flesh were as shown in Figure 1(a-d), and Table 2. The result revealed presence of gallic acid, catechin, chlorogenic acid, caffeic acid, caffeic derivative, ellagic acid, epicatechin, rutin, isoquercitrin, quercitrin, quercetin and kaempferol in purple peel, purple flesh, white peel and white flesh, with the absence of ellagic acid was in purple flesh sweet potato only. The phenolic compounds may contribute directly to anti-oxidative action elicited by the evaluated peels and flesh (Duh *et al.*, 1999). Quantitative estimate shows caffeic acid (2.97%) as the most abundant phenolic compounds in purple and white peel sweet potato while catechin (0.17%) and rutin (0.17%) respectively are the least abundant phenolics. Reports have shown that hydroxycinnamics are concentrated in the cell wall material of plant food and this account for the presence of higher level of caffeic acid on the peels of the evaluated sweet potatoes (Ibrahim *et al.*, 1987). Padda and Picha (2008) reported that individual phenolic acids identified in freshly harvested sweet potato root tissues were chlorogenic acid; caffeic acid; 4,5-dicaffeoyquinic acid; 3,5-dicaffeoyquinic acid; 3,4- dicaffeoyquinic acid. A study of the chemical composition of the exterior 3mm of sweet potato roots revealed that caffeic acid and two isomers of dicaffeoylquinic acid were the predominant phenolic compounds present in periderm and roots (Son *et al.*, 1991). Caffeic acid is known to be naturally present in fruits and vegetables, and has anti-inflammatory and anti-oxidative properties and can be very toxic to plants (Son and Lewis, 2002). Caffeic acid accumulate at high levels in the periderm under certain conditions (Harrison *et al.*, 2003) but is found at low concentration in the inner tissues and this is in agreement with the present investigation. Chlorogenic acid, an ester of caffeic acid is the second and fourth most abundant phenolic compound in purple peel and white peel sweet potato respectively. It has been reported that chlorogenic acid has the ability to lower blood pressure in mildly hypertensive patients, and its derivatives have shown to lower blood pressure in hypertensive rats (Cheplick *et al.*, 2010). The result further revealed that isoquercitrin (1.86%) and quercitrin (1.79%) are the most abundant phenolic compounds in flesh of purple and white skinned sweet potato. They also have long been recognized to possess anti-inflammatory, antiallergic, hepatoprotective, antithrombotic, antiviral and anticarcinogenic activities (Tapas *et al.*, 2008). Quercetin has been reported to exhibit both anti-infective and anti-replicative abilities. Quercetin, in particular, inhibits both cyclooxygenase and lipoxygenase activities, thus diminishing the formation of these inflammatory metabolites (Robak and Gryglewski, 1996).

The carbohydrate content of white and purple skinned sweet potato peels and flesh is as shown in Table 3. The carbohydrate content (%) ranked between 43.88 and 65.17, protein content (%) ranked between 4.96 and 8.40, while the fat content ranked between 11.77% and 23.17%. The result revealed a higher value of carbohydrate in the flesh and a higher value of fat and protein in peels of the evaluated sweet potato. Higher value of carbohydrate in the flesh of the evaluated sweet potato is as expected because sweet potato peel consists mainly of alcohol-insoluble matter (Mahmood *et al.*, 1998), with a high amount of dietary fiber content. The ash content (%) ranked between 1.47 and 5.40, while fiber content (%) ranked between 2.52 and 8.92, with a higher value in peels compared to the flesh of the evaluated sweet potato. This is in agreement with previous reports (Mahmood *et al.*, 1998; Barros *et al.*, 2012), establishing high fibre and ash content in plant food peels. Dietary fiber serves as a useful tool in the control of oxidative processes in food products and as functional food ingredient (Mandalari *et al.*, 2010) useful in protection against cardiovascular disease, colorectal cancer and obesity. Dietary fiber also decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes (Cust *et al.*, 2009). In general, the nutritional value of potato peels depends strongly on the peeling process and this may be responsible for the high fat and protein content that was recorded for the peels in both white and purple skinned potato that were obtained manually. The result further showed that the highest proximate index in the evaluated purple and white skinned sweet potato is carbohydrate and this is in agreement with previous reports (O’Hair and Martin, 1984).

The result of the mineral composition of the peels and flesh of the investigated sweet potatoes is as shown in Table 4. The result revealed that sweet potato is a good source of essential minerals with higher values in most of the evaluated minerals in the peels compared to the flesh. Potatoes are sources of different dietary minerals providing 18% dietary requirement of potassium, 6% of iron, phosphorus and magnesium, and 2% calcium and zinc (True *et al.*, 1979). The high amount of minerals in the peels of sweet potato is in agreement with previous reports establishing high values of minerals in plant food peels (True *et al.*, 1979; Barros *et al.*, 2012). Epidemiological studies have identified an inverse association between dietary intake of potassium and blood pressure (He and Whelton, 1997) and that magnesium plays an important role in insulin action (Paolisso *et al.*, 1990). Hypomagnesaemia may impair insulin secretion and promote insulin resistance in the diabetic patient (Sheehan, 1992). Calcium enhances the development of bones and teeth and helps in the formation of blood, intra cellular and extra cellular fluids within and outside the cells of the tissues (Mahan and Escott-Stump, 2004).

The starch: sugar ratio and amylose: amylopectin ratio content is presented in Table 5. Starch is composed of two major polysaccharides, amylose and amylopectin (Birkett and Brown, 2007). The result revealed a higher amylose-amylopectin ratio for purple skinned sweet potato flesh and peels compared with the peels and flesh obtained from white skinned sweet potato, while the flesh of white skinned sweet potato have the highest starch- sugar ratio. Behall and Howee (1995) reported that the consumption of high amylose: amylopectin foods normalized insulin response and even lowered glucose response. This by implication is that purple skinned sweet potato peels and flesh would be a valuable nutraceutical that could of immense benefits to diabetic patients.

Table 5: Starch: Sugar and Amylose: Amylopectin ratios of purple peel, purple flesh, white peel and white flesh sweet potato

Sample	Starch (%)	Sugar (%)	Starch: Sugar (%)	Amylose (%)	Amylopectin (%)	Amylose: Amylopectin
WPSP	65.71±0.58 ^d	22.32±0.05 ^d	2.95±0.03 ^a	92.18±0.20 ^c	7.72±0.06 ^b	11.94±0.09 ^c
WFSP	62.24±0.10 ^c	9.42±0.39 ^a	6.61±0.25 ^c	81.41±0.22 ^a	18.62±0.23 ^d	4.37±0.04 ^a
PPSP	48.51±0.32 ^a	12.50±0.23 ^b	3.88±0.05 ^b	93.20±0.11 ^d	6.81±0.11 ^a	13.67±0.23 ^d
PFSP	54.14±0.54 ^b	20.12±0.14 ^c	2.69±0.01 ^a	88.18±0.06 ^b	11.78±0.09 ^c	7.48±0.06 ^b

Means ± SE followed by different letter in a column are significantly different (p < 0.05) by Turkey Test

CONCLUSION

The high flavonoid and phenolic content, radical scavenging activities, phenolic composition, some essential minerals and amylose-amylopectin ratio in the peels of the studied sweet potato is an indication that leaving the potato skin intact during will contribute to the nutraceutical potentials and could be explored in the management of free radical mediated disorders.

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