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Chemical Compositions and Antioxidant Properties of Orange Fleshed Sweet Potato Leaves and the Consumer Acceptability in Vegetable Soup

Olufunmilayo Sade Omoba, Ganiyat Ololade Oyewole, and Rebecca Olajumoke Oloniyo

Department of Food Science and Technology, Federal University of Technology, Akure 34002, Nigeria

ABSTRACT: The purpose of this study is to determine the chemical compositions, anti-nutrient compositions, antioxidant properties, and phenolic profile of the leaves of orange fleshed sweet potato varieties [King J (UMUSPO1) and mother's delight (UMUSPO2)] in Nigeria and their suitabilities in soup preparation. Freshly harvested leaves of the two varieties of orange fleshed sweet potato were sorted, cleaned, dried, and milled into powder. The dried leaves were assessed for their chemical compositions *viz* proximate and mineral compositions, the anti-nutrient compositions, antioxidant properties, and phenolic profile. The overall acceptability of the leafy vegetables in the preparation of a local soup (*Edikang Ikong*) was evaluated. The ash, fat, and protein contents of UMUSPO1 leaves were higher than UMUSPO2, similarly UMUSPO1 leaves had higher mineral contents. Phytate and saponin contents were higher in UMUSPO2, however, the calculated molar ratios were below critical levels. The 2,2-diphenyl-1-picrylhydrazyl hydrate radical scavenging activity and ferric reducing antioxidant power assay were higher in UMUSPO1. Seven phenolic compounds were identified and quantified in both leaves with gallic acid being the most abundant. The taste of soup prepared with UMUSPO2 was rated higher, however, no significant difference was observed in the overall acceptability of the soups. The two leaves are good sources of nutritional antioxidants and can be suitable for the management of some disease conditions linked to oxidative stress.

Keywords: antioxidants, chemical compositions, orange-fleshed sweet potato leaves

INTRODUCTION

Leaf vegetables (leafy greens, vegetable greens, or greens) are leaves of plants which are consumed as vegetables and seldom go along with soft edible petioles and shoots. Leafy vegetables support and protect health due to the natural presence of bioactive compounds, such as polyphenols in plants. Plant polyphenols are a class of naturally occurring water soluble phenolic compounds suitable for optimum human health benefits (Omoba et al., 2019), and they are increasingly recognized owing to their abundance in fruits and vegetables. Traditionally, leafy vegetables are cooked and eaten as relish together with a starchy staple food in Africa. The dish can be prepared with a single plant's species or a combination of different species of vegetables for improved flavour, taste, and aesthetic appeal (Fasuyi, 2006). Local vegetables provide exceptional opportunities to diversify farming systems by guaranteeing food security and alleviating poverty as it increases income for farmers and improves health status. They are important sources of micronutrients such as Ca, Fe, Mg, K, Se, Na, Zn, and vitamins A, B_6, B_{12}, C, D, E, and K, as well as biotin, folic acid, niacin, pantothenic acid, and riboflavin, to mention a few. Traditional African leafy vegetables include waterleaf, spinach, pumpkin leaf, amaranths, cowpea leaves, sweet potato leaves, etc.

Sweet potato (*Ipomoea batatas*) is of great nutritional and health significance, mainly due to its beta-carotene and anthocyanin properties, and they are rich in dietary fibre, vitamins, and antioxidants (Yildirim et al., 2011). In Nigeria, they are mostly grown for their sweet tubers leaving the leaves for animal feed. Different varieties of sweet potato cultivars are cultivated and consumed worldwide. These cultivars contain different skin colours (pink, green, orange, and white) and flesh colour such as white, cream, orange, and yellow (Rose and Vasanthakaalam, 2011). Orange fleshed sweet potato (OFSP) is an improved breed of sweet potato with orange colour flesh and skin (Neela and Fanta, 2019). It is gaining attention in Nigeria because of its superior ability to decrease vitamin A defi-

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Correspondence to Olufunmilayo Sade Omoba, Tel: +234-706-488-0493, E-mail: osomoba@futa.edu.ng
Author information: Olufunmilayo Sade Omoba (Professor), Ganiyat Ololade Oyewole (Graduate Student), Rebecca Olajumoke Oloniyo (Researcher)

ciency while providing significant amounts of minerals (Fe, Zn, and Mn), vitamins B and C, fiber, and other micronutrients, such as polyphenols and carotenoids (Low et al., 2007). The leaves grow in large quantities on poor, wet, and rich soil, and could be continuously harvested until their roots are harvested. Sweet potato leaves are functional food capable of offering protection from degenerative diseases linked to oxidation such as cancer, allergies, aging, human immunodeficiency virus infection, and cardiovascular problems (Islam, 2006). However, the consumption of sweet potato leaves as vegetables is not popular in Nigeria unlike other Africa countries such as Ghana and Kenya, and in Asia such as Taiwan and China (Mosha and Gaga, 1999). The poor acceptability and consumption of sweet potato leaves as accomplices with starchy food, might be attributed to the erroneous belief that it is inferior in taste and nutritional value compared to vegetables such as waterleaf, spinach, amaranthus, etc. Many researchers have reported the nutritional compositions of sweet potato leaves (Ishiguro et al., 2004; Islam, 2006; Hue et al., 2012) from other countries, but there is dearth of information on the leaves of Nigerian varieties of sweet potato, especially orange fleshed sweet potato leaves. This study, therefore, seeks to provide information on the chemical compositions, phenolic profile, and antioxidant properties of leaves from two orange fleshed sweet potato varieties in Nigeria and their consumer acceptability in a soup preparation.

MATERIALS AND METHODS

Collection and preparation of vegetable samples

Leaves from the two varieties of orange-fleshed sweet potato [King J (UMUSPO1) and mother's delight (UMUSPO2)] used in this study were harvested from a local farm in Oba-Ile (latitude: 7.267 and longitude: 5.250), Akure North, Ondo State, Nigeria. Large surface area leaves were harvested in August 2017 during the raining season, the leaves were sorted, thoroughly washed in tap water, chopped using a kitchen knife and dried in a ventilating oven for 72 h at 40°C (the drying temperature and time employed were obtained through a preliminary study). The dried samples were finely milled into powder, vacuum sealed, and stored in an airtight container at room temperature prior to analysis.

Finely powdered dried leaf samples used for antioxidant assays were extracted with distilled water and 50% aqueous methanol in a sonication bath for 20 min (1.0 g sample/20 mL extraction solvent), concentrated in a rotary vacuum evaporator (Büchi, Flawil, Switzerland) at a temperature of 30°C, and transferred to sample bottles. The concentrated extracts were then dried to a constant weight under a stream of cold air at room temperature (22°C) and kept in the dark at 10°C until used in the assays. The dried extracts were re-dissolved in 50% aqueous methanol to a known concentration and immediately used for the determination of antioxidant capacities.

Proximate composition of orange fleshed sweet potato leaves

The proximate composition [moisture (AOAC 929.02), protein (AOAC 975.17), fat (AOAC 973.22), crude fibre (AOAC 962.09C), and ash (AOAC 922.02)] of milled leaves was determined using the standard method of AOAC (2010). Total carbohydrate was calculated by difference. The total energy content was obtained using Atwater conversion factors (Nguyen et al., 2007).

$$\text{Total energy (kcal/100 g)} = (4\times\%\text{ protein}) + (9\times\%\text{ fat}) + (4\times\%\text{ carbohydrate})$$

Mineral composition of orange fleshed sweet potato leaves

The ash content for the samples were determined by complete burning in a muffle furnace at 600°C for 3 h, using the official method of AOAC (2010). Na and K levels for the samples were determined using a flame emission photometer with NaCl and KCl as standards. All other metals were determined by atomic absorption spectrometry (AAS).

Anti-nutrient analysis of orange fleshed sweet potato leaves

Phytate content was determined according to Wheeler and Ferrel (1971), tannin content was determined as described by Makkar and Goodchild (1995), spectrophotometric method was used for saponin determination as described by Brunner (1984). The oxalate content was determined as described by Day and Underwood (1986).

Molar ratio of phytate to minerals

The moles of phytate and minerals were determined by dividing the weight of phytate and minerals with its atomic weight (phytate, 660 g/mol; Fe, 56 g/mol; Zn, 65 g/mol; Ca, 40 g/mol). The molar ratio between phytate and minerals was obtained after dividing the moles of phytate with the moles of each minerals (Norhaizan and Nor Faizadatul Ain, 2009).

$$\text{Molar ratio} = \frac{P_A/M_{wPA}}{M_{min}/M_{wmin}}$$

where P_A is calculated phytate content, M_{wPA} is phytate molecular weight, M_{min} is mineral content, and M_{wmin} is mineral molecular weight (Zn=65, Fe=56, and Ca=40).

Antioxidant assay of orange fleshed sweet potato leaves

The total phenols content of the dried leaves was determined using the Folin-Ciocalteu method (Singleton et al., 1999). The standard used was gallic acid and the results which were determined in triplicate were expressed as mg/100 g. The ferric reducing antioxidant power assay was determined as described by Benzie et al. (1999). The free radical scavenging ability of the extracts against 2,2-diphenyl-1-picrylhydrazyl hydrate (DPPH) were evaluated as described by Gyamfi et al. (1999). The Fe^{2+} chelating ability of the extracts were determined using a modified method of Minotti and Aust (1987), with slight modification as described by Puntel et al. (2005).

Identification of phenolic profile using high pressure liquid chromatography (HPLC)

***Reagents and reference samples*:** The reagents used as reference compounds *viz* gallic acid, gentisic acid, tyrosol, catechin, vanillic acid, caffeic acid, chlorogenic acid, syringic acid, epicatechin, *p*-coumaric acid, ferulic acid, *o*-coumaric acid, rutin, and 7-glucoside of apigenin and quercetin were obtained from Sigma Aldrich Co. (Steinheim, Germany); hydroxytyrosol, verbascoside, oleuropein, 7-*O*-glucoside of luteolin, 4-*O*-glucoside of luteolin, luteolin, and *m*-coumaric acid were obtained from renowned chemical company. 2,4-dihydroxybenzoic acid and naringenin were obtained from Alfa Aesar Co. (Ward Hill, MA, USA). Distilled water was used throughout.

***Separation, identification, and quantification of phenolic compounds*:** Phenolics were extracted as described by Mitsopoulos et al. (2016). The extract was analyzed by HPLC. Elution was injected in an analytical HPLC unit (Jasco Corporation, Tokyo, Japan) using a reverse-phase Spherisorb ODS-2/C18 (250×4.6 mm, and 5 μm particle size column; Waters Corporation, Milford, MA, USA). The solvent system according to Cai et al. (2004) was acetic acid aqueous solution (2.2%) (A) and methanol (B), starting with 95% A and installing a gradient to obtain 70% A at 15 min, 65% A at 40 min, 60% A at 50 min, 55% A at 55 min, 50% A at 60 min, 45% A at 70 min, and 100% A at 100 min. The flow rate was 1 mL/min and the injection volume was 20 μL. The identification of the chromatographic peaks was performed by comparing the retention times of the samples with the corresponding times of the reference compounds and by recording the UV spectra of the peaks in the range of 250~400 nm. Phenolic quantification was accomplished using the external standard method for each of the identified compounds. The data was processed using the Jasco Chrompass Version 1.7.403.1 software (Jasco Corporation).

Sensory evaluation of '*Edikang Ikong*' soup prepared from orange fleshed sweet potato leaves

The sensory experimental protocol was approved by the Ethics Committee at School of Agriculture and Agricultural Technology, Federal University of Technology, Akure, Nigeria (FUTA/SAAT/2019/013) and conformed to the ethical principles set forth in the Declaration of Federal Government of Nigeria. Ingredients used in the preparation of '*Edikang Ikong*' soup are as follows:

1 kg *ugwu* (pumpkin leaves)+200 g water leaves or sweet potato leaves+500 g of assorted meat (cow tripe, snails, cow's skin)

Stockfish: 250 mL of palm oil+28 g of ground crayfish+2 stock cubes+228 g of onions+2 fresh pepper (48 g)+5 g of salt

***Cooking instruction for 'Edikang Ikong' soup*:** The vegetables (*ugwu*, waterleaves, or sweet potato leaves) were washed, shredded, and kept aside. The assorted meat and stock fish are also washed, cut into bite size pieces, and placed in the pot. Little amount of water was added along with the chopped onions and the stock cube, cooking was done until soft and tender meat pieces were obtained. The palm oil, ground pepper, and crayfish were added to the soft meat in the pot and left to boil for 10 min, after which the water leaves or sweet potato leaves were added and allowed to cook for 3 min. The *ugwu* leaves and salt were then added, the vegetable soup was stirred thoroughly and allowed to cook for 5 min on low heat.

Sensory evaluation of '*Edikang Ikong*' soup cooked using the two varieties of OFSP leaves or water leaves was carried out using 30 panelists, recruited randomly comprising of students (18 males and 12 females) from Federal University of Technology, Akure, Ondo state, Nigeria. The criteria for selection were that panelists were regular consumers of the soup and neither sick nor hungry. Panelists were trained in the use of sensory evaluation procedures and the sensory sessions were carried out at ambient temperature in a sensory room furnished with white fluorescent lighting. The "*Edikang Ikong*" vegetable soups (75 g) were served to panelists hot (70°C) in see-through plastic glasses, and the panel sessions were held around 12~13 h in the morning. The samples were coded with 3-digit random numbers and presented in identical plastic glass containers. Panelists were seated in individual sensory booths and were provided with a glass of deionized water to rinse their palates which was used to rinse the mouth before tasting the soup sample. A rest period of 1 min was scheduled between samples, paper towels and small containers (where panelist can expel the sample) were also provided because swallowing the vegetable sample will affect the sensory of subsequent samples. Panelists were requested to rate the soup for taste, colour, texture, appearance, and overall acceptability by assigning a score based on a nine-point hedonic scale (dislike extremely at 1 and like extremely at 9).

Statistical analysis

Data were analyzed by analysis of variance (ANOVA) using SPSS version 16.0 software (SPSS Inc., Chicago, IL, USA). All analyses were carried out in triplicate. The results were presented as mean±standard deviation (SD) of 3 determinations. The means were separated using Turkey's test. Level of significance was set at $P<0.05$.

RESULTS AND DISCUSSION

Table 1 presents the proximate composition of king J (UMUSPO1) and mother's delight (UMUSPO2) leaves. The moisture contents of vegetables are 85.12% and 84.71% for UMUSPO1 and UMUSPO2, respectively. These values compared favorably with previous authors on sweet potato leaves (Antia et al., 2006; Oduro et al., 2008). High moisture content depicts high water activity needed for metabolic activities, hence reduced storage life. UMUSPO1 also exhibited the highest ash content (15.49%) compared to UMUSPO2, and this implies that UMUSPO1 might have higher mineral content than UMUSPO2. The ash contents of the leaves are greater than values 9.7 to 14.8% reported by Nkongho et al. (2014) for Cameroon sweet potato leaves and 8.71 to 11.60% reported by Oduro et al. (2008) for *Moringa oleifera* and *Ipomea batatas* leaves. Varietal and climatic differences may be responsible for the disparity. The crude fibre contents of 4.50 and 4.90% obtained for the leaves of OFSP were low compared to the values obtained by Nkongho et al. (2014) who reported 7.2%. The low fibre content of the OFSP leaves coupled with the reported high moisture content are responsible for the tender nature of the leaves, which suggest that it might be easily digestible. The protein content of OFSP leaves were 30.07 and 25.00% for UMUSPO1 and UMUSPO2, respectively, and these values are comparable with values reported for leaves of some species of sweet potato which ranged from 15 to 27% (Nkongho et al., 2014) and values above 20% reported by Oduro et al. (2008). OFSP leaves therefore might be regarded as a good source of protein. Underweight is a sign of protein energy malnutrition (PEM) especially in children. According to UNICEF (2006), 28% of children under-5 years in sub-Saharan Africa are moderately or severely underweight. Encouraging the consumption of OFSP leaves as vegetables might reduce the incidence of PEM in sub-Saharan Africa (especially Nigeria). The carbohydrate contents were 48.50 (UMUSPO1) and 55.65% (UMUSPO2), with UMUSPO2 having the highest carbohydrate content. Fat contents were 1.44 and 1.74% for UMUSPO1 and UMUSPO2, respectively; fat content compares with values previously reported for sweet potato leaves, 0.38～1.91% (Oduro et al., 2008) and lower than values 2.1 and 2.3% reported for local and exotic sweet potato leaves (Nkongho et al., 2014). The low-fat content would be of numerous health benefits as it reduces the risk of obesity and some cardiovascular disease (Kris-Etherton et al., 2002; Sharma et al., 2012). The calculated energy values were 327.24 and 338.26 kcal/100 g for UMUSPO1 and UMUSPO2, respectively, and these values compares favorably with values obtained for other vegetables, 354.20, 363.60, and 319.80 kcal/100 g for the leaves of *Telfairia occidentalis*, *Moringa oleifera*, and *Brassica oleracea*, respectively (Iyaka et al., 2014), and 300.94 kcal/100 g for water spinach leaves (Umar et al., 2007).

Table 1. Proximate composition of leaves of king J (UMUSPO1) and mother's delight (UMUSPO2) varieties of orange fleshed sweet potato (dry matter basis) (unit: g/100 g)

Proximate compositions	UMUSPO1	UMUSPO2
Moisture content	85.12±0.08[a]	84.71±0.05[b]
Ash content	15.49±0.06[a]	12.71±0.01[b]
Crude fibre content	4.50±0.02[b]	4.90±0.03[a]
Protein content	30.07±0.09[a]	25.00±0.08[b]
Carbohydrate	48.50±0.06[b]	55.65±0.03[a]
Fat	1.44±0.06[b]	1.74±0.04[a]
Calculated energy value (kcal/100 g)	327.24±0.05[b]	338.26±0.07[a]

Results are mean±SD of triplicates data.
Means with different letters (a,b) within the same row are significantly different ($P<0.05$).

Mineral composition and mineral ratio

The mineral compositions and mineral ratios are presented in Table 2. The Na contents for were 29.66 and 20.02 mg/100 g while K contents were 39.80 and 29.17 mg/100 g for UMUSPO1 and UMUSPO2, respectively. These values are low compared to values obtained for *Telfairia occidentalis*, *Moringa oleifera*, and *Brassica oleracea* (Iyaka et al., 2014), and for *Amaranthus viridis* and *Alternanthera sessilis* (Kumar et al., 2016). Na and K are vital cations involved in the regulation of plasma volume, acid-base balance, and nerve and muscle contraction. Diets rich in K are known to reduce the risk of kidney stone because the naturally occurring K salts in plant foods neutralizes acidity in the blood stream.

The Ca contents of OFSP vegetables were 315.00 (UMUSPO1) and 213.52 (UMUSPO2) mg/100 g. Ca is an important constituent of bones and teeth, and functions effectively in the regulation of nerve and muscle. Zn contents of the OFSP leafy vegetables were 5.75 and 4.32 mg/100 g for UMUSPO1 and UMUSPO2, while the Fe contents were 16.36 (UMUSPO1) and 15.34 (UMUSPO2) mg/100 g.

Vegetables are the cheapest sources of micronutrients crucial for the functioning of the immune system, physical, and mental development as well as other metabolic

Table 2. Mineral composition of leaves of king J (UMUSPO1) and mother's delight (UMUSPO2) varieties of orange-fleshed sweet potato (dry weight basis) (unit: mg/100 g)

Mineral composition	UMUSPO1	UMUSPO2
Na	29.66±0.02[a]	20.02±0.03[b]
K	39.80±0.02[a]	29.17±0.01[b]
Ca	315.00±0.17[a]	213.52±0.15[b]
Zn	5.75±0.01[a]	4.32±0.04[b]
Fe	16.36±0.03[a]	15.34±0.01[b]
Na : K ratio	0.74	0.68

Results are mean±SD of triplicates data.
Means with different letters (a,b) within the same row are significantly different (P<0.05).

processes in humans. Their operation as a dietary source of mineral is influenced by its mineral-mineral interaction, which affects the bioavailability of certain minerals in the body. The Na to K ratios obtained in this study are 0.74 (UMUSPO1) and 0.68 (UMUSPO2), which are less than 1, and is recommended for the prevention of high blood pressure (Perez and Chang, 2014). This suggest that, regular consumption of OFSP leaves as vegetables could lower high blood pressure.

Anti-nutrient composition and phytate:mineral molar ratio of leaves

Tannin content for the two varieties of OFSP leafy vegetables are 0.22 (UMUSPO1) and 0.19 (UMUSPO2) mg/100 g (Table 3). No significant difference was observed in the tannin contents of the vegetables. The tannin contents of the leafy vegetables are low and would not be able to form complexes with carbohydrates and proteins when consumed. Tannins are however known to be bioactive substances with nutraceutical properties. The oxalate content of the OFSP leaves are 0.36 (UMUSPO1) and 0.49 (UMUSPO2) mg/100 g. UMUSPO2 had the highest oxalate content and it compares favorably with values reported for some leafy vegetables in Southeast Nigeria (Chima and Igyor, 2007). Low oxalate values are of advantage as a high oxalate diet can increase the risk of renal Ca absorption. Oxalates make Ca unavailable by binding the Ca ion to form an insoluble Ca oxalate complex.

The phytate contents are 0.70 (UMUSPO1) and 1.05 (UMUSPO2) mg/100 g, while the saponin contents are 217.56 (UMUSPO1) and 220.35 (UMUSPO2) mg/100 g (Table 3). Phytic acid is an antioxidant, but it inhibits absorption of minerals as it chelates multivalent metal ions (Zn, Ca, and Fe); it is therefore a strong inhibitor of Fe-mediated free radical generation (Schlemmer et al., 2009). The phytate contents reported in this study for the OFSP leafy vegetables are low, which is of nutritional advantage, since diets high in phytate content reduces the bioavailability of Zn, Fe, and Ca. It can also negatively interfere with the digestibility of proteins and starches (Selle

Table 3. Anti-nutrient composition and phytate : mineral molar ratio of leaves of king J (UMUSPO1) and mother's delight (UMUSPO2) varieties of orange-fleshed sweet potato (dry weight basis) (unit: mg/100 g)

	UMUSPO1	UMUSPO2
Anti-nutrients		
Tannin	0.22±0.04[ns]	0.19±0.02
Oxalate	0.36±0.05[b]	0.49±0.01[a]
Phytate	0.70±0.01[b]	1.05±0.03[a]
Saponin	217.56±0.38[ns]	220.35±0.18
Phytate : molar ratio		
Phytate : Ca	0.0001	0.0003
Phytate : Fe	0.004	0.004
Phytate : Zn	0.02	0.02
Phy × Ca/Zn	0.09	0.13

Results are mean±SD of triplicates data.
Means with different letters (a,b) within the same row are significantly different (P<0.05).
[ns]Not significant.

and Ravindran, 2007). Onomi et al. (2004) reported that phytates should be lowered as much as 25 mg or less per 100 g for best health.

One of the proxies for estimating bioavailability of nutrients is in calculating phytate : mineral molar ratios, the lower the values the higher the bioavailability of the micronutrients. The calculated molar mass of phytate/Ca ratio in the two samples were below the critical level of 2.5 known to impair Ca bioavailability (Hassan et al., 2007). For Fe bioavailability, the phytate/Fe ratio should be <14, higher than this will intensely impair Fe bioavailability. The calculated phytate/Fe and phytate/Zn ratios of the vegetables were below the critical level, depicting that the bioavailability of the micronutrients will not be impaired with the consumption of the vegetables.

Antioxidant properties of leaves

The antioxidant assay of UMUSPO1 and UMUSPO2 leaves is shown in Table 4. Total phenol obtained for UMUSPO1 and UMUSPO2 leaves are 7.69 and 7.33 mg gallic acid equivalent (GAE)/g, respectively, and no significant difference (P>0.05) was observed between the two vegetables. The total phenol contents obtained were lower than values reported for other medicinal plants such as hibiscus (29.96 mg GAE/g) and ginger (39.06 mg GAE/g) as reported by Ghasemzadeh et al. (2010). The difference might be attributed to the variance in the polarities of solvents used in extraction as well as cultivars. Phenols are capable of scavenging free radicals in the body thereby smaintaining a healthy body.

UMUSPO1 leaves exhibited higher ferric reducing antioxidant power (FRAP) at 15.51 mg Trolox equivalent/g and also DPPH scavenging activity (60.51%) than UMUSPO2. These two methods are known to measure the total antioxidant capacity of the vegetables. The Fe^{2+} chelating activity of the leaves [55.08 (UMUSPO1) and

Table 4. Antioxidant assays of leaves of king J (UMUSPO1) and mother's delight (UMUSPO2) varieties of orange-fleshed sweet potato (dry weight)

Vegetable samples	Total phenol content (mg GAE/g)	FRAP (mg TE/g)	DPPH scavenging activity (%)	Fe^{2+} chelating activity (mg/g)
UMUSPO1	7.69±0.08^{ns}	15.51±0.29^{a}	60.51±0.20^{a}	55.08±0.20^{ns}
UMUSPO2	7.33±0.00	12.25±0.19^{b}	56.95±0.01^{b}	56.51±0.47

Results are mean±SD of triplicates data.
Means with different letters (a,b) within the same column are significantly different (P<0.05).
GAE, gallic acid equivalent; FRAP, ferric reducing antioxidant power; TE, Trolox equivalent; DPPH, 2,2-diphenyl-1-picrylhydrazyl hydrate.
^{ns}Not significant.

Table 5. Phenolic profile of leaves of king J (UMUSPO1) and mother's delight (UMUSPO2) varieties of orange-fleshed sweet potato (unit: μg/mL)

Vegetable samples	Tannic	Gallic	Vallic	Caffeic	Ferulic	Cinamic	Salicylic
UMUSPO1	5.06±0.01^{b}	9.36±0.01^{a}	0.06±0.00^{ns}	1.56±0.01^{a}	1.37±0.00^{b}	0.02±0.00^{b}	0.003±0.00^{b}
UMUSPO2	5.36±0.01^{a}	8.65±0.01^{b}	0.05±0.01	1.37±0.00^{b}	1.47±0.01^{a}	0.03±0.00^{a}	0.004±0.00^{a}

Results are mean±SD of triplicates data.
Means with different letters (a,b) within the same column are significantly different (P<0.05).
^{ns}Not significant.

56.51 (UMUSPO2) mg/g] are of great significance, because the transition metal ions contribute to the oxidative damage in neurodegenerative disorders like Alzheimer's and Parkinson's diseases (Aparadh et al., 2012). The values indicated the tendency of the vegetable leaves to reduce Fe^{3+} to Fe^{2+}, no significant difference was observed between the two species. The two vegetable leaves have substantial amounts of total phenolic compounds and consequently demonstrate important antioxidant activities. FRAP confirms the antioxidant potential of the leaves; the assay involves the reduction of ferric tripyridyl triazine complex to ferrous form (which has an intense blue colour) and this could be monitored by measuring the change in absorption at 593 nm. Similarly, DPPH free radical method is an antioxidant assay based on electron-transfer that produces a violet solution in ethanol.

Table 5 revealed the HPLC phenolic profile (μg/mL) of the UMUSPO1 and UMUSPO2 varieties of orange-fleshed sweet potato leaves. Quantitative estimation showed seven phenolic compounds namely: tannic, gallic, vallic, caffeic, ferulic, cinnamic, and salicylic. The most abundant phenolic compounds were gallic acid [9.36 (UMUSPO1) and 8.65 (UMUSPO2) μg/mL] and tannic acid [5.06 (UMUSPO1) and 5.36 (UMUSPO2) μg/mL]. Gallic acid is an organic acid, also known as 3,4,5-trihydroxybenzoic acid, found in gallnuts, sumac, witch hazel, tea leaves, oak bark, sweet potato leaves, and other plants. It is commonly used in the pharmaceutical industry for its anti-inflammatory and anti-diarrhea effect (Reynertson et al., 2008; Tapas et al., 2008).

Sensory evaluation of *Edika Ikong*

Table 6 revealed the sensory evaluation of the *Edikang Ikong* soup produced by complete replacement of water leaves (*Talinum triangulare*) with UMUSPO1 and UMUSPO2 sweet potato leaves while the control soup was prepared using water leaves as practiced traditionally. The colour ranged from 7.13∼7.40 (liked moderately); taste ranged from 6.80∼7.53 (liked moderately), texture ranged from 6.93∼7.46 (liked moderately), and aroma ranged from 7.13∼7.33 (liked moderately). No significant difference (P>0.05) existed between the soups in all sensory parameters as well as the overall acceptability except for taste. This observation corroborates the findings of Michon et al. (2010) who observed that even though there are differences in the sensory properties of the fish

Table 6. Sensory evaluation of "*Edikang Ikong*" soup from *ugwu* leaves with varieties of orange fleshed sweet potato leaves and *Talinum triangulare* as control

Vegetable samples	Colour	Taste	Texture	Aroma	Overall acceptability
Control	7.26±0.70^{ns}	7.46±0.64^{b}	7.20±1.01^{ns}	7.33±0.82^{ns}	7.64±0.74^{ns}
UMUSPO1	7.13±1.06	6.80±1.15^{c}	6.93±1.28	7.13±0.99	7.26±0.96
UMUSPO2	7.40±0.99	7.53±0.92^{a}	7.46±0.92	7.20±0.86	7.86±0.99

Results are mean±SD of triplicates data.
Means with different letters (a,b) within the same column are significantly different (P<0.05).
^{ns}Not significant.

soups, no difference was shown between the consumer liking/overall acceptability of the products. The taste of soup prepared with UMUSPO2 was rated higher than UMUSPO1 and the control (water leaves), implying that UMUSPO2 has the potential to completely replace water leaves in the preparation of *Edikang Ikong* soup. Colour is an imperative sensory quality of any food as its influences its acceptability while appearance is the visual quality of a food and the aroma is a sensory attribute that influences the acceptability of a food before it is tasted (Olubunmi et al., 2017). The complete replacement of water leaves with UMUSPO2 in the preparation of *Edikang Ikong* soup could therefore result in the preparation of acceptable vegetable soup rich in nutritional antioxidant properties capable of managing some disease conditions linked with oxidative stress.

The present study revealed the chemical, mineral compositions, and antioxidant properties of orange fleshed sweet potato leaves (UMUSPO1 and UMUSPO2). UMUSPO1 exhibited superior chemical, mineral compositions, and antioxidant properties than UMUSPO2. However the sensory evaluation showed that UMUSPO2 possesses a higher value in terms of taste compared to UMUSPO1 although no significant difference was observed in the overall acceptability. The potential use of the leaves (especially UMUSPO2) to completely replace water leaves in the preparation of a traditional *Edikang Ikong* soup was established in this study. The leaves are rich sources of nutritional antioxidants and are appropriate in the soup preparation. They could solve the problem of food security in developing countries especially Nigeria, and could also be efficient in the management of some disease conditions linked with oxidative stress.

AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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