EVALUATION OF THE NUTRITIONAL QUALITIES OF THE LEAVES OF *PARQUETINA NIGRESCENS, LAUNAEA TARAXACIFOLIA* AND *SOLANUM NIGRUM*

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ABSTRACT

Although previous studies have considered the composition of *Parquetina nigrescens*, *Launaea taraxacifolia* and *Solanum nigrum* individually, there is still a need to compare the nutrients distribution in these plants in order to enhance scientific knowledge on their human health benefits. The analyses' results showed that whereas the *L. taraxacifolia leaves* contain the highest level of ash and crude fibre, they have the least shelf life. The most beneficial Ca/P, Na/K and Zn/Cu ratios were respectively found in the *P. nigrescens*, *S. nigrum* and *L. taraxacifolia* leaves. Remarkably, the Cd and Pb contents of the three leaves were below the FAO/WHO Codex Alimentarius commission 2015 recommended maximum levels. Following the FAO/WHO/UNU requirement, only the composition of isoleucine, leucine and valine in the three leaves as well as the combination of phenylalanine and tyrosine in *L. taraxacifolia* and *S. nigrum* leaves were found to be above the required amount for all the age-brackets considered. *L. taraxacifolia* and *S. nigrum* leaves also had the highest concentration of vitamin A and C, respectively. Generally, this research revealed that the selected leaves are nutritionally rich with health-promoting advantages. Further investigation on *P. nigrescens* leaves to ascertain its safety for direct human consumption is, however, required.

Keywords: *Parquetina nigrescens*; *Launaea taraxacifolia*; *Solanum nigrum*; Essential Amino acids; Vitamins

INTRODUCTION

Plants are known to be essential sources of drugs (Sawadogo et al., 2012). In line with Edeoga et al. (2005), medicinal plants play important roles in human health, some of which are used as spices and food plants. Examples of such plants used in African traditional medicine are: *Parquetina nigrescens*, *Launaea taraxacifolia* and *Solanum nigrum*.

Parquetina nigrescens, a perennial plant which grows in secondary forest and around villages in Nigeria as well as Senegal (Oluwafemi and Debiri, 2008; Ayoola et al., 2011) is used by traditional healers in Nigeria (Ayoola et al., 2011). *Launaea taraxacifolia* is also one of the important traditional leafy vegetable, particularly in Nigeria (Sakpere et al., 2011), and according to Adinortey (2012), several authors have reported the application of this plant for the treatment of various diseases like conjunctivitis, yaws, measles as well as diabetes mellitus. In Ghana, the leaves of *L. taraxacifolia* are used as common vegetable, consumed as salad or cooked in soups and sauces (Adinortey, 2012). Meanwhile, in line with Atanu et al. (2011), *Solanum nigrum* is an African pediatric plant that is used for treating several ailments linked with infant mortality. *S. nigrum* is an herbaceous plant which has been used for food and medicinal purposes (Akubugwo, 2008; Wannang et al., 2008). In different parts of Africa, including Nigeria, the leaves are used to make soup, salad or eaten as spinach (Akubugbwo et al., 2008). It is consumed in Congo as green vegetables (Dhellot et al., 2006). In Nigerian folkloric medicine, the plant is used for the treatment of epilepsy (Wannang et al., 2008).

Although numerous attempts have been made by different researchers to assess the medicinal applications of the leaves of these plants and their individual nutritional levels, this paper provides additional information on their nutritional values as well as compares the nutrients distribution in these three plants in order to enhance scientific knowledge on their nutritional and medicinal potentials.

LITERATURE REVIEW

Parquetina nigrescens belongs to the Perplocaceae family (Guede et al., 2010) and is usefulness for the treatment of sickle cell anaemia (Imaga et al., 2010) and gastro-intestinal disorders (GIT) (Odetola et al., 2006) have been reported. It is also one of the three medicinal herbs used for the manufacture of Jubi Formula®, a commercial herbal preparation, which is said to be suitable as a nutritional supplement in stress, exhaustion and convalescent situations (Erah et al., 2003).

On the other hand, *Launaea taraxacifolia* (Compositae) known as Dandelion, a perennial herb and member of the Asteraceae family, is mainly found in the Tropics (Adinortey, 2012). The plant is referred to as wild lettuce (Adejuwon et al., 2014) as well as 'Efo yanrin' by the Yorubas in Southern Nigeria (Sakpere et al., 2011).

Solanum nigrum Linn., commonly referred to as Black Nightshade (Atanu et al., 2011) is a medicinal plant member of the Solanaceae family which comprises of many genera, noted for their therapeutic properties (Jain et al., 2011). The plant grows in Africa, Europe (Atanu et al., 2011) and America (Dhellot et al., 2006). It is mostly found near rivers, old walls (Dhellot et al., 2006), roadsides, fence rows, edges of woods and in cultivated lands (Atanu et al., 2011).

MATERIALS AND METHODS

Collection and Treatment of Samples

The three leaves samples were obtained within The Federal University of Technology, Akure, Ondo State, Nigeria campus and Akure metropolis. Identification and authentication of the vegetable leaves were carried out at the Crop, Soil and Pest Management Department of the University. Thereafter, they were washed, dried, ground and sieved prior to analysis.

Determination of Proximate Composition

The air-dried samples were analyzed for proximate composition (dry matter, ash, crude fat, crude fibre and crude protein contents) using the methods of Association of Official Analytical Chemists (AOAC, 1990). The dry matter content was determined by drying a known weight of the homogenized sample at 105^{o}C in an oven, until a constant weight was reached. For the total ash determination, the leaves' samples were weighed and converted to dry ash in a muffle furnace at 550^{o}C. The fat content was obtained by extraction with petroleum ether using a Soxhlet apparatus. Kjeldahl method was used for crude protein determination while the total carbohydrate content was obtained by difference. This was by deducting the total sum of the ash, crude fibre, crude protein and crude fat contents from 100% dry weight sample. The gross energy content (kcal/100 g) of the three leaves was calculated as described in FAO (2003) and Adinortey et al., (2012) which involved multiplying the percentages of the crude protein, crude fat and carbohydrate contents by 4.0, 9.0 and 4.0 respectively.

Determination of Minerals Contents

For the mineral analysis, sodium and potassium contents were determined via flame photometry using the JENWAY Flame photometer (PFP7 Model), phosphorus by vanado-molybdate method (AOAC, 1995) while the other minerals were determined after wet digestion using Atomic Absorption Spectrophotometer (BUCK 210 VGP model).

Determination of Amino Acids Profile

The amino acid profile of the leafy vegetables was determined by standard method described by Sparkman et al. (1958). The samples were dried to constant weight, defatted, hydrolysed, evaporated in a rotatory evaporator and loaded into the Technicon Sequential Multi-Sample Amino Acid Analyzer (TSM).

Determination of Vitamins Contents

Vitamin C content of the aqueous extract was determined according to the method described by Benderitter et al. (1998) while vitamin A was estimated using Pearson (1976) method.

Statistical Analyses

All data represent means of triplicate determinations and are expressed as mean ± standard deviation. The IBM Statistical Package for Social Scientists (Version 20) was used to carry out the One-way Analysis of Variance (ANOVA) of the results at 95% confidence level.

RESULTS

Proximate Analysis

In line with Emebu and Anyika (2011), including Andzouana and Mombouli (2012), moisture content is a common factor used in the processing and testing of food as well as a measure of water activity. In the present study, the moisture content (see Table 1) of the samples are also given in terms of their dry weight equivalence in Table 2 as the analysis of the composition of the samples are carried out on dry weight basis.

From the experimental result, the leaves of *L. taraxacifolia* had the significantly ($p < 0.05$) highest moisture, ash and crude fibre contents. *S. nigrum* leaves had the highest crude protein content while *P. nigrescens* had the highest ether as well as total carbohydrate contents as seen in Table 1. As shown in Table 2, *P. nigrescens* leaves had the significantly highest level of energy ($p < 0.05$).

Table 1: Proximate composition of the samples

Sample	Moisture content (%)	Ash content (%)	Crude Protein content (%)	Ether Extract content (%)	Crude Fibre content (%)	Total Carbohydrate content (%)
Parquetina nigrescens	12.4 ± 0.23[a]	15.4 ± 0.49[b]	20.6 ± 0.25[c]	15.8 ± 0.59[a]	11.9 ± 0.09[b]	24.1 ± 0.67[a]
Launaea taraxacifolia	16.4 ± 0.18[c]	19.3 ± 0.60[a]	23.3 ± 0.13[b]	15.0 ± 0.23[b]	18.3 ± 0.67[a]	7.83 ± 0.64[c]
Solanum nigrum	15.2 ± 0.20[b]	15.3 ± 0.36[b]	23.8 ± 0.18[a]	14.9 ± 0.33[b]	9.24 ± 0.23[c]	21.6 ± 0.74[b]

Values are the means of three replicates ± standard deviation.
Means followed by different letters are significantly different ($p < 0.05$) according to Tukey *post-hoc* test.

Table 2: Proximate composition g/100 g DW of the dried leaves (Energy measured in kcals/100 g)

Sample	Dry Weight	Ash content	Crude Protein content	Ether Extract content	Crude Fibre content	Total Carbohydrate content	Energy kcals/100 g
Parquetina nigrescens	87.6 ± 0.23[a]	13.4 ± 0.49[b]	18.0 ± 0.25[c]	13.8 ± 0.59[a]	10.4 ± 0.09[b]	21.1 ± 0.67[a]	321.0 ± 0.39[a]
Launaea taraxacifolia	83.6 ± 0.18[c]	16.1 ± 0.60[a]	19.5 ± 0.13[b]	12.5 ± 0.23[b]	15.3 ± 0.67[a]	6.56 ± 0.64[c]	259.5 ± 0.41[c]
Solanum nigrum	84.8 ± 0.20[b]	13.0 ± 0.36[b]	20.2 ± 0.18[a]	12.7 ± 0.33[b]	7.76 ± 0.23[c]	18.3 ± 0.74[b]	315.7 ± 0.34[b]

Values are the means of three replicates ± standard deviation.
Means followed by different letters are significantly different ($p < 0.05$) according to Tukey *post-hoc* test.

Minerals Content

Minerals' dietary importance is as a result of their physiological and metabolic functions in the body (Adjatin et al., 2013) in which green vegetables have been identified by Friday et al. (2011) as a good source. Vicente et al. (2009) and Odukoya (2015) also reported that vegetables have higher concentrations of minerals than fruits.

The analysis of the major dietary minerals in the samples considered in this study as shown in Table 3, indicated that there was no significant difference ($p > 0.05$) in the magnesium distribution in the three leaves. The level of sodium and potassium in the three leaves followed a similar pattern with *L. taraxacifolia* leaves having the highest concentration of these minerals and *P. nigrescens* leaves having the least. The leaves of *P. nigrescens* also had the least concentration of calcium and phosphorus.

Table 3: The distribution of the major dietary minerals (mg/kg DW) in the samples

Samples	Na	Mg	Ca	K	P
P. nigrescens	2.68 ± 0.01[c]	6.05 ± 0.21[a]	3.45 ± 0.07[b]	7.19 ± 0.01[c]	5.15 ± 0.07[c]
L. taraxacifolia	5.14 ± 0.01[a]	6.30 ± 0.14[a]	3.80 ± 0.14[a]	11.98 ± 0.02[a]	6.25 ± 0.07[b]
S. nigrum	3.37 ± 0.03[b]	6.25 ± 0.07[a]	4.00 ± 0.14[a]	9.22 ± 0.03[b]	7.05 ± 0.07[a]

Values are the means of three replicates ± standard deviation.
Means followed by different letters are significantly different ($p < 0.05$) according to Tukey *post-hoc* test.

Analysis of the minor dietary minerals' distribution in the three leaves (see Table 4), revealed that there was no statistically significant difference ($p > 0.05$) in the level of copper found in the three leaves. *S. nigrum* had the highest concentration of manganese and zinc while *P. nigrescens* had the least concentration of iron. The only significant difference ($p < 0.05$) in the nickel content was found between the *L. taraxacifolia* and *S. nigrum* leaves. Chromium and cobalt were, however, not detected in the three leaves and *L. taraxacifolia* leaves respectively.

Table 4: The distribution of minor dietary minerals and undesirable mineral contaminants* (mg/kg DW) in the samples

Samples	Cr	Mn	Co	Cu	Zn	Fe	Ni	Cd*	Pb*
P. nigrescens	ND	4.56 ± 0.11[c]	0.05 ± 0.01[a]	0.37 ± 0.01[a]	4.35 ± 0.06[b]	5.20 ± 0.14[b]	0.07 ± 0.02[a,b]	0.11 ± 0.02[b]	0.15 ± 0.01[b]
L. taraxacifolia	ND	4.92 ± 0.06[b]	ND	0.41 ± 0.05[a]	4.19 ± 0.13[b]	5.86 ± 0.15[a]	0.05 ± 0.02[b]	0.09 ± 0.01[a]	0.14 ± 0.01[b]
S. nigrum	ND	5.12 ± 0.11[a]	0.05 ± 0.01[a]	0.35 ± 0.01[a]	4.59 ± 0.13[a]	5.66 ± 0.14[a]	0.11 ± 0.01[a]	0.12 ± 0.01[b]	0.12 ± 0.01[a]

*Selected undesirable mineral contaminants analyzed in the samples.
Values are the means of three replicates ± standard deviation.
Means followed by different letters are significantly different ($p < 0.05$) according to Tukey *post-hoc* test.
ND = Not Detected.

On the other hand, heavy metals which are noted to have adverse effect on human (Sobukola et al., 2010) may accumulate in the edible and non-edible parts of vegetables (Jolly et al., 2013; Odukoya, 2015). These latter authors (i.e. Jolly et al., 2013 and Odukoya, 2015), also identified the soil-to-plant route as the key means by which human beings become exposed to metal contamination. Szefer and Nriagu (2007) and Odukoya (2015), specifically indicated cadmium and lead as part of the toxic metals that can be taken up by plants from the soil growing environment.

The statistical analysis of the levels of these selected undesirable contaminants in this study (cadmium and lead) in the three leaves (Table 4), indicated that *L. taraxacifolia* and *S. nigrum* leaves had the least concentration of cadmium and lead respectively.

Mineral Ratios

Among the three leaves, *P. nigrescens* leaves had the highest level of Ca/P ratio. Meanwhile, the highest Na/K ratio was found in *L. taraxacifolia* leaves which on the contrary had the least Zn/Cu ratio as shown in Table 5.

Table 5: Mineral ratios of the samples

Samples	Ca/P[1] ratio	Na/K[2] ratio	Zn/Cu[3] ratio
P. nigrescens	0.67 ± 0.01[a]	0.37 ± 0.00[b]	11.76 ± 0.16[b]
L. taraxacifolia	0.61 ± 0.01[b]	0.43 ± 0.00[c]	10.29 ± 0.95[a]
S. nigrum	0.57 ± 0.01[c]	0.36 ± 0.00[a]	13.11 ± 0.01[b]

[1]Ca/P ratio = Calcium: Phosphorus ratio.
[2]Na/K ratio = Sodium: Potassium ratio.
[3]Zn/Cu ratio = Zinc: Copper ratio.

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Values are the means of three replicates ± standard deviation.
Means followed by different letters are significantly different ($p < 0.05$) according to Tukey *post-hoc* test.

Amino Acids Distribution

Amino acids are organic substances with amino and acid groups (Wu, 2009). They are the building block of protein which assist in the growth/development of the body (Yisa et al., 2010) as well as affect the quantity and quality of protein (Moyo et al., 2011). As noted by Wu (2009), aside from the traditional classification of amino acids into essential and non-essential amino acids based on needs from the diet for nitrogen balance or growth, there should be another class of essential or conditionally essential amino acids based on functional needs. The amino acids under this latter category referred to as functional amino acids include: arginine, cysteine, glutamine, leucine, proline, and tryptophan (Wu, 2009).

Although a total of 24 amino acids comprising a number of essential, non-essential and functional amino acids were found in the three leaves (reported elsewhere), the investigation in this study is only focused on six of the essential amino acids, including the combinations of methionine and cysteine as well as phenylalanine and tyrosine. The values recorded in the samples were compared with the FAO/WHO/UNU patterns of requirement as provided in FAO (1991) (see Table 6).

Table 6: Comparison of the amino acids content of the samples with the FAO/WHO/UNU suggested patterns of requirements

Amino Acids	*P. nigrescens* Total Amino acid (g/100g)	*L. taraxacifolia* Total Amino acid (g/100g)	*S. nigrum* Total Amino acid (g/100g)	Pre-School Child (2-5 years)*	School-Child (10-12 years)*	Adult*
Histidine	2.21	1.89	2.14	(1.9)[a]	(1.9)	1.6
Isoleucine	4.00	3.74	3.93	2.8	2.8	1.3
Leucine	7.1	8.19	7.54	6.6	4.4	1.9
Lysine	3.62	4.00	4.16	5.8	4.4	1.60
Methionine + cysteine	1.83	1.95	2.00	2.5	2.2	1.7
Phenylalanine + tyrosine	5.89	6.88	7.72	6.3	2.2	1.9
Threonine	2.82	1.89	2.59	3.4	2.8	0.9
Valine	4.34	5.18	3.65	3.5	2.5	1.3

[a]Values in parentheses interpolated from smoothed curves of requirement versus age.
*Source: FAO (1991, p. 23)

Vitamins Contents

With respect to nutrition, vitamins which are complex organic compounds are important in the human diet as they are not synthesized in the body (Gaman and Sherrington, 1996; Odukoya, 2015). Although vegetables are considered a good source of vitamins (Taura and Habibu, 2009; Odukoya, 2015), this study was based on two of the most important vitamins in food science and technology – vitamin A (a fat-soluble vitamin) and vitamin C (a water-soluble vitamin) (Birch et al., 1986; Odukoya, 2015).

Vitamin A, an antioxidant (Bakare et al., 2010), is required for maintaining the skin, mucous membrane, bones, teeth, hair, vision and reproduction (Akubugwo et al., 2007). Meanwhile, vitamin C as noted by Ajatin et al. (2013) helps in the maintenance of health and prevention of diseases. This vitamin (i.e. vitamin C) also acts as an antioxidant, strengthens the immune system (Mensah et al., 2008) and according to Friday et al. (2011) is vital for the formation of healthy bones as well as teeth.

The statistical analysis results as shown in Table 7, revealed that *L. taraxacifolia* and *S. nigrum* leaves had significantly ($p < 0.05$) highest concentration of vitamin A and C respectively.

Table 7: Vitamins A and C contents of the samples

Samples	Vitamin A (units/g)	Vitamin C (g/100g)
Parquetina nigrescens	40.67 ± 0.53^{b}	1.12 ± 0.00^{c}
Launaea taraxacifolia	48.47 ± 0.64^{a}	3.66 ± 0.28^{b}
Solanum nigrum	18.30 ± 0.32^{c}	14.62 ± 0.00^{a}

Values are the means of three replicates ± standard deviation.
Means followed by different letters are significantly different ($p < 0.05$) according to Tukey *post-hoc* test.

DISCUSSION

Proximate Analysis

The result of the moisture content analysis as given in Table 1 with *L. taraxacifolia* leaves having the highest moisture content, showed that among the three studied leaves, *L. taraxacifolia* leaves are the most prone to microbial attack during storage with the least shelf life (Agbaire, 2011; Andzouana and Mombouli, 2012). It indicated that this plant (i.e. *L. taraxacifolia*) leaves need the most care in terms of preservation against deterioration (Kwenin et al., 2011).

Several authors, such as Iniaghe et al. (2009), Lewu et al. (2009), Bakare et al. (2010), Coimbra and Jorge (2011) as well as Andzouana and Monbouli (2012), as identified ash content as an indicator of the mineral content of samples. Hence, the result of the ash content determination on dry weight basis as shown in Table 2, revealed that the leaves of *L. taraxacifolia* with the significantly highest level of ash would contain the most nutritionally important minerals. Based on the information provided by Yisa et al. (2010) with respect to the report of several authors that green leafy vegetables in Nigeria have ash contents within the range of 9.20 to 10.83%, all the three leaves samples (i.e. the *P. nigrescens*, *L. taraxacifolia* and *S. nigrum* leaves) as highlighted in Table 1, would generally have high concentration of minerals as a result of their high ash contents.

Most of the proteins consumed by humans are from plants (Fennema et al., 1996; Odukoya, 2015). Analysis of the crude protein contents of the leaves of the three plants considered in this research showed that all the samples are suitable for consumption as they all have protein contents above the 3.3% USDA standard reference for protein (Emebu and Anyika, 2011). Their protein contents, however, slightly fall below (see Table 2) the reported range of protein level found in green leafy vegetables (20.48 – 41.66%) on dry weight basis as noted in Ponka et al. (2005) and Hussain et al. (2010). The statistical analysis of the results, however, showed that *S. nigrum* leaves with the significantly ($p < 0.05$) highest level of protein (see Table 1) would have the highest amount of essential amino acids (Iheanacho and Udebuani, 2009; Adjatin et al., 2013). These amino acids act as another source of energy when carbohydrate metabolism is impaired via gluconeogenesis (Iheanacho and Udebuani, 2009).

The result of the ether extract contents of the three samples supports the finding of Emebu and Anyika (2011) as well as Andzouana and Mombouli (2012) that products with low moisture contents have high fat values as *P. nigrescens* with the least moisture content (see Table 1) had the significantly highest level of fat ($p < 0.05$). Meanwhile, with respect to Amata (2010) as well as Hussain et al. (2010), the ether extract contents of the three investigated leaves fall within the range (8.3 – 27.0%) reported for some leafy vegetables consumed in Nigeria and Niger Republic. According to Antia et al. (2006), Iniaghe et al. (2009), Friday et al. (2011) and Adjatin et al. (2013), dietary fats aid the palatability of food by the absorption and retaining of flavours.

Dietary fibres, which are non-starchy polysaccharides (Iqbal et al., 2012), help in the cleaning of the digestive tract via the removal of potential carcinogens from the body and prevention of the absorption of excess cholesterol (Emebu and Anyika, 2011). These authors (i.e. Emebu and Anyika, 2011) also indicated that fibre add bulk to the food and keep blood sugar levels under control. In addition, the consumption of dietary fibre helps in preventing constipation, bowel problems and pile (Asaolu et al., 2012) as well as reduces the risks of cardiovascular diseases (Adjatin et al., 2013).

From the result of the analysis as presented in Table 2, *L. taraxacifolia* leaves had the significantly highest level of fibre while *S .nigrum* leaves had the least. This indicated that the leaves of *L. taraxacifolia* with the highest level of fibre may assist in the treatment of chronic diseases like heart disease, diabetes and cancer (Saldanha, 1995; Lewu et al., 2009). Notably, the crude fibre contents of the leaves of the three plants as shown in Table 1 fall within the range of 8.5 – 20.9% as commonly found in some Nigerian vegetables (Hussain et al., 2010).

Carbohydrate is the chief solid matter of plants (Fennema et al., 1996; Odukoya, 2015). It is required in the human body mainly for the production of energy for its activities (Yisa et al., 2010; Emebu and Anyika, 2011; Adjatin et al., 2013) which is found in different amounts in vegetables (Agbaire, 2011). From Table 1, carbohydrate has the highest concentration in only the *P. nigrescens* leaves which according to Iniaghe et al. (2009), makes it possible for the leaves of this plant to be termed carbohydrate-rich leaves. The statistical analysis of the carbohydrate contents of the three plants showed that *L. taraxacifolia* leaves gave the least carbohydrate content of 6.56 g/100 g DW (Table 2).

Although Isong et al. (1999) noted that the calorific densities of most vegetables are low (30 – 50 kcals/100 g), the results obtained in the present study showed that the three leaves considered have appreciable calorific values.

Minerals Content

The result of the distribution of major dietary minerals showed that among the three leaves, the consumption of *L. taraxacifolia* leaves would contribute mostly to the maintenance of body water balance and functioning of nerves as a result of the highest concentration of sodium and potassium (Ahmed and Chaudhary, 2009). Meanwhile, the inclusion of *P. nigrescens* in the human diet would present the least support among the three leaves towards blood clotting and nerve functions (Moyo et al., 2011) owing to its least concentration of Ca. In addition, the leaves of this plant (i.e. *P. nigrescens*) would also be the least contributor to the formation/strengthening of the bone and teeth as a result of its least concentration of phosphorus and calcium (Ahmed and Chaudhary, 2009), if consumed.

The research outcome on the minor dietary minerals' contents revealed that on consumption, *S. nigrum* leaves among the three leaves would assist the most in carbohydrates metabolism (Ismail et al., 2011) as a result of its highest concentration of manganese. The highest level of zinc in *S. nigrum* leaves indicated that the leaves of this plant, among the three leaves on consumption, would contribute mostly to: (i) normal functioning of immune system (Akubugwo et al., 2007), (ii) stimulation of the synthesis of metallothionein (Ooi et al., 2012), (iii) maintenance of cell and organ integrity (Emebu and Anyika, 2011), (iv) prevention and treatment of diarrhoeal episode (Bakare et al., 2010), (v) functioning/structure of some enzymes like peptidases, transphosphorylase, aspartate transcarbamylase (Brisibe et al., 2009), as well as (vi) cell production and growth (Moyo et al., 2011).

Meanwhile, *P. nigrescens* leaves with the least concentration of iron among the three leaves would contribute the least to haemoglobin formation (Bakare et al., 2010) and normal functioning of the central nervous system (Adeyeye and Otokiti, 1999; Bakare et al., 2010), if consumed. The non-detectable (or extremely low level) of cobalt in *L. taraxacifolia* leaves as recorded in Table 4 indicated that only the leaves of this plant, among the three investigated, would not support the prevention and treatment of pernicious anaemia (Sobukola et al., 2010). The analytical result also showed that *S. nigrum* leaves would contribute more to enzyme functioning than the leaves of *L. taraxacifolia*.

Be that as it may, the rather low levels of some of the major dietary minerals recorded in this investigation, compared to those found in previous studies involving the distribution of minerals in these plants leaves, such as Adinortey et al. 2012 (for *L. taraxifolia* leaves) and Akubugwo et al. 2007 (for *S. nigrum* leaves), could be as a result of the changes in the response of the instrument used during the analysis (Proehl and Nelson, 1950).

The concentration of the selected undesirable mineral contaminants in the three leaves were below FAO/WHO Codex maximum level of 0.20 mg/kg and 0.30 mg/kg for cadmium and lead respectively in leafy vegetables (Codex Alimentarius, 2015; Odukoya, 2015). This shows that the inclusion of the leaves of any of these plants in human diet would not give rise to these metals' contamination.

Mineral Ratios

Following the suggestion of Nieman et al. (1992) that a food source is poor if the Ca/P ratio is < 0.5, all the three leaves considered in this study are thus not poor food sources. There was also a statistically significant difference ($p < 0.05$) in the Na/K ratio of the three leaves with *S. nigrum* leaves having the most desired value. The Na/K ratio is important in the prevention of high blood pressure (Akubugwo et al., 2007) and in line with Nieman et al. (1992) as well as Odukoya (2015), Na/K ratios < 0.6 will not contribute to high blood pressure. Hence, these three leaves, if consumed, would not contribute to high blood pressure.

Furthermore, although there was a statistically significant difference in the Zn/Cu ratio of the three leaves with the maximum level in *P. nigrescens* and *S. nigrum* leaves, the results as shown in Table 5, revealed that the bioavailability of these minerals would not be affected (Ooi et al., 2012) and there would be reduced risk of cardiac abnormalities since the Zn/Cu ratios are < 16 (Sanstead, 1995; Ma and Betts, 2000; Ooi et al., 2012).

Amino Acids Distribution

Among the considered essential amino acids, leucine was the most predominant in the three leaves. Following the report of Anhwange et al. (2004) as well as Yisa et al. (2010), the consumption of these leaves, based on their high leucine contents, would support the regulation of blood sugar concentrations, growth and repairs of tissues. Comparison of the amino acids content of the three leaves with that of the FAO/WHO/UNU requirement showed that only the composition of isoleucine, leucine and valine in the three leaves as well as the combination of phenylalanine and tyrosine in *L. taraxacifolia* and *S. nigrum* leaves were above the required amount for all the age-brackets considered (i.e. from pre-school age to adulthood). In addition, only the histidine content of the *L. taraxacifolia* leaves was below the pre-school and school-children requirement.

However, the concentrations of lysine as well as the combination of methionine and cysteine in the three leaves only satisfied the adult requirement while only the threonine content in the *P. nigrescens* leaves met the school-children and adult amino acids' benchmarks as shown in Table 6.

Vitamins Contents

The analysis of vitamin A and C contents of the three leaves indicated that the leaves of *L. taraxacifolia* and *S. nigrum* would contribute more as antioxidants when consumed than those of *P. nigrescens*. Nonetheless, the relatively low level of vitamin C (ascorbic acid) particularly in the *L. taraxacifolia* and *P. nigrescens* leaves support the report of Mwanri et al. (2011) that tropical leafy vegetables lose a high percentage of vitamin C immediately after harvest. Birch et al. (1986) and Odukoya (2015) also noted that vitamin C is easily destroyed by oxygen, particularly in the presence of sunlight.

CONCLUSIONS

The result of the present investigation revealed that although the leaves of *L. taraxacifolia* present important medicinal advantages in the management of some diseases, the leaves of this plant, among the three considered, need the most care in terms of preservation. The levels of the minerals in the three plants are safe for human consumption and would not give rise to heavy metals' poisoning. The research findings also revealed that the consumption of these leaves, in terms of their amino acids distribution, would be most beneficial to adults.

On the other hand, the results of the vitamins' analyses showed that the exposure of vegetables by market women in many local markets to sunlight would have a negative effect on vitamins' concentration in these vegetables intended for human consumption. As Birch et al. (1986) and Odukoya (2015) indicated that freezing can significantly help in the preservation of vitamins, storage of vegetables in a very cool environment by market women is encouraged while freeze-drying method is recommended for the laboratory determination of the actual levels of vitamins in vegetables. The usual practice by some market women involving sprinkling of water, at different time intervals, on the displayed vegetables for sale is also supported as vitamin content of plants, among other factors, is affected by postharvest storage conditions and processing (Fennema et al., 1996; Odukoya, 2015). The extent of the loss of vitamins in the exposed vegetables, however, depends on the varieties involved (Mwanri et al., 2011).

To a large extent, the results of this study support the inclusion of the three leaves in the human diet. Although *L. taraxacifolia* and *S. nigrum* leaves are already consumed as vegetables, the use/application of *P. nigrescens* leaves as herbs or in herbal products for concoction involving direct human consumption demands further investigation to avoid human health hazard arising from antinutrients and possible toxic compounds present in this plant.

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