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Momoh TB *

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Research Article

Vitamin, antioxidant and anti-nutrient Evaluation of African Black Night Shade (*Solanum nigrum*) ethanolic leaf extract used by traditional medicine practitioners in Ogodo, Ankpa Kogi State, Nigeria

Momoh TB [1]*. Appah J [2], Onwumere GB [2], Dan VMY [2]

[1]Department of Plant Science and Biotechnology, Kogi State University, Anyigba, Kogi State Nigeria.

[2]Department of Biological Sciences, Nigerian Defence Academy, Kaduna, Nigeria.

Corresponding author: Momoh, TB, Department of Plant Science and Biotechnology, Kogi State University, Anyigba, Kogi State Nigeria.

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Abstract:

The objective of this paper is to evaluate the vitamin, anti-nutrients and antioxidant contents of the ethanolic extracts of African black night shade (*Solanum nigrum*) using appropriate standard methods. The anti-nutrient constituents evaluated are cyanide (21.01 mg/100g), nitrate (6.15 mg/100g), phytate (13.81 mg/100g) and oxalate (9.23 mg/100g). Also, the vitamin constituents evaluated are Vitamin A (34.13 mg/100g), Vitamin B1 (20.17 mg/100g), Vitamin B2 (1.07 mg/100g), Vitamin B6 (0.98 mg/100g), Vitamin B9 (14.80 mg/100g), Vitamin B12 (3.72 mg/100g), Vitamin C (58.22 mg/100g), Vitamin D (2.04 mg/100g), Vitamin E (12.74 mg/100g), Vitamin K (9.82 mg/100g) and Beta carotene (10.48 mg/100g). Furthermore, the antioxidants values were significant statistically at different concentrations. At 25 mg/g, DPPH radical recorded the highest antioxidant (47.10 mg/g), followed by FRAP (34.21 mg/g) while vitamin C recorded the lowest antioxidant power (21.00 mg/g). Similar trends occurred at 50, 100, 200, 400 and 800 mg/g in a concentration dependent manner. At 800 mg/g the antioxidant activities exhibited its peak as demonstrated in the results in table 3. DPPH scavenging activity recorded (168.20 mg/g), FRAP antioxidant power recorded (125.22 mg/g) while vitamin C recorded (98.00 mg/g). The vitamin concentration and antioxidant activity of *Solanum nigrum* is a proof of its therapeutic potential and remarkable nutritional properties. Thus, the use of *S. nigrum* in the treatment of many ailments among the rural dwellers in Ogodo, Ankpa Kogi State could be justified by its vitamin and antioxidant contents.

Key words: solanum nigrum; vitamin; antinutrient; antioxidant; african black night shade

Introduction

Medicinal plants are used to maintain and promote healthy life, prevent disease and cure ailments (Acharya and Pokhrel, 2006). Each medicinal plant species has its own nutrient composition besides having pharmacologically important secondary metabolites. These nutrients are essential for the physiological functions of human body (Afolabi and Afolabi, 2013). *Solanum nigrum* L. belongs to the *Solanaceae* family to Europe, Asia, and North America and was introduced in South America, Australia, and Africa. It represents one of the largest and most variable species groups of the genus. It is well commonly known as African Black Nightshade (Akubugwo *et al*., 2012).

Solanum nigrum has a long history of medicinal usage, dating back to ancient times (Barnea *et al*., 2000). It is a common vegetable in Ogodo, Ankpa Kogi State, where the leaves are utilized in the treatment of various diseases such as bone fracture, diabetes, blood booster and arthritis by traditional medicine practitioners in the area. The decoction and juice of the berries are useful in the treatment of cough, diarrhoea, inflammatory and skin diseases, anti-oxidative, anti-inflammatory and anti-pyretic (Chinedu *et al*., 2011, Chinthana and Ananthi, 2012; Cai *et al*., 2010).

Globally, focus on plant research traditionally has increased tremendously. Production cost of plant based pharmaceuticals attracts

more capital investment in research and the development of new therapeutics, giving patients easier access to new drugs (Mishra *et al*., 2010).

The traditional system of medicine, especially the herbal medicine, in Nigeria is directly linked to its rich floral diversity. In spite of enormous progress in modern medical system, about 80% of the world population still depends on traditional systems of medicine for primary health care (Florence *et al*., 2017). Medicine in this contemporary world is a fascinating blend of traditional system with conventional one and often been used for various historical, cultural and ecological and socio-economical reasons (Ajai *et al*., 2013). It is very important to document, analyze and evaluate this knowledge not only for their scientific reasons, but also for their commercial value, as ethno-medicinal uses of plants is one of the most successful criteria used by the pharmaceutical industry in finding new therapeutic agents (Langdahl *et al*., 2016).

Though information on the pharmacological properties seems to abound in literature, there is little information on the vitamin, antioxidant and antinutrient compositions of *S. nigrum* leaves. Most importantly, no study had been carried out on *S. nigrum* plants from Ogodo, Ankpa Kogi State. Also, climatic conditions are known to greatly influence the nutritive and bioactive constituents of plants. Hence, the present study was aimed to evaluate the vitamin, antioxidant and antinutrient composition of *S. nigrum* in order to bridge this gap in knowledge as regards African Black nightshade leaves especially from the study area.

Materials and Methods

Collection and extraction of plant

The leaves of *Solanum nigrum* was collected from the derived savannah vegetation of Ogodo, Ankpa LGA of Kogi State. The plant specimen was identified botanically by a taxonomist at the Department of Plant Science and Biotechnology, Kogi State University, Anyigba. Leaf samples were washed with distilled water to avoid dirt and microbial contamination. The samples were dried at room temperature. The dried leaves were grounded to get a coarse powder which was stored in an air-tight, high-density polyethylene container before extraction by percolation method. Then 50 g of plant powder was soaked in 100 mL of ethanol followed by Soxhlet extraction overnight. The mixture was concentrated in a rotary vacuum evaporator, dissolved in water, and was used for the study.

Vitamin evaluation of the leaves of *Solanum nigrum*

Determination of Vitamin A

This carried out using the method of Nollet (2000). A 10 g of the extract was weighed into a 1 L round flask. A 20 ml of a 50% NaOH solution was added and the mixture was warmed in a water bath. Thereafter, a 100 ml of diethyl alcohol and 2 ml of a hydroquinone solution that was obtained by dissolving 20 g in 100 ml of pure alcohol was added. The water bath was maintained at 90°C for 30 minutes. The contents of the round flask was poured into a decanting vial and 100 ml of water was added. Furthermore, 50 ml of ethylic ether was added and was properly shaked. A 50 ml of petroleum ether was also added, shaked and allowed to decant. This was extracted twice with 50 ml of petroleum ether. The ether phase was washed three times with 100 ml of water. It was filtered, evaporated and concentrated until 1 ml is obtained. After extraction, the determination was carried out on the solvent of the liquid. Vitamin A was determined through calorimetric method. In determining vitamin A, the hexane phase obtained earlier was taken again and concentrated in a vacuum. The extract was re-dissolved in a chloroform. Then, to the volume of chloroform, four volumes of the trifluoroacetic acid reagent prepared was added by mixing 1 v of trifluoroacetic acid with three volumes of chloroform. The OD was observed at 620 nm

Determination of Vitamin B (Complex)

Thiamine (vitamin B1) was analyzed quantitatively by fluorometric methods. The method of choice was the thiochrome procedure, which involves treatment of thiamine with an oxidizing agent (hydrogen peroxide) to form a fluorescent compound (thiochrome). The intensity of fluorescence was proportional to the thiamine concentration (Aguilera-Méndez *et al*., 2012).

Riboflavin (vitamin B2) was assayed fluorometrically by measuring its characteristic yellowish green fluorescence. It was also assessed microbiologically, using *Lactobacillus casei*, where the growth of this riboflavin-dependent microorganism correlates with the amount of vitamin in the sample. The growth response of the organism was measured either by titration (Aguilera-Méndez *et al*., 2012).

Niacin (vitamin B2) was assayed semi-quantitatively with sulfanilic acid to yield a yellow colour. The intensity of the yellow colour correlates with the amount of niacin present, which was measured against a set of standards (Aguilera-Méndez *et al*., 2012).

Pyridoxine (vitaminB6): microbiological assays for quantifying pyridoxine (vitaminB6) and its isomers, pyridoxal and pyridoxamine, relied on the growth response of *Saccharomyces uvarum*. Microbiological assays was also used for quantitative determination of folic acid, pantothenic acid, and vitamin B12. The test organisms used in folate assays were *Streptococcus faecalis* and *Lactobacillus casei*. These are the common test organisms used in determining pantothenic acid because they do not grow in the absence of pantothenic acid (Aguilera-Méndez *et al*., 2012).

Note: High pressure liquid chromatography (HPLC) methods used to determine most B-complex vitamins have been considered and evaluated but have not yet been validated as official methods by the Association of Official Analytical Chemists (AOAC). There is ongoing interest in developing and validating these methods.

Determination of Vitamin C (Ascorbic Acid)

The method described by Asard *et al*. (2003) was used. Exactly 10g of the sample was extracted with 50ml EDTA/TCA (50g in 50ml of water). Extracting solution for 1 hour and filtered through a Whatman filter paper into a 50ml volumetric flask and made up to the mark with the extracting solution. Twenty (20) ml of the extract was pipette into a 250ml conical flask and 10ml of 30% KI was added and also 50ml of distilled water added. This was followed by 2ml of 1% starch indicator. This was titrated against 20% CuSO solution to a dark 4 end point. Vitamin C was determined using the formula:

$$\text{Vitamin C} = (\text{Mg}) = \frac{0.88 \times 100}{100} \times \frac{\text{VF}}{5} \times \frac{\text{T}}{20} \times 1$$

Where:

Vf = Volume of extract,

T = Sample titre- blank titre

Determination of Vitamin D

10 g of the extract was weighed. A 1 g of propanol was added followed by 90 ml of a mixture of 60 ml absolute ethanol, and 30 ml of a 50% potash solution. This was extracted three times each with 50 ml of petroleum ether. The ether extract and the material was washed three times with water. It was filtered, evaporated and concentrated until 1 ml is obtained. Vitamin A was detected by liquid chromatography using fatty acid analysis column with 55% MeCN (acetonitrile) as a solvent. A mixture of water/acetic acid (4 ml of acetic per liter) at a concentration of 45%, a flow rate of 1 ml/min and wave length of 265 nm. This was carried out a solvent temperature of 25℃ and oven temperature of oven: 40℃ (Angeline *et al*., 2013).

Determination of Vitamin E

A 10 g of the extract was weighed and 100 ml of ascorbic acid methanol solution obtained was added. Thereafter, a 0.5 g of ascorbic acid, 4 ml of water, and 20 ml of ethanol was also added and was brought to 100 ml with methanol. This was kept in boiling water for minutes. Then, 15 ml of a 70% KOH solution was added and it was placed again in the water bath for 40 minutes. The contents of the flask was decanted into a separation flask and the flask was washed with 50 ml of water. Subsequently, 120 ml of ethylic ether was added and the mixture was stirred. This was also decanted and filtered on Na2SO4. It was also extracted again with 120 ml of ethyl ether, filtered, evaporated and concentrated to 1 ml. After extraction and evaporation, the residue was re-dissolved using n-heptane, 1 ml of dipyridyl solution was added and the absorbance was determined at 460 nm (Brion *et al*., 2003).

Determination of Beta carotene

β- Carotene was determined by the method described by AOAC (2000). Two (2) grams of the leaves sample was mixed with approximately 0.5 grams of sea sand and was ground in a mortar and pestle in a mixture and the β carotene contents extracted completely with acetone. The homogenate was filtered through glass wool and rewashed with acetone and collected in a 50ml volumetric flask and until the filtrate was colourless. About 25ml of the extract was evaporated in a rotary vacuum evaporator in a water bath at 65^0C. The chromatographic column was prepared by packing silica gel to 15cm depth and two (2) drops of ethanol and petroleum ether each was added to remove any moisture and activate the silica gel. The top of the column was lined with 1mm of anhydrous sodium sulphate to remove any traces of water in the sample. The evaporated sample was dissolved in 2ml of petroleum ether (boiling point 400C-600C), then poured into the chromatographic column, and separated through petroleum spirit. The first yellow eluate was collected in a 25ml flask and made to the mark with petroleum spirit. β- carotene fraction was measured at 450nm using a CE 440 UV/VIS Double Beam Scanning Spectrophotometer (Cambridge, England). The spectrophotometer was calibrated with pure petroleum spirit. The absorbance was converted to β-carotene equivalents using the formula. B-carotene equivalent = 0.4/ 0.12 X Absorbance X dilutions/sample weight X 100 (expressed as mg/100g of extract on dry matter basis).

Determination of Anti nutrient composition of the leaves of *Solanum nigrum*

Determination of Oxalates:

Determination of oxalates was carried using standard method of AOAC (2000). A 0.5 g fresh weight of sample was homogenized in 4 mL of 0.5N HCL. The homogenate was heated at 800 C for 10 minutes with intermittent shaking. To the homogenate, distilled water was added up to a volume of 25 mL About 3 mL of the solution was withdrawn and centrifuged at 12000 rpm for 10 minutes. About 1 ml of supernatant was passed through a micro filter (0.45µ) before HPLC analysis. Standards were prepared at varying concentrations for quantification. HPLC analysis was done using Shimadzu UV-VIS detector, Hypsil C18 column (5µ M, 4.6 mm *250 mm) equipped waters 550 was used as the static phase and the mobile phase was a solution 0.01 N H2SO4. Flow rate was 0.6 mL min-1, pressure of 62 kgf and detection wavelength of 221 nm

Determination of Phytate:

Phytate was determined using HPLC standard methods of AOAC (2002). Approximately 0.5 g of sample was extracted with 10 mL of 3% H2SO4. Contents were filtered and the filtrate transferred to a boiling water bath for 5 minutes followed by 3 mL of FeCl3 solution (6 mg ferric iron per mL in 3% H2SO4) added. Contents were heated for 45 minutes to complete precipitation of the ferric phytate complex. They were then centrifuged at 2500 rpm for 10 minutes and the supernatant discarded. The precipitate was washed with 30 mL distilled water, centrifuged and the supernatant discarded. A 3 mL of 1.5 N NaOH was added to the residues and the volume brought to 30 mL with distilled water. Contents were heated for 30 minutes in a boiling water bath to precipitate the ferric hydroxide. Cooled samples were centrifuged and the supernatant transferred into a 50 mL volumetric flask. The precipitate was rinsed with 10 mL distilled water, centrifuged and the supernatant added to the contents of the volumetric flask. This was micro filtered and kept awaiting HPLC analysis. HPLC analysis was done using Shimadzu Refractive Index Detector (RID- 6A). The mobile phase was 0.005 N sodium acetate in distilled water, at a flow rate of 0.5 µL/min.

Determination of cyanide

The cyanide content was determined with method number 915.03B. (AOAC, 2000). *Solanum nigrum* leaves were finely chopped into small pieces to increase surface area to volume ratio and to enable easy cyanide extraction. About 10g of sample was weighed and dissolved in 100ml distilled water in boiling tubes. The mixture was kept at room temperature for 2 hours and distilled in distillation unit until 200mls of the distillate was obtained. The distillate was divided into 2 portions of 100ml each. The Eight (8) mls of 5% potassium iodide (KI) was added to each of the 100ml portions of the distillate and the solutions titrated with 0.02N Silver nitrate (AgNo3) until the solution turns light blue (turbidity). The titre value was obtained and the cyanide content for the sample was calculated as equivalent to 1.08mg of HCN/5 g and then expressed as HCN mg/kg of sample of fresh leaves.

Determination of nitrate

The nitrate content of the samples was determined by the method described by AOAC (2000). Different concentrations (0, 12.5, 25, 37.5, 50 and 62.5 with standards containing ~0 to 60 µg NO3-N in a 0.25 ml aliquot) of Potassium nitrate were used to prepare the nitrate standard curve and nitrates calculated as equivalent mg/100g sample. The previously dried sample was ground and re-dried overnight in a hot air oven at 700C. Approximately 0.1g of the dried sample was suspended in 10ml of distilled water in a beaker and incubated at 450C for 1hr to extract the nitrates. The mixture was filtered using (GE Healthcare Life sciences, Whatman CAT No.1441-150) Whatman filter paper and about 0.2ml of the filtrate pipetted into a 50ml beaker. About 0.8ml of 5% (w/v) Salicyclic acid in Sulphuric acid was added and mixed thoroughly and the

mixture allowed to stand for 20 min at ambient temperatures (280C-300C). About 19ml of 2N Sodium hydroxide was added to the mixture and allowed to cool for 30 mins. The absorbance reading was obtained using the CE 440 UV/VIS Double Beam Spectrophotometer (Cambridge, England) at 410nm.

Antioxidant Analysis

Antioxidant activity against DPPH

Ethanol extracts of polyphenols was analyzed for their antioxidant capacity by DPPH. The DPPH scavenging activity was evaluated according to the procedure described by Brand-Williams *et al.* (1995). The DPPH radical was stable in ethanol solution; extracts of antioxidants scavenge the DPPH and the reduction of DPPH was monitored by the decrease of the absorbance at wavelength 517 nm. An aliquot of ethanol solution (0.1 mL) containing different concentrations (from 2–10 mg/mL of initial sample) was added to 0.25 mL of 1 mM DPPH and 2 mL of methanol. The mixtures were mixed and the absorbance was measured after 20 min (λ=517 nm) using a spectrophotometer.

The Ferric Reducing Antioxidant Power (FRAP)

The FRAP was determined according to the assay reported by Karamac *et al*. (2019). A total of 20 µL of ethanolic solution of extracts (20 mg/mL) was mixed with 2 mL ABTS + diammonium salt radical cation. It was vortexed and heated at 30°C. The absorbance was read at λ = 734 nm using a spectrophotometer within 6 min. The final results were expressed as FRAP equivalents)/g of samples.

Data Analysis

The results were analysed using One-way Analysis of Variance (ANOVA) at 95% confidence limits upper confidence limit and lower confidence limit using the SPSS, IBM statistics version 21.0 software. Ducan Multiple Range Test (DMRT) were used to separate means. The data was be expressed as mean ± standard deviation and difference between groups was considered to be statistically significant at $p \leq 0.05$

Results

Anti-nutrient composition of ethanol extract of the leaves of *Solanum nigrum*

The results of the anti-nutrient composition of the ethanolic leaf extract of *Solanum nigrum* is shown in table 1. Cyanide recorded the highest (21.01 ± 200.11), followed by phytate (13.81 ± 12.41), oxalate (9.23 ± 10.21) and nitrate (6.15 ± 10.25).

Anti-nutrient	Concentration (mg/100g)
Cyanide	21.01 ± 200.11
Nitrate	6.15 ± 10.25
Phytate	13.81 ± 12.41
Oxalate	9.23 ± 10.21

Mean ± SD, n= 3

Table 1: Anti-nutrient Composition of the Ethanol Extract of Solanum nigrum leaves

Vitamin compositions of ethanol extracts of the leaves of *Solanum nigrum*

The results of the vitamin composition of the ethanolic leaf extract of *Solanum nigrum* is shown in table 2. Vitamin C recorded the highest vitamin (58.22 ± 0.06), followed by vitamin A (34.13 ± 0.83), thiamine (20.17 ± 0.03), folic acid (14.80 ± 0.11), vitamin E (12.74 ± 0.01), beta carotene (10.48 ± 0.06), vitamin K (9.82±0.51), Vitamin B12 (3.72 ± 0.02), Vitamin D (2.04±0.02), Vitamin B2 (1.07 ± 0.01) while Vitamin B6 (0.98 ± 0.02) recorded the lowest vitamin. However, Vitamins B3, B5 and B7 where not detected.

Vitamins	Relative Presence
Vitamin A (retinol)	34.13 ± 0.83
Vitamin B1 (thiamine)	20.17 ± 0.03
Vitamin B2 (riboflavin)	1.07 ± 0.01
Vitamin B3 (niacin)	ND
Vitamin B5 (pantothenic)	ND
Vitamin B6 (pyridoxine)	0.98 ± 0.02
Vitamin B7 (biotin)	ND
Vitamin B9 (Folic acid)	14.80 ± 0.11
Vitamin B12 (cyanocobalamine)	3.72 ± 0.02
Vitamin C (ascorbic acid)	58.22 ± 0.06
Vitamin D (calciferol)	2.04±0.02
Vitamin E (tocopherol)	12.74 ± 0.01
Vitamin K (antihemorrhagic)	9.82±0.51
Beta carotene	10.48 ± 0.06

Mean ± SD, n= 3, ND = not detected

Table 2: Vitamin Composition of the Ethanol Extract of *Solanum nigrum* leaves

Antioxidant activity of Ethanol Extract of *Solanum nigrum* leaves

The results of the DPPH scavenging activity, FRAP antioxidant power of *Solanum nigrum* and Vitamin C is shown in Table 3. The antioxidants values were significant statistically at different concentrations. At 25 mg/g, DPPH radical recorded the highest antioxidant (47.10 ± 0.03^a), followed by FRAP (34.21 ± 0.09^b) while vitamin C recorded the lowest antioxidant power (21.00 ± 0.00^c). Similarly, at 50 mg/g, DPPH radical recorded the highest antioxidant (56.16 ± 0.04^a), followed by FRAP (42.70 ± 0.32^b) while vitamin C recorded the lowest antioxidant power (35.00 ± 0.00^c). Similar trends occurred at 100, 200, 400 and 800 mg/g in a concentration dependent manner. At 800 mg/g the antioxidant activities exhibited its peak as demonstrated in the results in table 3. DPPH scavenging activity recorded (168.20 ± 0.01^a), FRAP antioxidant power recorded (125.22 ± 0.07^b) while vitamin C recorded (98.00 ± 0.00^c).

Treatment	25	50	100	200	400	800
DPPH	47.10 ± 0.03^a	56.16 ± 0.04^a	68.32 ± 0.05^a	72.10 ± 0.00^a	96.25 ± 0.22^a	168.20 ± 0.01^a
FRAP	34.21 ± 0.09^b	42.70 ± 0.32^b	56.15 ± 0.05^b	60.02 ± 0.00^b	71.87 ± 0.19^b	125.22 ± 0.07^b
Vitamin C	21.00 ± 0.00^c	35.00 ± 0.00^c	49.00 ± 0.00^c	53.00 ± 0.00^c	63.00 ± 0.00^c	98.00 ± 0.00^c

Data were represented as "Means ± Standard Deviation of triplicate readings. Values with different letters on the same column are statistically different at $p\leq0.05$

Table 3: Antioxidant activities of different concentration of Solanum nigrum leaf extracts (mg/g)

Discussion

Antinutrient composition

The results of the antinutrient composition revealed that *S. nigrum* leaf contains a high amount of phytate, oxalate, cyanide and nitrate. These findings are summarized in Table 6. The Antinutritional factors present in the leaves of *Solanum nigrum* might have affected the absorption and availability of some minerals and nutritional components in the plant. This is in line with the report of Shi *et al.* (2018) who documented that anti-nutritional factors reduces the nutrient utilization and or food intake of plants. The need for adequate processing to reduce the antinutritional factors in plants used as human foods and animal feeds have been reviewed by (Kumar *et al*., 2010).

Phytate is primarily present as a salt of the mono- and divalent cations K+, Mg2+, and Ca2+. In addition, phytate has been suggested to serve as a store of cations of high energy phosphoryl groups and by chelating free iron, as a potent natural antioxidant (Mueller, 2001). Phytate works in a broad pH-region as a highly negatively charged ion, and therefore its presence in the diet has a negative impact on the bioavailability of divalent, and trivalent mineral ions such as Zn2+, Fe2+/3+, Ca2+, Mg2+, Mn2+, and Cu2+. Whether or not high levels of consumption of phytate-containing foods will result in mineral deficiency will depend on what else is being consumed. In areas of the world where cereal proteins are a major and predominant dietary factor, the associated phytate intake is a cause for concern (Mueller, 2001).

Oxalate is a salt formed from oxalic acid. Calcium oxalate, which has been found to be widely distributed in plants. Strong bonds are formed between oxalic acid, and various other minerals, such as Calcium, Magnesium, Sodium, and Potassium. This chemical combination results in the formation of oxalate salts. Some oxalate salts, such as sodium and potassium, are soluble, whereas calcium oxalate salts are basically insoluble. The insoluble calcium oxalate has the tendency to precipitate (or solidify) in the Kidneys or in the Urinary tract, thus forming sharp-edged calcium oxalate crystals when the levels are high enough. These crystals play a role to the formation of kidney stones formation in the urinary tract when the acid is excreted in the urine (Nachbar *et al.*, 2000). Oxalate is an anti-nutrient which under normal conditions is confined to separate compartments. However, when it is processed and/or digested, it comes into contact with the nutrients in the gastrointestinal tract (Noonan and Savage, 2009).

The cyanide, which occurs as cyanogenic glucosides, is a toxic compound that has been associated with adverse health outcomes among humans (FAO/WHO, 2001). Excessive intake of cyanide is known to cause cretinism and goitre which are associated with iodine deficiency (Nhassico *et al*., 2008). This is as a result of the production of thiocyanate as a by-product of cyanide metabolism, which restricts the uptake of iodide by thyroid gland (Ermans *et al*., 2000). As such, prior to consumption, it is important for leaves and vegetables to be properly processed in view of reducing the content of cyanide (Gomez and Valdivieso, 2005).

Nitrates occur naturally in most soils and water sources; hence they are taken up by growing plants (Mohri, 2003). Leafy vegetables are the main contributors of nitrates in diets, and contributes about 75% of the total foods ingested (Mohri, 2003). Nitrates in themselves are not toxic at the levels present in most foods but the toxicity occurs when the nitrates are reduced to nitrites (Mohri, 2003). However, since nitrates and nitrites are water soluble, some amounts may be lost through leaching during the preparation process. Further, most of the nitrites present are oxidized to nitrate and upon cooking, they leach out of the food (Ricardo, 2003).

Vitamin Composition

The results of the vitamin composition revealed that *S. nigrum* leaf constitute a good source of Vitamin A, Vitamin B1, B9, B12, Vitamin C, Vitamin D, Vitamin E, Vitamin K and Beta carotene. These findings are summarized in Table 7. Vitamins are essential for growth and health. Their main function is to facilitate and regulate body processes. Vitamins are divided into two main groups, fat soluble and water soluble (Akubugwo *et al*., 2007).

Water-soluble vitamins of the B vitamin group are crucial for maintaining healthy cell metabolism (Angeline *et al.*, 2013; Asard, *et al*., 2003). Thiamine and riboflavin (vitamin B1 and vitamin B2) are natural components found in many foods and also acts as an essential nutrient in food items. Vitamin C is an essential component for several animals, including humans. Animals use a number of vitamins to help them generate vitamin C (Calvo *et al*., 2005).

Vitamin E is one of the most important lipid-soluble primary defense antioxidants (Handan *et al*., 2007). The various function are maintenance of normal conditions of cells, and healthy skin and tissues, protection of red blood cells and enhancement of immunity (Vivek and Surendra, 2006).

Beta-carotene has antioxidant properties that can help neutralize free radicals – reactive oxygen molecules potentially damaging lipids in cell membranes and genetic material, which may lead to the development of cardiovascular disease and cancer (Pavia and Russel, 2009).

Antioxidant activity

The results of the antioxidant activity revealed that *S. nigrum* leaf has a high antioxidant activity. These findings are summarized in Table 3. The values for DPPH scavenging activity were the highest. This was followed by FRAP antioxidant and then vitamin C from 25 mg/g - 800 mg/g in a concentration dependent array. These values were higher compared to the results of Zebish *et al*. (2016). This result is comparable to that of synthetic antioxidants such as BHA and BHT (Buitrago *et al*., 2019).

Many scientists have concerns about safety because synthetic antioxidants have recently been shown to cause health problems such as liver damage, due to their toxicity and carcinogenicity. Therefore, the development of safer antioxidants from natural sources has increased, and plants have been used as a good source of traditional medicines to treat different diseases. Many of these medicinal plants are indeed good sources of phytochemicals that possess antioxidant activities. With an increasing awareness of the negative effects of synthetic preservatives, there has been increased demand for the use of nontoxic, natural preservatives, many of which are likely to have antioxidant activities (Aiyegoro and Okoh, 2010).

Conclusion

The results of this study revealed the therapeutic potentials of the leaf extracts of *Solanum nigrum*. The vitamin concentration and

antioxidant activity of *Solanum nigrum* is a proof of its therapeutic potential and remarkable nutritional properties. Maintaining the balance between vitamins, free radicals and antioxidants is a prerequisite for staying healthy. This study also revealed that the leaves of *S. nigrum* leaf contains a high amount of phytate, oxalate, cyanide and nitrate which could be reduced during processing. Thus, the use of *S. nigrum* in the treatment of many ailments among the rural dwellers in Ogodo, Ankpa Kogi State could be justified by its vitamin and antioxidant contents.

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