HOSTED BY
ELSEVIER

Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Biomedicine

journal homepage: www.elsevier.com/locate/apjtb

Original article http://dx.doi.org/10.1016/j.apjtb.2017.01.016

Nutritional evaluation of *Kedrostis africana* (L.) Cogn: An edible wild plant of South Africa

Jeremiah Oshiomame Unuofin, Gloria Aderonke Otunola*, Anthony Jide Afolayan

Medicinal Plants and Economic Development (MPED) Research Centre, Department of Botany, University of Fort Hare, Alice 5700, South Africa

ARTICLE INFO

Article history:
Received 21 Sep 2016
Received in revised form 25 Oct, 2nd revised form 4 Nov 2016
Accepted 22 Dec 2016
Available online 6 Jan 2017

Keywords:
Kedrostis africana
Proximate analysis
Nutritional value
ICP-OES
Edible wild plant

ABSTRACT

Objective: To evaluate the nutritional composition and elemental constituents of *Kedrostis africana* and their safety aspect.
Methods: Proximate parameters (moisture, ash, crude fibre, crude fat, proteins, and carbohydrate and energy) were evaluated using ALASA methods, and elemental analysis by ICP-OES technique.
Results: The results from nutritional analysis showed that the tuber used for this study had a low content of crude fat and high content of ash, crude protein, crude fibre, carbohydrate and energy having the recommended dietary allowances. The tuber was rich in major minerals Na, K, Ca and Mg, there was sufficient amount of trace elements Fe, Cu, and Zn while the anti-nutrients oxalate, phytate, alkaloids, and saponins were detected in amounts that are not harmful according to Food and Agriculture Organization/World Health Organization.
Conclusions: The outcome of this study suggests that this wild plant has very good nutritional potentials to meet the recommended dietary allowance and it could be a cheap source of essential nutrients that may ameliorate most nutritional challenges and can contribute remarkably to the amount of nutrient intake in human and animal diet.

1. Introduction

With ever-increasing population pressure and fast depletion of natural resources, it has become extremely important to diversify the present day agriculture produce in order to meet various human needs [1]. This diversification of agricultural products and their consumption habits has now shed light on a broader range of plant species, particularly those which are currently identified as underutilized and these could significantly contribute to improved health, nutrition, livelihoods, and ecological sustainability [2].

These edible wild plants as noted by Afolayan and Jimoh [3] and Ali-Shtayeh *et al.* [4] are important sources of dietary nutrients in food and contribute to the proper growth and functioning of the body. Based on FAO reports, about 1 billion people especially in developing countries depend on edible wild plants in their diets [5]. Traditionally, some of these plants are not only edible but also have high medicinal properties [6]. An ethnobotanical study carried out [7] revealed that wild plants play a crucial role in sustenance of life most especially to the rural dwellers as they depend majorly on wild plants for food and medicine [8,9]. This has lead researchers to re-examine each and every plant with a fresh new approach towards their possible use for food or medicine. Plants are generally rich in primary metabolites including proteins, carbohydrates, vitamins, sterol and lipids, which are essential for its survival. These primary metabolites provide the world with food and are the basis of nutrition for the entire world [9].

Trace elements that have been implicated in combating a variety of human ailments and disease are found mainly in indigenous medicinal plants [10,11]. The functional activities of specific organs could be affected by the continuous dietary ingestion of certain elements; which can lead to their bioaccumulation beyond normal or safe levels [12].

Kedrostis africana (Linnaeus) Cogn. (*K. africana*) is a monoecious caudiciform plant, commonly known as “Baboon's

*Corresponding author: Gloria Aderonke Otunola, Medicinal Plants and Economic Development (MPED) Research Centre, Department of Botany, University of Fort Hare, Alice 5700, South Africa.
Tel: +27 74 527 6130
E-mail: gotunola@ufh.ac.za

Peer review under responsibility of Hainan Medical University. The journal implements double-blind peer review practiced by specially invited international editorial board members.

Cucumber" with lots of herbaceous climbing or creeping vines growing rapidly from the swollen base, resembling an English ivy with a tuber. The shoots emerge from a massive underground tuberous rootstock (or caudex). This tuber is a water-storage organ that is very resistant to drought [13]. The specie is native to Namibia and South Africa (Eastern Cape, Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape, North West and Western Cape). *K. africana* tuber is widely used in traditional medicine as an emetic, purgative, diuretic, anti-dropsy and to treat syphilis [14]. Also, a decoction from the crushed fresh bulb is taken twice daily for the management of obesity [15,16]. Keeping in mind its medicinal importance, the present investigation was undertaken to ascertain the nutritive potential of the specie harvested from the Eastern Cape of South Africa, which has been lacking in the literature.

2. Materials and methods

The tubers of *K. africana* used for this study were harvested in August 2015 at Fort Beaufort in the Amathole District Municipality, Eastern Cape, South Africa. This area lies at Latitude 32°43′28.66″ and Longitude 26°34′5.88″. The plant's identity was validated by Mr. Tony Dold of Selmar Schonland Herbarium, Rhodes University, South Africa, and a voucher specimen (Unuofin Med, 2015/2) was prepared and deposited in the Giffen Herbarium, University of Fort Hare. The bulb was rinsed with deionised water and gently blotted with paper towel, chopped into small bits, oven-dried (LABOTEC, South Africa) at 55 °C for 72 h until constant weight was achieved and then ground into powder (Polymix® PX-MFC 90D Switzerland).

2.1. Determination of moisture content

The moisture content was determined as published methods [17]. An empty weighing vessel was oven dried at 105 °C for one hour, cooled in a desiccator and weighed (W1). A dry sample weighing (2.000 ± 0.001) g (W2) was put into the vessel and oven dried at 105 °C until constant weight was attained. This was then cooled in a dessicator, after which it was weighed (W3). The percentage moisture was calculated as:

$$\%\ \text{Moisture content} = \frac{W2 - W3}{W2 - W1} \times 100$$

2.2. Measurement of ash content

The ash content was determined as described methods [17]. A porcelain crucible marked with a heat resistant marker was dried at 105 °C for 1 h, left to cool in a desiccator and weighed (W1). Then 2 g of the ground sample was placed in the previously weighed crucible and reweighed (W2). The crucible with its content was then ashed first at 250 °C for an hour and at 550 °C for 5 h in a muffle furnace. The samples were allowed to cool in a desiccator and then weighed (W3). The percentage ash was calculated as:

$$\%\ \text{Ash content} = \frac{W2 - W3}{W2 - W1} \times 100$$

2.3. Determination of crude fat

The powdered sample (5 g) was extracted in 100 mL of diethyl ether and then placed on an orbital shaker for 24 h. The extract was then filtered and the ether extract was collected in a previously weighed (W1) clean beaker. It was thereafter equilibrated with 100 mL diethyl ether and shaken for another 24 h; the filtrate was collected in the same beaker (W1). The ether was concentrated to dryness in a steam bath and dried in an oven at 40–60 °C and the beaker was reweighed (W2). The crude fat content was calculated as:

$$\%\ \text{Crude fat} = \frac{W2 - W1}{\text{Weight of original sample}} \times 100$$

2.4. Determination of crude fibre

A modification of the method described by Aina et al. [18] was used where 2 g of sample was digested by boiling with 100 mL of 1.25% sulphuric acid solution for 30 min, then filtered under pressure. The residue was rinsed four times with boiling water. This process was repeated on the residue using 100 mL of 1.25% NaOH solution. The final residue was then dried at 100 °C, cooled in a desiccator and weighed (C1). It was thereafter incinerated in a muffle furnace at 550 °C for 5 h, then transferred to cool in a desiccator and reweighed (C2). The percentage crude fibre was calculated as:

$$\%\ \text{Crude fibre} = \frac{C2 - C1}{\text{Weight of original sample}} \times 100$$

2.5. Determination of crude protein

The powdered sample (2 g) was digested in a Kjeldahl flask by boiling with 20 mL of concentrated H_2SO_4 and a digestion tablet (catalyst) until the mixture was clear. The digest was filtered and made up to mark in a 250 mL volumetric flask, then distilled. The aliquot plus 50 mL of 45% sodium hydroxide solution was transferred into a 500 mL round bottom flask and distilled. 150 mL of the distillate was collected into a flask containing 100 mL 0.1 N HCl. This was then titrated against 2.0 mol/L NaOH using methyl orange as indicator. The end point was indicated by a colour change to yellow.

The % nitrogen content was calculated as:

$$\frac{[(\text{mL standard acid} \times \text{N of acid}) - (\text{ml blank} \times \text{N of base})] - (\text{ml std base} \times \text{N of base}) \times 1.4007}{\text{Weight of sample in grams}}$$

where, N = normality, percentage crude protein was obtained by multiplying the nitrogen value by a factor of 6.25. % crude protein = Nitrogen in sample × 6.25.

2.6. Determination of carbohydrate

The carbohydrate content was calculated by subtracting the total crude protein, crude fibre, ash and lipid from the total dry matter as:

$$\%\ \text{Total carbohydrate} = 100 - (\%\ \text{Moisture content} + \%\ \text{Total Ash} + \%\ \text{crude Fat} + \%\ \text{Crude Fibre} + \%\ \text{Crude Protein})$$

2.7. Determination of energy content

The estimated energy value in kilocalorie (Kcal/100 g) was calculated by summing the multiplied values for crude protein, crude lipid and carbohydrate respectively, using the factors (4 kcal, 9 kcal and 4 kcal) as:

$$\text{Energy value}(\text{kcal}/100\ \text{g}) = [(\text{crude protein} \times 4) + (\text{crude fat} \times 9) + (\text{total carbohydrate} \times 4)]$$

2.8. Determination of oxalate content

The modified titration method [18,19] was used to determine the oxalate content of the plant. The pulverized sample (1 g) was weighed into a conical flask; 75 mL of 3 mol/L H_2SO_4 was added and stirred with a magnetic stirrer for an hour. This was filtered and 25 mL of the filtrate was collected and heated to 80–90 °C. This filtrate was kept above 70 °C at all times. The hot aliquot was titrated continuously with 0.05 mol/L of $KMnO_4$ until the end point revealed by a light pink colour which persisted for 15 s was reached.

The oxalate content was calculated by taking 1 mL of 0.05 mol/L of $KMnO_4$ as equivalent to 2.2 mg oxalate.

2.9. Determination of phytate content

Phytic acid was determined as described [20]. The sample (2 g) was weighed into a flask, 100 mL of 2% HCl was added and allowed to stand for 3 h, after which it was filtered. 25 mL of the filtrate was placed in a separate 250 mL conical flask with 5 mL of 0.3% ammonium thiocyanate solution as indicator. 53.5 mL of distilled water was added to give the desired acidity. This was then titrated with standard iron III chloride solution (0.001 95 g of iron per mL) until a brownish yellow colour persisted for 5 min. Phytic acid was calculated as:

$$\text{Phytic acid}\ (\%) = \text{titre value} \times 0.001\ 95 \times 1.19 \times 100$$

2.10. Determination of saponins

Saponin content was estimated as described [21]. Briefly, 5 g of the pulverized plant sample was added to 50 mL of 20% ethanol, kept on a shaker for 30 min and then heated in a water bath at 55 °C for 4 h. The resulting mixture was filtered and the residue re-extracted with another 200 mL of 20% aqueous ethanol. The filtrates were combined and reduced to 40 mL in a water bath at 90 °C. The concentrate was transferred into a separating funnel, 20 mL of diethyl ether was added, and shaken vigorously. The ether layer which was the upper layer was discarded and the aqueous (bottom) layer retained in a beaker. The retained layer was re-introduced into a separating funnel and 60 mL of *n*-butanol was added and shaken vigorously. The butanol extract which is the upper layer was retained while the bottom layer was discarded. The butanol layer was washed twice with 10 mL of 5% aqueous sodium chloride. The remaining solution was collected and heated to evaporation in a water bath, then dried to constant weight at 40 °C in an oven. The saponin content was calculated using the equation:

$$\%\ \text{Saponin content} = \frac{\text{Weight of residue}}{\text{Weight of original sample}} \times 100$$

2.11. Determination of alkaloids

The described method [22] was adopted. Briefly, 5 g of plant extract was mixed with 200 mL of 10% acetic acid in ethanol. The mixture was covered and allowed to stand for 4 h. This was filtered and the filtrate was concentrated on a water bath to a quarter of its original volume. Concentrated ammonium hydroxide was added in drops to the extract until precipitation (cloudy fume) was completed. The solution was allowed to settle, washed with dilute ammonium hydroxide and then filtered. The residue collected was dried and weighed and the alkaloid content was calculated using the equation:

$$\%\ \text{Alkaloid} = \frac{\text{Weight of precipitate}}{\text{Weight of original sample}} \times 100$$

2.12. Elemental analysis

The method described [23] using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES; Varian 710–ES series, SMM Instruments, Cape Town, South Africa) was used to determine the elemental constituent of the sample. All analyses were carried out in triplicates.

2.13. Statistical analysis of data

All experiments were carried out in triplicates and the data expressed as mean ± SD using the Microsoft Excel 2010 spreadsheet.

3. Results

3.1. Proximate composition

The result of the proximal content of *K. africana* tuber is presented in Table 1. The moisture content was low (3.77 ± 0.14)%, with high ash value (8.94 ± 0.28)%. The percentage fibre content was relatively high (25.52 ± 0.23)%, crude fat content was very low (1.12 ± 0.42)%, while crude protein was (6.95 ± 0.11)%. The carbohydrate content was high (46.36 ± 0.23)% and the overall estimated energy value of the whole plant of *K. africana* was (223.37 ± 0.88) Kcal/100 g.

Table 1
Proximate composition of *K. africana*.

Parameters	%
Moisture	3.77 ± 0.14
Total ash	16.28 ± 0.06
Crude fat	1.12 ± 0.42
Crude fibre	25.52 ± 0.23
Crude protein	6.95 ± 0.11
Carbohydrate	46.36 ± 0.23
Energy value (Kcal/100 g)	223.37 ± 0.88

Values are expressed as mean ± SD, $n = 3$.

3.2. Anti-nutrient factors

The antinutritional composition of *K. africana* is shown in Table 2. The saponin content was (1.94 ± 0.42)%, alkaloid was (0.30 ± 0.08)%, phytate was (2.42 ± 0.17)%, while oxalate content was (0.298 ± 0.150)%.

Table 2
Anti-nutrient composition of *K. africana*.

Anti-nutrient	%
Phytic acid	2.42 ± 0.17
Oxalate	0.28 ± 0.15
Saponins	1.94 ± 0.42
Alkaloids	0.30 ± 0.08

Each value represents the mean ± SD of three determinations on dry weight basis.

3.3. Elemental content

The result for the mineral analysis of *K. africana* whole plant is presented in Table 3. Calcium content (2505.00 mg/100 g) was highest compared to other minerals analysed. The potassium content was 2225.00 mg/100 g, phosphorus was 240 mg/100 g, magnesium content was 485 mg/100 g, sodium 430.00 mg/100 g; while iron content was 89.9 mg/100 g, zinc 4.80 mg/100 g, manganese 3.1 mg/100 g and copper content was 0.1 mg/100 g.

Table 3
Mineral composition of *K. africana*.

Mineral	mg/100 g DW
Calcium	2505.00 ± 21.21
Magnesium	485.00 ± 7.07
Potassium	2225.00 ± 35.36
Phosphorous	240.00 ± 0.00
Sodium	430.00 ± 14.14
Zinc	4.80 ± 0.28
Copper	0.10 ± 0.00
Manganese	3.10 ± 0.00
Iron	89.90 ± 0.85

Each value represents the mean ± SD of three determinations on dry weight basis.

4. Discussion

The stability and shelf-life of any food component is determined by its moisture content [24]. The low moisture content implies that *K. africana* may have a long shelf life and reduced microbial contamination [24]. The high ash value suggests that the plant is a rich source of mineral since ash content is an indication of mineral composition. Dietary fiber encourages the proliferation of advantageous organisms in the intestinal flora and lessens the risk of colon cancer [25]. The relatively high fibre content is an indication that the intake of *K. africana* could aid digestion, facilitate peristaltic movement and thus prevent constipation [26]. High fibre intake could lead to a decline in the incidence of certain diseases associated with metabolic disorders [27]. However when fibre is present in abundance, it could negatively affect the absorption of certain minerals which are beneficial to the body *e.g.* iron [28]. Dietary lipids improve the taste of food by preserving its flavours [29]. Excess intake of dietary fat is a major cause of cardiovascular diseases, cancer, and aging. It has been suggested that 1%–2% of caloric energy from fat is best for healthy living [30]. In this regard, the low crude fat content of *K. africana* implies that it could prevent certain chronic ailments in humans associated with lipids. This perhaps justifies its folkloric use in the management of obesity [15].

Dietary proteins are pivotal in the manufacturing and safeguarding of certain organic materials necessary for the smooth functioning of the human body [31]. The relatively high protein content of *K. africana* could make it a useful supplement to diets with little amount of proteins most especially grains. The high carbohydrate content makes it a rich source of energy and this could be used to enrich the energy content of diets [29]. The low overall estimated energy value of the whole plant of *K. africana* can be attributed to its low crude fat and moisture levels. This corroborates the fact that *K. africana* as a low energy food source may be very helpful in weight management programmes as used by traditional healers.

The saponin content of *K. africana* was low and within the safe limit, since an amount below 10% is not hazardous to the body [32]. High saponin levels in human and animal diets have been implicated in growth impairment, reduction in bioavailability of nutrients and inhibition of biochemical reactions that facilitate breakdown of ingested proteins [33].

Alkaloids are one of the most efficient therapeutic bioactive substances in plants. For instance, consumption of high tropane alkaloids will cause rapid heartbeat, paralysis and in fatal case, lead to death. Uptake of a high dose of tryptamine alkaloids will lead to the staggering gait and death [34]. Other toxic action includes disruption of the cell membrane in the gastrointestinal tract [35]. The alkaloid content recorded in this study was quite low, mitigating the fear of anti-nutrient activity.

The phytate content of *K. africana* was low. A dietary phytate content of 1%–6% over a long period decreases the bioavailability of mineral elements in monogastric animals [36]. The excessive intake of phytate rich diets is associated with nutritional diseases such as rickets and osteomalacia in children and adults respectively. However, this anti-nutrient could easily be removed by soaking, boiling or frying [37].

The presence of oxalate in foods causes irritation in the mouth and could decrease the absorption of calcium and increase the formation of kidney stone [38,39]. The concentrations of anti-nutrients (saponin, oxalate, phytate and alkaloids) recorded in this study were however within the safe limit and may not elicit toxic effect when consumed especially when thermally treated before use.

Minerals are considered to be essential in human nutrition for the overall mental and physical well being, as well as important constituents of bones, teeth, tissues, muscles, blood, and nerve cells.

The recommended daily allowance (RDA) of calcium for adults is 1000 mg [40]. Therefore *K. africana* is capable of contributing almost three times the RDA for calcium. Calcium is needed for growth and maintenance of bones, teeth, and muscle, and as such may be used as supplements in diets low in calcium ion. Calcium plays a vital role in muscle contraction; strong bones, neurological function and also to surmount the problems of high blood pressure, heart attack, premenstrual syndrome, colon cancer and osteoporosis in old age [41,42].

The RDA for potassium in adults is 4700 mg [43]. *K. africana* is able to contribute 47% (almost half) of this

amount if included in the diet. Potassium is effective in reducing hypertension, maintaining the cardiac rhythm and is also crucial in many physiological functions [44]. It regulates heartbeat, neurotransmission and water balance of the body [45].

The magnesium content of this plant is high, and could contribute about 1.2 times more than the RDA of 450 mg/day required for humans [46]. Magnesium enhances the beta cells functions thus preventing onset of diabetes and hypertension [47]. Also, it has been implicated as necessary for a number of enzymatic reactions such as oxidative metabolism of nutrients, cell constituents synthesis, transmission of nerve impulses, body temperature regulation, detoxification, energy production and the formation of strong bones and teeth [48].

K. africana is capable of contributing up to 29% of the RDA of sodium for adults in relation to the 1 500 mg recommended for adults [49]. A ratio of sodium to potassium ion less than one ($Na^+/K^+ < 1$) has been reported to be suitable for reducing high blood pressure. This therefore suggests that the plant could be a good dietary supplement for hypertensive patients. Sodium is involved in the maintenance of osmotic pressure of the body fluids, irritability of muscles and cell permeability. It plays an important role in the maintenance of membrane potentials, transmission of nerve impulses and also in the absorption of monosaccharides, amino acids, pyrimidines, and bile salts [50].

Phosphorus is an important mineral that aids the absorption of calcium which is required for growth, maintenance of bones, teeth and muscles [51]. The potassium content of *K. africana* is within the RDA of 200–1 000 mg/day for children and adults, respectively [52]. Phosphorus in association with calcium contributes to bones and teeth reinforcement especially in children and nursing mothers [53].

The high amount of iron found in *K. africana* indicates that the plant could be a good source of dietary iron and could contribute almost 5 times more than the RDA of 18 mg/day needed by adults [54] to overcome the nutritional deficiency of iron if used as a supplement in the diet. Iron deficiency is a common nutritional problem affecting many people worldwide; primarily, it occurs as a result of chronic bleeding, infections, inadequate intake of bioavailable iron, deficiencies of folic acid, vitamin A or vitamin B_{12}, pregnancy, increased requirements throughout growing periods and menstrual losses in women during reproductive age [55].

The zinc content is relatively high and is able to contribute up to 34% of the daily requirement for children and adults; since the RDA for zinc is 4–14 mg/day [52]. Zinc is a vital trace element and plays an important role in various cell processes including normal growth, brain development, behavioural response, bone formation, and wound healing [56]. In addition, it is crucial in the metabolism of carbohydrates and proteins, vitamin A storage and synthesis of nucleic acids in cells [57]. The deficiency of zinc is associated with diseases like Crohn's disease, hypothyroidism and some viral infections. Zinc has been reported to boost the immune system, aid in wound healing, reduce prostate enlargement and stress [58].

The manganese content can contribute about 1.35 times the recommended RDA value [59]. Manganese plays a crucial role in skeletal growth and development, and also functions with vitamin K in the formation of prothrombin. It acts as a catalyst and co-factor in many enzymatic processes, involved in the synthesis of fatty acids and cholesterol and is also necessary for mucopolysaccharide and glycoprotein synthesis [60,61].

The copper content of *K. africana* is however below the RDA of 0.7, or 1.1 mg/day required for children and adults, respectively [52]. Copper is involved in erythropoiesis, erythrocyte function and regulation of red blood cell survival. However, high concentration of copper can lead to diarrhoea, epigastric pain and discomfort, blood in the urine, liver damage, hypotension and vomiting [62].

The study revealed that *K. africana* had high fibre, calcium, iron, manganese, and magnesium contents. The anti-nutrients content were within acceptable limits and hence may not interfere with absorption of other nutrients. The level of these anti-nutrients can also be reduced or totally eliminated by preparation techniques such as soaking, blanching, steaming, boiling and cooking. *K. africana* is rich in many macro and micro nutrients and can therefore serve as a supplement to prevent many mineral deficiencies. *K. africana* should therefore be considered a plant with great potential in the food, nutritional and pharmaceutical industries. Further studies on toxicity of *K. africana* are on-going to ascertain its possible adverse effects and to confirm some of the ethno-pharmacological claims.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

The authors wish to acknowledge the financial support of the National Research Foundation (NRF 85294), South Africa.

References

[1] Deb CR, Jamir NS, Sungkumlong O. A study on the survey and documentation of underutilized crops of three districts of Nagaland, India. *J Glob Biosci* 2013; **2**(3): 67-70.
[2] Romojaro MA, Botella C, Pretel MT. Nutritional and antioxidant properties of wild edible plants and their use as potential ingredients in the modern diet. *Int J Food Sci Nutr* 2013; **64**(8): 944-52.
[3] Afolayan AJ, Jimoh FO. Nutritional quality of some wild leafy vegetables in South Africa. *Int J Food Sci Nutr* 2009; **60**(5): 424-31.
[4] Ali-Shtayeh MS, Jamous RM, Al-Shafie JH, Elgharabah WA, Kherfan FA, Qarariah KH, et al. Traditional knowledge of wild edible plants used in Palestine (Northern West Bank): a comparative study. *J Ethnobiol Ethnomed* 2008; **4**: 13.
[5] Taylor M, Kambuou R, Lyons GH, Hunter D, Morgan EH, Quartermain A, et al. Realizing the potential of indigenous vegetables through improved germplasm information and seed systems. *Acta Hortic* 2015; **1102**: 29-42.
[6] Ubwa ST, Tyohemba RL, Oshido BA, Amua QM. Chemical analysis of some wild underutilized mucilaginous vegetables and a domesticated vegetable in Benue State, Nigeria. *Br J Appl Sci Technol* 2014; **4**: 4566-74.
[7] Bhogaonkar PY, Vishal RM, Prachi PK. Documentation of wild edible plants of Melghat Forest, District. Amravati, Maharashtra State, India. *Ethnobot Leafl* 2010; **14**: 751-8.
[8] Chen B, Qiu Z. Consumers' attitudes towards wild edible plants. A case study of Noto Peninsula, Ishikawa, Prefecture, Japan. *Int J Res* 2011; **5**: 1-16.
[9] Karuna SV, Vijaya SK. Nutritive assessment of different plant parts of *Carica papaya* Linn of Jabalpur region. *J Nat Prod Plant Resour* 2014; **4**(1): 52-6.
[10] Shirin K, Imad S, Shafiq S, Fatima K. Determination of major and trace elements in the indigenous medicinal plant *Withania somnifera* and their possible correlation with therapeutic activity. *J Saudi Chem Soc* 2010; **14**: 97-100.

[11] Achudume AC, Owoeye D. Quantitative assessment of heavy metals in some tea marketed in Nigeria-bioaccumulation of heavy metals in tea. *Health* 2010; **2**: 1097-100.
[12] Jaishankar M, Tseten T, Anbalagan N, Mathew BB, Beeregowda KN. Toxicity, mechanism and health effects of some heavy metals. *Interdiscip Toxicol* 2014; **7**(2): 60-72.
[13] Eggli U. *Illustrated handbook of succulent plants: dicotyledons*. 1st ed. New York: Springer-Verlag Berlin Heidelberg; 2004, p. 547.
[14] van WykA BE. Review of Khoi-San and Cape Dutch medical ethnobotany. *J Ethnopharmacol* 2008; **119**: 331-41.
[15] Afolayan AJ, Mbaebie BO. Ethnobotanical study of medicinal plants used as anti-obesity remedies in Nkonkobe Municipality of South Africa. *Phcog Mag* 2010; **2**(11): 368-73.
[16] George P, Nimmi OS. Cent percent safe centum plants for anti-obesity. *Int J Innov Technol Creat Eng* 2011; **1**(3): 1-19.
[17] Agricultural Laboratory Association of Southern African (ALASA). *Wet ashing Plant and feed analysis handbook*. 2nd ed. 2007. South Africa.
[18] Aina VO, Sambo B, Zakari A, Haruna HMS, Umar K, Akinboboye RM, et al. Determination of nutritional and anti-nutritional content of *Vitis vinifera* (Grapes) grown in Bomo (Area C) Zaira, Nigeria. *Adv J Food Technol* 2012; **4**(6): 225-8.
[19] Day RA, Underwood AL. *Quantitative analysis*. 5th ed. Prentice Hall Publication; 1986, p. 701.
[20] Olayeye LD, Owolabi BJ, Adesina AO, Isiaka AA. Chemical composition of red and white cocoyam (*Colocasia esculenta*) leaves. *Int J Sci Res* 2013; **11**(2): 121-5.
[21] Obadoni BO, Ochuko PO. Phytochemical studies and comparative efficacy of the extracts of some haemostatic plants in Edo and Delta States of Nigeria. *Glob J Pure Appl Sci* 2001; **8**: 203-18.
[22] Omoruyi BE, Bradley G, Afolayan AJ. Antioxidant and phytochemical properties of *Carpobrotus edulis* (L.) bolus leaf used for the management of common infections in HIV/AIDS patients in Eastern Cape Province. *BMC Complement Altern Med* 2012; **12**: 215.
[23] Bvenura C, Afolayan AJ. Heavy metal contamination of vegetables cultivated in home gardens in the Eastern Cape. *S Afr J Sci* 2012; **108**(9): 1-6.
[24] Uyoh EA, Ita EE, Nwofia GE. Evaluation of the chemical composition of *Tetrapleura tetrapter* (Schum and Thonn.) Tuab. accessions from Cross River State, Nigeria. *Int J Med Arom Plants* 2013; **3**: 386-94.
[25] Slavin J. Fiber and prebiotics: mechanisms and health benefits. *Nutrients* 2013; **5**(4): 1417-35.
[26] Ogungbenle HN, Omosola SM. The comparative assessment of nutritive values of dry nigerian okra (*Abelmoschus esculentus*) fruit and oil. *Int J Food Sci Nutr Eng* 2015; **5**: 8-14.
[27] Ikewuchi CC, Ikewuchi JC. Chemical profile of *Pleurotus tuberregium* (fr) sing's sclerotia pacific. *J Sci Technol* 2009; **10**: 295-9.
[28] Ekwumemgbo PA, Sallau MS, Omoniyi KI, Zubairu SY. Proximate and anti-nutritional constituents of *Abelmoschus esculentus* grown in Fadaman Kubanni, Zaria, Kaduna State. *Niger J Sci Res Rep* 2014; **3**: 2015-27.
[29] Anita BS, Akpan EJ, Okon PA, Umoren IU. Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. *Pak J Nutr* 2006; **5**: 166-8.
[30] Aruah BC, Uguru MI, Oyiga BC. Nutritional evaluation of some Nigerian pumpkins (*Cucurbita* spp.). *Fruit Veg Cereal Sci Biotechnol* 2011; **5**: 64-71.
[31] Hayat I, Ahmad A, Ahmed A, Khalil S, Gulfraz M. Exploring the potential of red kidney beans (*Phaseolus vulgaris* L.) to develop protein-based product for food applications. *J Anim Plant Sci* 2014; **24**: 860-8.
[32] Igile GO, Iwara IA, Mgbeje BIA, Uboh FE, Ebong PE. Phytochemical, proximate and nutrient composition of *Vernonia calvaona* Hook (Asterecea): a green-leafy vegetable in Nigeria. *J Food Res* 2013; **2**(6): 1-10.
[33] Das TK, Banerjee D, Chakraborty D, Pakhira MC, Shrivastava B, Kuhad RC. Saponin: role in Animal system. *Vet World* 2012; **5**(4): 248-54.
[34] Gemede HF, Ratta N. Antinutritional factors in plant foods: potential health benefits and adverse effects. *Int J Nutr Food Sci* 2014; **3**(4): 284-9.
[35] Fernando R, Pinto MDP, Pathmeswaran A. Goitrogenic food and prevalence of goitre in Sri Lanka. *J Food Sci* 2012; **41**: 1076-81.
[36] Oke OL. Chemical studies on the more commonly used vegetables in Nigeria. *Afr Sci Ass* 1969; **11**: 42-8.
[37] Ekop AS, Eddy NO. Comparative studies of the level of toxicants in the seed of Indian almond (*Terminalia catappa*) and African walnut (*Coula edulis*). *Chem Cl J* 2005; **2**: 74-6.
[38] Fekadu H, Beyene F, Desse G. Effect of traditional processing methods on nutritional composition and anti-nutritional factors of anchote (Coccinia Abyssinica Cogn) tubers grown in Western Ethiopia. *J Food Process Technol* 2013; **4**: 249.
[39] Food and Agricultural Organization of the United Nations (FAO) World Health Organization. *Human vitamin and mineral requirements*. Report of a Joint FAO. Rome: WHO expert consultation, Bangkok, Thailand; 2001.
[40] Khan KY, Khan MA, Niamat R, Munir R, Fazal H, Mazari P, et al. Element content analysis of plants of genus *Ficus* using atomic absorption spectrometer. *Afr J Pharm Pharmacol* 2011; **5**: 317-21.
[41] Senga Kitumbe P, Opota Onya D, Tamba Vemba A, Tona Lutete G, Kambu Kabangu O, Covaci A, et al. Chemical composition and nutritive value study of the seed oil of *Adenanthera pavonina* L. (Fabaceae) growing in Democratic Republic of Congo. *Int J Pharmtechnol Res* 2013; **5**: 205-16.
[42] Anon A. *National institute for health and welfare, nutrition unit*. Fineli. Helsinki: Finnish food composition database; 2011.
[43] Ekmekcioglu C, Elmadfa I, Meyer AL, Moeslinger T. The role of dietary potassium in hypertension and diabetes. *J Physiol Biochem* 2016; **72**(1): 93-106.
[44] Houston MC. The importance of potassium in managing hypertension. *Curr Hypertens Rep* 2011; **13**(4): 309-17.
[45] Alinnor IJ, Oze R. Chemical evaluation of the nutritive value of *Pentaclethra macrophylla* benth (African Oil Bean) seeds. *Pak J Nutr* 2011; **10**(4): 355-9.
[46] Jahnen-Dechent W, Ketteler M. Magnesium basics. *Clin Kidney J* 2012; **5**(1): 3-14.
[47] Haq F, Ullah R. Comparative determination of trace elements from *Allium sativum, Rheum australe* and *Terminalia chebula* by atomic absorption spectroscopy. *Int J Biosci* 2011; **1**: 77-82.
[48] Kartika H, Shido J, Nakamoto ST, Li QX, Iwaoka WT. Nutrient and mineral composition of dried mamaki leaves (*Pipturus albidus*) and infusions. *J Food Compost Anal* 2011; **24**: 44-8.
[49] McCarron DA, Kazaks AG, Geerling JC, Stern JS, Graudal NA. Normal range of human dietary sodium intake: a perspective based on 24-hour urinary sodium excretion worldwide. *Am J Hypertens* 2013; **26**(10): 1218-23.
[50] Soetan CO, Olaiya CO, Oyewole OE. The importance of mineral elements for humans, domestic animals and plants: a Review. *Afr J Food Sci* 2010; **4**(5): 200-22.
[51] Veum TL. Phosphorus and calcium nutrition and metabolism. In: Vitti DMSS, Kebreab E, editors. *Phosphorus and calcium utilization and requirements in farm animals*. UK: Oxfordshire; 2010, p. 94-111.
[52] NHMRC. Nutrient reference values for Australia and New Zealand including recommended dietary intakes. Department of Health and Ageing, Australian Government, Australia.
[53] Andzouana M, Mombouli JB. Assessment of the chemical and phytochemical constituents of the leaves of a wild vegetable *Ochthocharis dicellandroides* (Gilg). *Pak J Nutr* 2012; **11**(1): 94-9.

[54] Alibabić V, Šertović E, Mujić I, Živković J, Blažić M, Zavadlavd S. The level of nutrition knowledge and dietary iron intake of bosnian women. *Procedia Soc Behav Sci* 2016; **217**: 1071-5.
[55] Ooi DJ, Shahid I, Maznah I. Proximate composition, nutritional attributes and mineral composition of *Peperomia pellucida* L. (ketumpangan air) grown in Malaysia. *Molecules* 2012; **17**: 11139-45.
[56] Mlitan AM, Sasi MS, Alkherraz AM. Proximate and minor mineral content in some selected basil leaves of *Ocimum gratissimum* L, in Libya. *Int J Chem Eng Appl* 2014; **5**: 8-17.
[57] Jabeen S, Shah MT, Khan S, Hayat MQ. Determination of major and trace elements in ten important folk therapeutic plants of Haripur basin. *Pak J Med Plant Res* 2010; **4**(7): 559-66.
[58] Kermanshah A, Ziarati P, Asgarpanah J, Qomi M. Food values of two endemic wild *Almond* species from Iran. *Int J Plant Anim Environ Sci* 2014; **4**: 380-8.
[59] National Nutrition Surveys of Australia Ministry of Health. *NZ food: NZ people. Key results of the 1997 National Nutrition Survey*. Wellington: Australia. 1998.
[60] McDonald RA, Edward FD, Morgan CA. *Animal nutrition*. London: Prentices Hall; 1995, p. 101-22.
[61] Shomar S. Major and trace elements in Nigella sativa provide a potential mechanism for its healing effects. *J Med Plants Res* 2012; **6**(34): 4836-43.
[62] Johnson WT. In: Lieberman HR, Kanarek RB, Prasad C, editors. *Nutritional and neuroscience*. Boca Raton: Taylor & Francis; 2005, p. 17.