Websites:
http://www.sciencepub.net
http://www.sciencepub.net/researcher

Emails:
editor@sciencepub.net
marslandresearcher@gmail.com

Researcher

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

EVALUATION OF PHYTOCHEMICAL IN SOME SELECTED PLANT EXTRACT (BITTER LEAF (*Vernonia amygdalina*), LIME (*Citrus aurantifolia*) AND LEMON (*Citrus limon*)

Sunmonu, B. A[1]*., Akinsola, A. O[2]*., Olaniyan, S[1]., Akinfolarin, O. A[2]. & Oyeleye, B. R[2].

[1]Department of Food Technology, Federal Polytechnic Offa, Nigeria
[2]Department of Home Economics, Federal College of Education (Special), Oyo, Nigeria
*Correspondence author's email: foliekay@yahoo.com; akinsola4gold@gmail.com

Abstract: This study evaluated phytochemical properties of selected plant extracts of bitter leaf, lime and lemon. Samples were extracted according to standard method and each sample extract were evaluated for tannin, alkaloids, flavonoids, vitamin C, β-carotene, and minerals according to standard methods. Results revealed that values for phytochemical properties of the samples ranged from 19.51 – 60.96 mg/g, 0.66 – 2.49 mg/g and 13.31 – 66.09 mg/g for tannn, alkaloids and flavonoids, respectively. Vitamin C and β-carotene content ranged from 0.35 – 7.93 mg/g and 0.01 – 0.10 mg/g, respectively. Mineral composition of samples showed that potassium, magnesium, iron, phosphorus and zinc ranged from 34.92 to 105.22 mg/g, 15.82 to 22.62 mg/g, 0.59 to 1.23 mg/g, 2.61 to 5.19 mg/g and 0.01 to 1.40 mg/g, respectively. The bitter leaf extract had the best values in all nutrients assayed. This infers that bitter leaf could provide the required phytonutrients, vitamins and minerals needed by the body for varying physiological functions. Although, commendable results were acknowledged for the lemon and lime extract, they still appear insufficient as the body requires more nutrients to fulfill its biological functions. Hence, there is need to obtain additional nutrients from other food sourceswhen using lemon and lime extract.
[Sunmonu, B. A., Akinsola, A. O., Olaniyan, S., Akinfolarin, O. A. & Oyeleye, B. R.**EVALUATION OF PHYTOCHEMICAL IN SOME SELECTED PLANT EXTRACT (BITTER LEAF(*Vernonia amygdalina*), LIME (*Citrus aurantifolia*) AND LEMON (*Citrus limon*)**. *Researcher* 2022;14(7):14-23] ISSN 1553-9865 (print); ISSN 2163-8950 (online) http://www.sciencepub.net/researcher. 3. doi:10.7537/marsrsj140722.03.

Keywords: Assay, biological functions, physiological, phytochemical properties, plant extract.

Introduction

Plants consist of various kinds of chemical constituents known as phytoconstituents. Phytoconstituents serve the plants by contributing some secondary functions like; helps in plant growth, safeguarding the plants by activating defense mechanism, imparting color, odor, and flavor to the plants.[1] Natural products and their derivatives exhibit minimal side effects and improved efficacy than other synthetic counterparts.[2] These plant-derived components like flavonoids, quinine, terpenoid, etc conduct certain biological functions that enhance therapeutic activities such as anti-carcinogenic, anti-mutagenic, anti-inflammatory and antioxidant properties.[2] Herbaceous plants have a wide range of biological, health care and diseases protection including activities such as pharmacological, antibacterial and anti-fungal activities.[3] Extracts of fruits, herbs, vegetables and other plants' part rich in flavonoids, phenolic acid, vitamins and other phytochemicals are used in the preparation of traditional medicine in the treatment of liver cirrhosis, hepatitis and are also used to improve the quality of nutritional foods.[4]

Vernonia amygdalina, known as 'Pokok Bismillah', is a perennial shrub from *Asteraceae* family and also commonly called 'Bitter Leaf' because of bitter taste of its leaves. Not only named Bitter Leaf, this plant also has a lot of other local names in different languages of the different regions of the world, such as *Ewuro, Onugbu, Oriwo, Etidot* and *Ityuna* in Nigeria, *Mululuza* and *Omubirizi* in Uganda, Ebichaa in Ethiopia and *Awonwono* in Ghana.[5] Although it is well distributed in Asia, Nigerians are more aware about its benefit and have been utilizing this plant to its maximum usage because of its health benefits compared to other region.[6] In some African countries including Nigeria, this plant species is traditionally used to treat many ailments including diabetes, malaria, helminth infections, fever,[7] promote wound healing,[8] and to treat microbial infections.[9]

Lime (*Citrusaurantifolia*) belongs to the family of *Rutaceae* and is grown almost in every home garden. Lime juice is rich in vitamin C, responsible for a series of health benefits. Lime juice reduces the body

heat and increases appetite. Drinking lime juice with salt reduces the stomach pain. It helps in digestion of foods.[10] Lemon (*Citrus limon* Burm. f.) is the medicinally important plant and belongs to the family Rutaceae. Lemon is the third most important citrus fruit following orange and mandarin.[11] Alkaloids in crude extracts of different parts of lemon plant such as stem, root, leaves and flower have been reported by Kawaii.[12] Fruits of lemon plants are appreciated for their high content of flavonoids, aascorbic acid, citric acid and minerals. Lemon juice in the form of beverage is enjoyed by people of all age groups including children and elders due to their refreshing taste and medicinal benefits.[13]

According to Sharma,[3] phytochemical screening refers to the scientific process of analyzing, examining, extracting, experimenting, and thus identifying different classes of phytoconstituents present in various parts of plant for the base for the discovery of phytochemicals which are capable of varying pharmacological purposes. Hussain[4] reported that quinine, flavonoids, tarpenoid and other phytochemicals are water soluble which are capable of antioxidant and anti-inflammatory properties, prevents carcinogenesis and oxidative cell damage. Boots[14] also added that plants containing beneficial phytochemicals may supplement the needs of the human body by acting as natural antioxidants. Previous studies have revealed that plants contain tremendous phytochemical compounds.[15] The phytochemical screening of the selected plants in this study would undoubtedly help in unraveling phytochemical constituents of the selected plants, hence, the need for their consumption for health and wellness promotion.

Materials and Methods

Source of Materials

Bitter leaf, lime and lemon were obtained from the research farm of the Federal Polytechnic Offa, Kwara State, Nigeria.

Raw material preparation

Preparation of bitter leaf extract

Bitter leaf extract was prepared according to the modified method of Achuba.[16] The bitter leaves were rinsed using portable water and vigorously washed manually. The extract was sieved using 250 µm mesh size to obtain clear bitter leaves extract.

Preparation of lime and lemon extract

The method of Sindhu and Khatkar[17] was used for the preparation of lime and lemon extract.Each citrus fruits were separately washed using clean water, cut into halves and squeezed manually to extract the juice. The juices were filtered separately to obtain clear lime and lemon extracts.

Methods

Determination of phytochemical composition of the sample extracts

Selected phytochemical factors of the sampmes such as tannin, alkanoids and flavonids weredetermined using established methods. The method described by Komlaga[17] was used to determine tannin of the samples while alkaloids was determined according to Harbone[19] method. Flavonoids of the samples were determined as described by the method of Mahajan and Badujar[20].

Determination of selected vitamin composition of the sample extracts

Vitamin C and beta carotene of the samples were determined using the method of Khan[21] and Harborne[19], respectively. About 5 g of well blended sample was weighed into a conical flask and 25ml of 5% metaphosphoric acid in 10% acetic acid solution was added and thereafter gently agitated to obtain a homogenous dispersion. This was filtered and made up to volume of 50ml using methaposphoric acid. It was filtered and 4mls of filtrate was pipette into a text tube 0.1 ml of 2,4-dinitrophenyl hydrazine dye was added and put in a water bath set at 37 degree Celsius for 3hrs. After 3hrs the tube was cooled and 5ml of cool 85% sulphuric acid was added. Absorbance was read and recorded at 521 nm and vitamine C concentration determined. About 2 g of each sample was weighed into a centrifuge tube and 10 ml of 80% acetone added. This was agitated severally for extraction of the carotenoid after which the tubes were place in a centrifuge and centrifuged at a speed of 3000 rpm for 10 min. The supernatant was thereafter decanted and the optical density read using a ultra violent visible spectrophotometer at a wavelength of 480 nm.

Determination of selected mineral composition of the sample extracts

The method of AOAC[22] was used to determine the selected mineral composition of the sample extracts. Using the Atomic Absorption Spectrophotometer (AAS) corresponding lamp for corresponding mineral was placed in the AAS and the wavelength specific to a particular mineral or heavy metal was set. The AAS siphoning hose was dipped into the digested sample after running the standards for the selected minerals (phosphorus,potassium, magnesium, iron and zinc). The concentration of the metal in the solution was displayed on the screen of the AAS machine, read and recorded accordingly for each selected mineral.

Statistical Analysis

The means and standard deviations of all the analyses were calculated. The results were subjected to analysis of variance (ANOVA) to detect significant differences amongst the samples. Duncans' multiple range test at $p \leq 0.05$ was used to determine the difference between means.

Results and Discussion

Phytochemical composition of selected plant extracts samples

Table 1 presents the results for the selected phytochemical composition of plant extracts samples. Phytochemicals are plant chemicals that possess varying degrees of therapeutic activities and may display their health protective effects in diverse ways. They can act as antioxidants (polyphenols, carotenoids) and protect cells against free radical damage.[23] The mean results for tannin content of samples ranged from19.51 mg/g to 60.96 mg/g with bitter leaf extract having the highestvalue (60.96 mg/g) while the least value (19.51 mg/g) was observed inthe lime extract. Tannin is one of the most abundant phytochemical in bitter leaf which is responsible for its bitter taste.[8] hence, justifying the highest value observed in the bitter leaf juice extract. Inusa *et al.*[24] further reported that the high tannin content possessed by bitter leaf may explain the reason for its antimicrobial actions since the antimicrobial properties. There are nosignificantdifference ($p \geq 0.05$) between lemon extract and lime extract while bitter leaf extract differed significantly ($p \leq 0.05$). These values are in agreement with the findings of Ajayi[25] whose study reported (44.27 mg/g) for tannin content of lime juice. Contrarily, Adebayo-Tayo[26] reported (525 mg/g) for tannin content of lime juicewhich is higher than the values reported for samples in this study. Ekpete[27] reported (4.75 mg/g) for tannin content of senna leaves extract which is lower than the values observed for tannin content of samples in this current study. Lower tannin contents have been reported by different researchers for different plant extracts; (0.02 mg/g) for grape fruit juice by Kolawole,[28] (1.9 mg/g) for black nightshade leaves extract by Akubugwo, [29] (1.20 mg/g) for bitter leaves by Ali,[30] (0.11 mg/g) for water leaf previously by Adekanmi,[31] (2.48 mg/g) for scent leaves by Udochukwu,[32] all of which are lower thanthe values recorded for tannin content of samples in this study. Variation may be attributed to the different plant varieties, period of harvest and extraction methods. Tannins have been discovered to be effective antioxidants, antimicrobial and anti-carcinogenic agents.[33]

Table 1: Selected phytochemical composition of plant extract samples

Parameter, mg/g	Sample A	Sample B	Sample C
Tannin (mg/g)	19.58 ± 0.11^{a}	19.51 ± 0.71^{a}	60.96 ± 0.06^{b}
Flavonoid (mg/g)	13.31 ± 0.04^{a}	33.27 ± 0.09^{b}	66.09 ± 0.72^{c}
Alkaloids (mg/g)	0.98 ± 0.13^{b}	0.66 ± 0.02^{a}	2.49 ± 0.04^{c}

Values are means ± standard deviation of triplicate. Values in the same row having a different superscripts are significantly different @ $p \leq 0.05$. Sample A: bitter leaf extract, sample B: lime extract, sample C: lemon extract.

The flavonoid content of samples ranged from13.31 mg/g to 66.09 mg/g with bitter leaf extract having the highest value (66.09 mg/g) while the least value (13.31 mg/g) was observed in lemon extract. There was significant difference between all samples ($p \leq 0.05$). Flavonoids are the most common group of polyphenolic compounds in the human diet and are found ubiquitously in plants.[34] Flavonoid are known to be potent as free radical scavengers which prevent oxidative cell damage and have strong anticancer activity.[35] These results are higher than the values (2.76 mg/g) reported for grape fruit juice reported in the previous work of Kolawole[28] and those of bitter leaf (2.31 mg/g) and water leaf (0.86 mg/g) by Adekanmi.[31] Contrarily, higher flavonoid contents in moringa leaves (66.1 – 96.9 mg/g) and nightshade leaves (315.65 mg/g) have been reported by Lean[36] and Huang,[37] respectively as compared to this study with lower values (13.31 – 66.09 mg/g). The pharmacological effects of flavonoids include cardiotonic, lipid lowering, antiulcer, hepatoprotective, antiinflammatory, antineoplastic, antimicrobial, antioxidant and hypoglycemic activity. Dietary intake of flavonoids containing foods potentially lowers the risk of certain free radical related pathophysiology.[38]

The mean results for alkaloid content of samples ranged between 0.66 to2.49 mg/g. Bitter leaf extract had the highest value (2.49 mg/g) while the

least value (0.66 mg/g) was observed in the lime extract. There was significant difference between all samples ($p \leq 0.05$). Higher alkaloids have been detected in six (*Jatropha curcas* (120.38 mg/g), *Levisticum officinales* (113.50 mg/g), *Dracaen aloureiri* (133.45 mg/g), *Foeniculum vulgare* (197.62 mg/g), *Sapindus saponaria* (170.29 mg/g) and *Annonasqua mosal* (100.58 mg/g)) selected medicinal plants in the previous work of Sivakumar,[39] all of which are greater than the values reported for samples in this current study. Alkaloids were undetected for *Citrusaurantifolia*in the previous work of Adebayo-Tayo.[26] In like-some, Kalita[40] recently reported (70.49 mg/g), (12.51 mg/g) and (43.19 mg/g) for alkaloids content of apple, grapefruit and banana respectively which are higher than the results for the alkaloids content of samples in this current study. Although slight conformity of alkaloids, in comparison with this study, for *Senna mimosoides* leaves (1.97 mg/g) were reported by Ekpete;[27] the findings of Ajiboye[41] and *Seneciobiafrae* leaf (0.23 mg/g)are lower the values reported for samples in this study. Alkaloids are very important in medicine and constitute most of the valuable drugs. They have marked physiological effect on animals. [42]

Table 2: Vitamin C and β-carotene composition of plant extract samples

Parameter, mg/g	Sample A	Sample B	Sample C
Vitamin C (mg/g)	7.93 ± 0.16^{c}	3.72 ± 0.04^{b}	0.35 ± 0.04^{a}
β-carotene (mg/g)	0.01 ± 0.05^{a}	0.01 ± 0.00^{a}	0.10 ± 0.01^{b}

Values are means ± standard deviation of triplicate. Values in the same row having a different superscripts are significantly different @ $p \leq 0.05$. sample A: bitter leaf extract, sample B: lime extract, sample C: lemon extract. 6 µg of beta carotene equal 1 retionol activity equivalent and 1 retinol equivalent of viatamin A activity (FAO/WHO/UNU, 1985).

Vitamin C and β-carotene composition of selected plant extracts samples

The results for the vitamin C and β-carotene composition of plant extract samples are as depicted in Table 2. The mean results for the vitamin C content of samples varied between 0.35 to 7.93 mg/g with lemon extract having the best value (7.93 mg/g) while the least score (0.35 mg/g) was reported by bitter leaf extract. All samples had statistical variation ($p \leq 0.05$). As compared to bitter leaf extract, significant amount of vitamin C in lemon and lime extract of lemon extract and lime extract justifies the claim of Boudries[43] that citrus fruits are good sources of vitamin C (ascorbic acid). Blessing[44] evaluated the vitamin C (ascorbic acid) content of some Nigerian pumpkins to be (3.62 – 4.39 mg/g) while Rajeswari[45] reported (5.1 mg/g), (1.5 mg/g) and (1.9 mg/g) for mandarin orange, pomegranate and tea leaves respectively; the values for the cited literatures are slightly in agreement with the vitamin C content of samples in this current research. Contrarily, higher vitamin C content wasreported by Boudries[43] for mandarin fruit juice (68.35 mg/g) and clementine fruit juice (63.80 mg/g), respectively. Also, (40 – 62 mg/g) of ascorbic acid was reported for different citrus juices in the study of Dongmo.[46] Several factors influence the ascorbic acid content. Lee and Kader[47] contributed that pre-harvest factors include climatic conditions (sunlight exposure and weather), cultural practices (fertilizers), maturity at harvest, harvesting method, postharvest handling conditions (storage), species, cultivars, tissues, as well as the genotype and treatment.[37] All these factors are responsible for the wide variation in vitamin C content of fruits and vegetables.[43]

The mean results for the β-carotene content of samples ranged between 0.01 to 0.10 mg/g with bitter leaf extracthaving the highest value (0.10 mg/g) while the least value was observed in lemon extract and lime extract. With exception of bitter leaf extract, there was no significant difference ($p \leq 0.05$) between lemon extract and lime extract. These values are lower than the values (0.70–2.48 mg/g) reported for β-carotene content of some Nigerian pumpkins by Blessing.[44] Contrarily, Wang[48] reported (0.02 –0.34 mg/g) for the carotenoid level of eight citrus fruit varieties which slightly agree to those reported for samples in this current study. The findings of Fatma[49] for orange-yellow cactus pear fruit (0.017 mg/g) which is in agreement with the values obtained for samples in this study. The β-carotene content of clementine and mandarin fruits (75.14 mg/g) and (38.31 mg/g) previously reported by Boudries[43] are also higher than

the β-carotene content of samples in this current study. The β-carotene content of bitter leaves (97.82 mg/g) reported by Oboh[50] was higher than the values obtained for β-carotene content of samples in this study. Variation in their value and those of this present study may be attributed to the period of harvest. The β-carotene contents of samples in this study are lower than the recommended daily intake of β-carotene which lies at the range (2–7 mg/100 g);[51] therefore, obtaining the body's required amount of beta-carotene from other rich sources of β-carotene such as orange fleshed sweet potato, carrot, pumpkin, cantaloupe, spinach and potato leaves is encouraged.

Table 3: Selected mineral composition of samples

Parameter, mg/g	Sample A	Sample B	Sample C
Potassium	84.04±4.55^{b}	34.92±0.26^{a}	105.22±0.07^{c}
Magnesium	16.36±0.53^{a}	15.82±0.27^{a}	22.62±0.76^{b}
Iron	0.87±0.01^{b}	0.59±0.04^{a}	1.23±0.06^{c}
Phosphorus	2.98±0.07^{b}	2.61±0.07^{a}	5.19±0.03^{c}
Zinc	0.08±0.00^{a}	0.01±0.00^{a}	1.40±0.02^{b}

Values are means ± standard deviation of triplicate. Values in the same row having a different superscripts are significantly different @ p≤0.05. sample A: bitter leaf extract, sample B: lime extract, sample C: lemon extract.

Mineral composition of selected plant extracts samples

Table 3 presents the results for the mineral composition of the plant extracts samples. The potassium content of samples ranged between 34.92 mg/g to 105.22 mg/g with bitter leaf extract having the highest value (105.22 mg/g) while the least score (34.92 mg/g) was observed in the lime extract. There was significant difference between all samples (p≤0.05). These values are in agreement with the values (24.50 mg/g), (31.67 mg/g), (47.84 mg/g) and (195.45 mg/g) reported for grape fruit, lime juice, oranges juice and lemon juice respectively in the study of Chuku and Chinaka.[52] However, the values obtained for clementine (4.17 mg/g) and mandrine fruit pulps (6.00 mg/g), respectively in the study of Boudries[43] are lower than the potassium content of samples in this study. Contrarily, higher potassium content of different fruit juices (128.0–305.00 mg/g) has been reported by Nwozo.[53] Despite the higher amount of potassium in this study, they seemingly fall short of (4700 mg/g) which is the recommended daily dietary intake for potassium as reported by Yarkwan and Oketunde[54] Thus, in reference to the adequate intakes (AI) and recommended dietary allowance (RDA), the different samples in this study are not good sources of potassium and so cannot be relied upon to provide potassium. However, this can be easily sourced from other diets in enough quantities. Even though high potassium in the blood could be life-threatening problem;[55] it however helps in maintaining water and electrolyte balance in the body.[53]

The mean result for the magnesium content of samples ranged from15.82 mg/g to 22.62 mg/gwith bitter leaf extract having the best score (22.62 mg/g) while the least value (15.82 mg/g) was reported by lime extract. Except for bitter leaf extract, there was no significant difference between other samples (p≥0.05). The magnesium content of different fruit juices (6.77 – 16.84 mg/g) observed for samples in the study of Nwozo[53] slightly agree to the values obtained for magnesium content of samples in this current study. Akani[56] reported (0.45 and 0.49 g/100g) for magnesium content of fresh and dehydrated bitter leaves respectively in their study which are lower than the values reported for samples in this study. The results reported for the magnesium content of samples in this study do not meet the recommended dietary allowance (RDA) of (400 mg/day) for men of about (19-30 years old) and (310 mg/day) for women of about (19 – 39 years old) as affirmed by Asaolu.[57] Contrarily, Ekpete[27] reported the magnesium content of some Nigerian fruits to be (15.67 –32.50 mg/g) which are higher than the values reported for magnesium content of samples in this current study. Magnesium (Mg) is used to prevent muscle cramping and it enhances nerve functioning, relieves tight sore muscles and improve bone density. It also plays a major role in relaxing muscles along the airway to the lung thus allowing asthma patients to breatheeasier. Its deficiencies include severe diarrhoea, migraines, hyper-tension, cardiomyopathy, arteriosclerosis and stroke. [27]

The mean results for the iron (Fe) content of samples had ranged from 0.59 mg/g to 1.23 mg/g. Bitter leaf extract was observed to be of highest value (1.23 mg/g) while the least value (0.59 mg/g) was observed in lime extract. There was significant difference ($p \leq 0.05$) between all samples. The higher iron content reported for bitter leaf extract justifies the report of Agomuo[58] whose study reported that whole bitter leaf contains about (21.59 mg/g) of iron; variation in their value and those reported for samples in this study may be due to the period of harvest or method of solvent extraction. The values reported for samples in this study compare favorably with the values (0.40 –3.28 mg/g) for iron content some Nigerian fruits in the previous work of Ekpete.[27] Contrarily, Nwozo[53] reported (0.08 –0.39 mg/g) for iron content of different fruit juices which are lower than the values reported for iron content of samples in this study. Lower iron contents have also been reported for grape fruit juice (0.80 mg/g), lime juice (2.99 mg/g), orange juice (0.47 mg/g) and lemon juice (1.33 mg/g) respectively in the study of Chuku and Chinaka.[52] The iron content of samples in this study may be considered inadequate when viewed against a recommended dietary allowance (RDA) of 8 mg/day of men of ages 19 and above and women over 40 years, 18 mg Fe/day for girls and women between the ages of 11 and 50.[59] Iron is important in the diet, especially of infants, expectant / nursing mothers, convulsing patients and the elderly for the prevention of anemia.[60] The deficiency of iron has been described as the most prevalent nutritional deficiency and iron deficiency anemia is estimated to affect more than one billion people worldwide.[61]

The phosphorus content of samples ranged between 2.61 mg/g to5.19 mg/g with bitter leaf extract having the highest value (5.19 mg/g) while the lime extract had the least value (2.61 mg/g). There was significant difference between all samples. These values are higher than the values (0.80 mg/g) and (0.01 –1.09 mg/g) reported for phosphorus content of bitter leaf and some Nigerian pumpkin in the studies of Ibrahim.[34] According to Nagy,[62] citrus fruits are good sources of phosphorus; the highest phosphorus content of bitter leaf extract in this study may imply that bitter leaf stands a better chance of supplying phosphorus to the body, thus justifying the claim of Agbogidi[63] that bitter leaves are cost-friendly leaves which have been found to be rich in phosphorus. Contrarily, the phosphorus contents (5.6 – 13.6 mg/g) of combined dates and lemon juices reported in the study of Alfadul and Hassan[64] are higher than the values obtained for samples in this current work. Variation may be attributed to the dates fruit utilized in their study.

The mean result for the zinc content of samples ranged between 0.01 mg/g to 1.40 mg/g with bitter leaf extract having the highest zinc content (1.40 mg/g) while lime extract reported the least (0.01 mg/g). There was no significant difference ($p \geq 0.05$) between lemon extract and lime extract while bitter leaf extract differed significantly ($p \leq 0.05$) from other samples. Akunna and Edbert[65] reported (0.01 mg/g) for the zinc content of bitter leaf which falls short of the values obtained for values in this study. The findings of Kolawole[28] for zinc content of grape fruit juice (0.09 mg/g) are lower than the values reported for samples in this study. Contrarily, (2.08 mg/g) was declared for the zinc content of whole bitter leaf in the study of Agomuo[58] which is slightly higher than the values reported for samples in this study. Lean[36] reported that the recommended nutrient intake (RNI) for zinc per day is 9 mg/day. The zinc content of samples in this study may not seemingly be good enough to meet the RNI of Zinc and therefore supplementation with other good sources of the mineral is recommended. Zinc increases the affinity of haemoglobin for oxygen, participates in taste perception and interacts with a number of hormones.[66] It is required for cell replication and gene expression as well as for tissue repair, wound healing, reticular development and integral constituent of insulin.[67]

Conclusion

This study evaluated the phytochemical, vitamins and mineral composition of different plant extracts (lemon, lime and bitter leaf). The bitter leaf extracts outwitted the lemon and lime extracts in respect to all assayed phytochemicals, selected vitamins and minerals. This infers that bitter leaf stands a better chance at making available the body's required phytonutrients, vitamins and minerals. Commendable levels of nutrients evident in other plant extracts (lemon and lime) also render them consumable as part of dietary intake. Despite the remarkable higher nutritional values observed in the respective plant extracts in this study, most of the assayed nutrients fall short of the recommended dietary intake; hence, obtaining the nutrients from other food products by people are recommended. Further studies are recommended on the in vitro, antibacterial activity and proximate composition of the plant extracts in this study.

Funding and conflict of interest

The project was self-funded; there was no direct funding for the research, and authors declare no conflict of interest.

REFERENCES

[1]. Mercy, A.G., Light, W.F., Gospel, S.A. Qualitative and quantitative phytochemical screening of some plants used in ethnomedicine in the Niger Delta region of Nigeria, *Journal of food and Nutrition Sciences*, 5(5), 198-205, 2017.

[2]. Batiha, G.E. and Beshbishy, A.M. Gas chromatography-mass spectrometry analysis, phytochemical screening and anti-protozoal effects of the methanolic Viola tricolor and acetonic Laurus nobilis extracts. *BMC Complementary Medicine and Therapies*, 20(87), 20-30, 2020.

[3]. Sharma, T., Pandey, B., Shrestha, B.K., Koju, G.M., Karki N. Phytochemical screening of medicinal plants and study of the effect of phytoconstituents in seed germination. *Tribhuvan University Journal*, 35(2), 1-11, 2020.

[4]. Hussain, I., Ullah, R., Ullah, R., Khurra, M., Ullah, N., Baseerm A., Khan, F.A., Khattak, M.R., Zahoor, M., Khan, J., Khan, N. Phytochemical analysis of selected medicinal plants. *African Journal of Biotechnology*, 10(38), 7487-7492, 2011.

[5]. Kiguba, R., Ononge, S., Karamagi, C., Bird, S.M. Herbal medicine use and linked suspected adverse drug reactions in a prospective cohort of Ugandan inpatients. *BMC Complement. Alternative Medicinal*, 16, 145-150, 2016.

[6]. Farombi, E.O., Owoeye, O. Antioxidative and chemopreventive properties of *Vernonia amygdalina* and *Garciniabi flavonoid*. *Int J Environ Res Public Health*, 8, 2533-2555, 2011.

[7]. Magadula, J.J., Erasto, P. Bioactive natural products derived from the East African flora. *Natural Product Reports*, 26, 1535–1554,2009.

[8]. Adetutu, A., Morgan, W.A., Corcoran, O. Ethnopharmacological survey and in vitro evaluation of wound-healing plants used in South-western Nigeria. *Journal of Ethnopharmacology,* 137, 50–56, 2011.

[9]. Noumedem, J.A.K., Mihasan, M., Kuiate, J.R., Stefan, M., Cojocaru, D., Dzoyem, J.P., Kuete, V. In Vitro antibacterial and antibiotic-potentiation activities of four edible plants against multidrug-resistant gram-negative species.*BMC Complementary and Alternative Medicine*, 13, 190, 2013.

[10]. Thamilseli, C., Krishnakumar, T., Amutha, S. Preparation and quality evaluation of lime based herbal blended RTS beverage. *Asian J. Dairy & Food Res.*, 34(1), 54-58, 2015.

[11]. Perez-Perez, J.G., Porras Castillo, I., Garcia-Lidon, A., Botia, P., Garcia-Sanchez, F. Fino lemon clones compared with the lemon varieties Eureka and Lisbon on two rootstocks in Murcia (Spain). *Scientia Horticulturae*, 106, 530-538., 2005.

[12]. Kawaii, S., Yasuhiko, T., Eriko, K., Kazunori, O., Masamichi, Y., Meisaku, K., Hiroshi, F. Quantitative study of flavonoids in leaves of Citrus plants. *J Agric Food Chem*, 48, 3865-3871, 2000.

[13]. Mishra, P., Rai, G.K., Mahatana, C.L. Process of standardization for development of spray-dried lemon juice powder and optimization of amla-lemon based RTS (Ready-to-serve) drink using response surface methodology. *Journal of Food Processing and Preservation*, 39, 1216-1228, 2015.Kjh

[14]. Boots, A.W., Haenen, G.R., Bast, A. Health effects of quercetin: From antioxidant to nutraceutical. *Eur. J. Pharmacol.*, 585, 325–337, 2008.

[15]. Klimek-Szczykutowicz, M., Agnieszka, S., Ekiert, H. *Citrus limon* (Lemon) Phenomenon: A Review of the Chemistry, Pharmacological Properties, Applications in the Modern Pharmaceutical, Food, and Cosmetics Industries and Biotechnological Studies. *Plant*, 9, 119, 2019.

[16]. Achuba, F.I. Role of bitter leaf (*Vernonia amygdalina*) extract in prevention of renal toxicity induced by crude petroleum contaminated diets in rats. *International Journal of Veterinary Science and Medicine*, 1-6, 2018.

[17]. Sindhu, R., Khatkar, B.S. Preservation and storage of lemon (*Citrus limon*) juice. *International Journal of Advanced Engineering Research and Science*, 5(3), 154-158, 2018.

[18]. Komlaga, G., Agyare, C., Dickson, R.A., Mensah, M.L., Annan, K., Loiseau, P.M. Medicinal plants and finished marketed herbal products used in the treatment of malaria in the Ashanti region, Ghana. *Journal of Ethnopharmacology*, 172, 333– 346, 2015.

[19]. Harborne, J. Phytochemical methods. Chapman and Hall, Ltd London, 49-88, 1973.

[20]. Mahajan, R.T., Badujar, S.B. "Phytochemical investigations of some laticiferous plants belonging to Khandesh region of Maharashtra" *Ethnobotanical Leaflets*. 12, 1145–1152, 2008.

[21]. Khan, M.M., Rahman, M.M., Murad, A.T.M., Begum, S.A. Determination of vitamin C content in various fruits and vegetables by UV-spectrophotometric method at Sylhet area, Bangladesh. *J. Environ. Sci*., 11, 190-193, 2005.

[22]. AOAC. Official method of Analysis.20th Edition, Association of Officiating Analytical Chemists, Washington, DC, 2010.

[23]. Omoregie, E.S., Osagie, A.U. Antioxidant properties of methanolic extracts of some Nigerian plants on nutritionally-stressed rats. Niger. *J. Basic Appl. Sci*., 20 (1), 7–20, 2012.

[24]. Inusa, A., Sanusi, S.B., Linatoc, A.C., Mainassara, M.M., Awawu, J.J. Phytochemical analysis and antimicrobial activity of bitter leaf (*Vernonia amygdalina*) collected from Lapai, Niger state, Nigeria on some selected pathogenic microorganisms. *Science World Journal*, 13(3), 15-18, 2018.

[25]. Ajayi, A., Ude, A.N., Balogun, O.J. Qualitative and quantitative phytochemical analysis of *Moringaoleifera* and *Vernonia amygdalina*. *Agricultural and Biological Sciences*, 3(2), 51-57, 2017.

[26]. Adebayo-Tayo, B.C., Akinsete, T.O., Odeniyi, O.A. Phytochemical Composition and Comparative Evaluation of Antimicrobial Activities of the Juice Extract of *Citrus aurantifolia* and its Silver Nano particles.*Nig. J. Pharm. Res*., 12 (1), 59-64, 2016.

[27]. Ekpete, O.A., Edori, O.S., Fubara, E.P. Proximate and Mineral Composition of Some Nigerian Fruits. *British Journal of Applied Science & Technology*, 3(4), 1447-1454, 2013.

[28]. Kolawole, S.E., Obueh, H.O., Emokpae, B.A. Nutritional and antinutritional evaluation of grape fruit (*Citrus paradisi*) juice using different extraction methods. *Journal of advances in food science and Technology*, 4(2), 84-90, 2017.

[29]. Akubugwo, I.E., Obasi, A.N., Ginika, S.C. Nutritional potential of the leaves and seeds of black nightshade- *Solanum nigrum* L. Var virginicum from Afikpo-Nigeria. *Pakistan Journal of Nutrition*, 6, 323–326, 2007.

[30]. Ali, M., Diso, S.U., Waiya, S.A., Abdallah, M.S. Phytochemical Screening and Antibacterial Activity of Bitter Leaf (*Vernonia amygdalina*).*Annals of Microbiology and Infectious Diseases*, 2(4), 1-7, 2019.

[31]. Adekanmi, A.A., Adekanmi, U.T., Adekanmi, A.S., Oyekanmi, H.A. Assessment of Proximate Composition and Phytochemical Properties of Bitter Leaf (*Vernonia amygdalina*) and Water Leaf (*Talinum triangular*). *UIJRT/United International Journal for Research & Technology*, 1(9), 13-21, 2020.

[32]. Udochukwu, U., Omeje, F.I., Uloma, I.S., Oseiwe, F.D. Phytochemical analysis of *Vernonia amygdalina* and *Ocimum gratissimum* extracts and their antibacterial activity on some drug resistant bacteria. *American Journal of Research Communication*, 3(5), 1-12, 2015.

[33]. Lai, P.K., Roy, J. Antimicrobial and Chemopreventive Properties of Herbs and Spices.*Curr. Med. Chem*., 11(11), 1451-1460, 2004.

[34]. Ibrahim, A., Yakubu, S., Ketim, A. Phytochemical Screening and Elemental Analysis of Leaf Extract of *Vernonia amygdalina* (Bitter Leaf). *International Journal of Research and Innovation in Applied Science*, 4(1), 1-3, 2019.

[35]. Okwu, D.E. Phytochemicals and vitamin contents of indigenous spices of South eastern Nigeria. *Journal of Sustainable Agriculture and the Environment*, 6(1), 30-37, 2004.

[36]. Lean, M.N. Vitamins and other bioactive food constituents in: Food Science, Nutrition and Health (7th edition). Edward Hodder Ltd, London, pp, 198-216, 2006.

[37]. Huang, Y.C., Chang, Y.H., Shao, Y.Y. Effects of genotype and treatment on the antioxidant activity of sweet potato in Taiwan. *Food Chem*., 98, 529-538, 2006.

[38]. Adewole, E., Ojo, A., Ogunmodede, O.T., Adewumi, D.F. Antioxidant Activities and Nutritional Composition of *VernoniaAmygdalina.Int J Basic Appli Sci*., 4(1), 9-16, 2015.

[39]. Sivakumar, D., Chen, L., Sultanbawa, Y. A comprehensive review on beneficial dietary phytochemicals in common traditional Southern African leafy vegetables.*Food science and Nutrition*, 6, 714-727,2017.

[40]. Kalita, P.P., Sapam, R., Sarma, M.P., Talukdar, N., Das, H. Screening of phytochemicals and determination of total phenolic content, antioxidant and antimicrobial activity of methanolic extract of *Piper nigrum* leaves.*Indo American J of Pharma Res* 8(2), 1354- 1360, 2018.

[41]. Ajiboye, B.O., Ibukun, E.O., Edobor, G., Ojo, A.O., Onikanni, S.A. Qualitative and quantitative analysis of phytochemicals in *Seneciobiafrae* leaf.*Int.J.Inv.Pharm.Sci*., 1(5), 428-432, 2013.

[42]. Edeoga, H.O., Okwu, D.E., Mbaebie, B.O. Phytochemical constituents of some Nigerian medicinal plants. *African Journal of Biotechnology*, 4(7), 685-688, 2005.

[43]. Boudries, H., Madani, K., Touati, N., Souagui, S., Medouni, S., Chibane, M. Pulp antioxidant activities, mineral contents and juice nutritional properties of Algerian Clementine Cultivars and

Mandarin. *African Journal of Biotechnology*, 11(18), 4258-4267, 2012.

[44]. Blessing, A.C., Ifeanyi, U.M., Chijioke, O.B. Nutritional evaluation of some Nigerian pumpkins (*Cucurbita spp.*). *Fruit, vegetable and cereal science and biotechnology*, 5(2), 64-71, 2011.

[45]. Rajeswari, A. Evaluation of phytochemical constituents, quantitative analysis and antimicrobial efficacy of potential herbs against selected microbes.*Asian journal of pharmaceuticl and clinical research*, 8(2), 232-237, 2015.

[46]. Dongmo, P.M.D., Tatsadjieu, L.N., Tchinda, E.S., Kuate, J., Amvam, P.H.Z., Menut, C. Essential oils of Citrus aurantifolia from Cameroon and their antifungal activity against *Phaeoramularia angolensis*. *African Journal of Agricultural Research*, 4(4), 354-358, 2009.

[47]. Lee, S.K., Kader, A.A. Pre-harvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biol. Technol*., 20, 207-220, 2000.

[48]. Wang, L., Gaziano, J.M., Liu, S., Manson, J.E., Buring, J.E., Sesso, H.D. Wholeand refined-grain intakes and the risk of hypertension in women.*Am J Clin Nutr*., 86(2), 472-479, 2007.

[49]. Fatma, H., Abd, E., Eman, M.E., Gaber, M.G.S., Amal, A.H., Anhar, M.G. Effects of cactus pear (*Opuntiaficus indica*) juice on oxidative stress in diabetic cataract rats, 1(1), 23-29, 2012.

[50]. Oboh, G., Raddatz, H., Helen, T. Antioxidant properties of polar and non-polar extracts of some tropical green leafy vegetables. *J. Sci. Food Agric.*, 88, 2486-2492, 2008.

[51]. Koushik, A., Hunter, D.J., Spiegelman, D., Anderson, K.E., Buring, J.E., Smith-Warner, S.A. Intake of the major carotenoids and the risk of epithelial ovarian cancer in a pooled analysis of 10 cohort studies. *International Journal on Cancer*, 119 (9), 2148–2154, 2006.

[52]. Chuku, L.C., Chinaka, N.C. Protein and mineral element levels of some fruit juices (*Citrus spp.*) in some Niger Delta areas of Nigeria. *International Journal of Nutrition and Food Sciences*, 3(6-1), 58-60, 2014.

[53]. Nwozo, S.O., Aladesuru, O.O., Hammed, W.A. Evaluation of the proximate, mineral and vitamin content of juices produced from imported and local lesser known fruits in Nigeria. *Annals Food Science and Technology*, 402-412, 2017.

[54]. Yarkwan, B., Oketunde, O. A study of the nutritional composition of freshly squeezed and processed orange juices. *Food Sience and Quality Management*, 48, 126-132, 2016.

[55]. Allison, A. The possible role of vitamin K deficiency control in the pathogenesis of Alzeimer's disease and in augmenting brain damage associated with cardiovascular diseases. *Medical Hypothesis,* 57(2), 151-155, 2001.

[56]. Akani, N.P., Jumbo, B., Nwankwo, C.E. Effect of Drying Temperatures on Mineral Composition and Bacterial Populations of *Vernonia amygdalina* (Bitter Leaf).*Research Journal of Food Science and Quality Control*, 3(2), 39-49, 2017.

[57]. Asaolu, S.S., Adefemi, O.S., Oyakilome, I.G., Ajibulu, K.E., Asaolu, M.F. Proximate and mineral composition of Nigerian leafy vegetables. *Journal of Food Research*, 1(3), 1-10, 2012.

[58]. Agomuo, J.K., Akajiaku, L.O., Alaka, I.C., Taiwo, M. Mineral and antinutrients of fresh and squeezed-washed bitter leaf (*Vernonia amygdalina*) as affected by traditional de-bittering methods. *European Journal of Food Science and Technology*, 4(2), 21-30, 2016.

[59]. Food and Nutrition Board, FNB, Institute of Medicine. Dietary Reference intakes for Vitamin A, Vitamin K, Arsenic, Boron, Molybdenum, Nickel Sillicon, Vanadium and Zinc. Washton D.C. Standing Committee on scientific Evaluation of Dietary Reference intakes national-Academic press, 2001.

[60]. Oluyemi, E.A., Akinlua, A.A., Adenuga, A.A., Adebayo, M.B. Mineral content of some commonly consumed Nigerian Food. *Sci. Focus*, 11(1), 153-57, 2006.

[61]. Abbaspour, N., Hurrell, R., Kelishadi, R. Review on iron and its importance for human health. *Journal of Research in Medical Sciences*, 19(2), 1-10, 2014.

[62]. Nagy, V., Szabo, Z., Mark, L., Deli, J. Comparative study on the carotenoid citrus. *Innovative Food Science and Emerging Technologies*, 8, 390 – 394, 2007.

[63]. Agbogidi, O.M. Akpomorine, M.O. Health and nutritional benefits of bitter leaf (*Vernonia amygdalina* del*). Int JA PS. BMS Hetero Group*, *J*, 2, 164-70, 2013.

[64]. Alfadul, S.M., Hassan, B.H. Chemical Composition of Natural Juices Combining Lemon and Dates. *International Journal of Food Engineering*, 2(1), 9-15, 2016.

[65]. Akunna, D.I., Edbert, D.C. Infrared Studies and Mineral Element Analysis of the leaf of *Vernonia amygdalina.Word News of Natural Sciences*, 13, 1-9, 2017.

[66]. Magaia, T., Usmusse, A., Sjohol, I., Skog, K., (2013). Dietary fiber, organic acids and minerals in selected wild edible fruits in Mozambique. *Springer Plus*, 2, 88-95, 2013.

[67]. Murray, R.K., Granner, D.K., Meyes, P.A., Rodwell, V.W. Harpers biochemistry 25th Edition McGraw- Hill health Profession Division, USA, 2000.

5/22/2022