Determination of the Micronutrient (Vitamin A, C, E, Zinc and Selenuim) Content of Four Indigenous Aromatic Spices in Nigeria

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Abstract: Micronutrients are nutrients required for human's physiological functions and health maintenance. They are described as organic compounds required in micrograms or milligrams This study is aimed at comparing the micronutrient (Vitamin A, C, E, zinc and selenuim) content of four indigenous spices (Scent leaf, garlic, Aidan seed and guinea pepper) in Nigeria. Standard analytical methods was utilized for the analysis. Results revealed that *Xylopia aethiopca* (guinea pepper) had the highest amount of vitamin C and E contents (38.17mg/100g and 113.63mg/100g) respectively. *Tetrapleura tetratera* contained the highest concentration of Zinc and selenium (4.74mg/g and 3.39mg/g) content while *Allium Sativum* (garlic) has the highest amount of beta-carotene (1.75mg/g). Overall, these results demonstrate that these different spices possess varying levels of essential vitamins and minerals. Guinea pepper and garlic are particularly rich in vitamin C, vitamin E, and beta-carotene, while *Tetrapleura tetratera* stands out for its high zinc and selenium content. Incorporating these spices into the diet can provide additional nutritional and potential health benefits.

Keywords: Micronutrient, Properties, Aromatic, Indigenous, Spice

I. Introduction

Micronutrients are essential elements required by human and other organisms in varying quantities throughout life to coordinate a range of physiological functions for health maintenance. For human nutrition, micronutrients are required in amounts generally below 100 milligrams per day, while macronutrients are required in gram amounts daily. Vitamins and minerals are essential micronutrients (Awuchi *et al.*, 2020). Micronutrients are important bioactive molecules and cofactors of enzymes as well. Besides being cofactors for enzymes, some vitamins such as the fat-soluble vitamins, vitamin A and D have been shown to exhibit hormone-like functions. Although they are required in small amount, they play an influential role in the proper functioning of a number of enzymes, which are involved in many metabolic, biochemical and physiological processes that contribute to growth, production and health. (Upadhaya *et al*., 2020). Micronutrient requirements for humans also include vitamins, which are organic compounds required in micrograms or milligrams (Corvallis, 2018). Since plants are the main origin of nutrients for humans and other animals, some micronutrients can be in low quantities and deficiencies can occur when there is insufficient dietary intake, as occurs in malnutrition, indicating the need for initiatives to prevent inadequate supply of micronutrient in plant foods (Blancquaert *et al*., 2017). Different aromatic spices and herbal plants have been recognized as being those whose roots, stems, leaves, and seeds contain these micronutrients. According to Ogbunugafor *et al*. (2017), a spice may be a plant's bud, bark, root, aromatic seed, leaves, or flower stigma. Spices have been used as food preservatives and for their health-improving properties in addition to improving the taste of food (Ogueke *et al*., 2018). Due to their distinct essential oils and extracts, spices are used in products other than food, such as cosmetics, medications, perfumes, incense, and others. Among the numerous Nigerian indigenous spices are *Ocimum gratissimum* (scent leaf), *Tetrapleura tetraptera* (Aidan), *Allium sativum* (garlic) and Xylopia aethiopica (Guinea pepper)*;* these spices have been used over the years in food preparation (Ogueke *et al.*, 2018).

Scent leaf (*Ocimum gratissimum*) is an herbaceous plant which belongs to the family *Lamiaceae* and is widely distributed in tropical and warm temperate regions of the world (Ibrahim *et al.*, 2020). The phytochemical screening of *Ocimum gratissimum* shows that it is rich in alkaloids, tannins, phytates, flavonoids and oligosaccharides (Udochukwu *et al.*, 2015). The nutritional importance of *Ocimum gratissimum* centres on its usefulness as a seasoning because of its aromatic flavor. In folk medicine, *Ocimum gratissimum* is extensively used throughout West Africa as a febrifuge, anti-malarial, anti-convulsant and against cough. The volatile aromatic oil from the leaves consists mainly of thymol (32-65%) and eugenol. It also contains xanthones, terpenes and lactone (Chao *et al*., 2017; Imosemi *et al.*, 2020).

Aidan (*Tetrapleura tetraptera*) is a perennial, single-stemmed plant belonging to the family of *Mimosaceae* (Famobuwa *et al.*, 2016). It is found in the rain forest belt of West Africa. The fruit of the plant has fleshy pulp with insect repelling pungent odour and little black-brown seeds. Nutritionally, the fruit is rich in protein, fat, fibre and minerals (Oguoma *et al.*, 2015). The dry fruit shell, fruit pulp and seed of *T. tetraptera* were examined for nutritional quality by Essien *et al*.(2014) and were found to contain varying amounts of nutrients- protein, lipids and mineral which were comparable in content or even higher in content than as found

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in more popular spices such as red pepper, onion, curry and ginger. The fruits are usually charred and the ash resulting from burnt fruits is collected and used in the making of black soaps traditionally formulated, in admixture with certain plant materials such as charred *Threobroma cacao* fruits and *Cola nitida* fruits, to wash off feverish conditions, skin rashes, treat ulcers or even drunk in very low doses for internal cleansing in herbal medicine (Adesina *et al.*, 2016).

Garlic (*Allium sativum*) which belongs to the family of *Amaryllidaceae* is a medicinal plant that is widespread across the world and is being used mainly in gastronomy (Herrera-Calderon *et al.,* 2021). Garlic is considered a rich source of volatile compounds, which are responsible for the distinct flavor and the bioactive properties of dry bulbs (Lanzotti *et al.,* 2014). There is also a high content of non-volatile compounds with well-known medicinal and therapeutic properties, such as amides, nitrogen oxides, phenolic compounds, especially flavonoids, proteins, saponins and sapogenins, as well as antioxidants, minerals and vitamins (Petropoulos *et al.,* 2018). Therapeutic use of garlic has been recognized as a potential medicinal value for thousands of years to different microorganisms. For example; antifungal, antiviral, antibacterial antihelmantic, antiseptic and anti-inflammatory properties of garlic are well documented. It can inhibit and kill bacteria, fungi, lower (blood pressure, blood cholesterol and blood sugar), prevent blood clotting, and contains anti-tumor properties (Gebreselema and Mebrahtu, 2013). It can also boost the immune system to fight off potential disease and maintain health.In Africa, particularly in Nigeria, it is used to treat abdominal discomfort, diarrhea, otitis media and respiratory tract infections (Muhammad and Idris, 2019).

Guinea pepper (Xylopia aethiopica) belongs to the Annoneceae family (Fetse *et al*. 2016). It is an evergreen aromatic dicotyledenous plant bearing fruits that contain 3 to 9 seeds, which are used as substitute for pepper. The Igbo speaking communities of Southeastern Nigeria (Imo *et al*., 2018) locally call the plant "uda". The seed consists of flavonoids, alkaloids, tannins, saponins, glycosides, carbohydrates, terpenes, etc. and have shown to have laxative and antimicrobial properties (Anumudu *et al*., 2020). It is a plant used as both a spice and herb. It has been reported in folklore that *X. aethiopica* is very potent in curing several ailments including cough, rheumatism and nerve pains as well as in elimination of blood clots when used to prepare pepper soup for newly delivered mothers (Ekpo *et al*., 2012). The roots of *Xylopia aethiopica* are employed in tinctures, administered orally as an anthelminthic, or in teeth-rinsing and mouth-wash extracts against toothache. They are also used as an antihemorrhagic agent. Aqueous concoction of the root is administered after child birth as an anti-infective agent (Nwangwa, 2012).

The objective of this work was to determine the micronutrient content of some of the indigenous spices (Scent leaf, garlic, Aidan seed and guinea pepper) in Nigeria in order to create room for its incorporation into the human diet for the provision of additional nutritional and potential health benefits.

II. Materials and Methods

Sample collection

Scent leaf (nchuanwu), aidan (oshosho), garlic and guinea pepper (uda) used in this study were purchased from Ose market, Onitsha, Anambra state. These spices were packaged in a clean polyethylene bag and taken to the laboratory for further processing and analysis. All chemicals used were of analytical grade.

Sample preparation

The method described in the study of Mgbemena and Amako (2020) was used in preparation of scent leaf powder with slight modifications. Scent leaves (*Ocimum gratissimum*) were manually separately from the stalk and washed with distilled water to remove adhering dusts. The leaves were spread on a drying tray at room temperature, allowed to dry for two weeks and pulverized using Thomas Willey milling machine into fine powder and sieved through 2mm mesh sieve to produce fine dried sample. The dried ground sample were stored in airtight containers at room temperature until needed for further analysis.

Scent leaves
↓
Destalking
↓
Washing
↓
Drying (room temperature 25ºC)
↓
Milling
↓
Sieving
↓
Scent leaf powder.

Fig. 1: Flow chart for processing of scent leaf powder.

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The method described by Olaniran *et al*. (2019) was adopted in the preparation of garlic powder with slight modification. The outer layers of garlic bulbs (*Allium sativum*) were peeled manually using sterile kitchen knife. The bulbs were chopped, dried in a cabinet dryer for 72hrs at 60^{o}C. The dried garlic chips were grinded into fine powder, sieved and packaged in an airtight container until needed for further use.

Garlic Bulbs
↓
Peeling
↓
Chopping
↓
Drying (60^{o}C; 72hrs)
↓
Milling
↓
Sieving
↓
Garlic Powder

Fig.2: Flow chart for the production of garlic powder.

The methods of Ogueke *et al.* (2018) were used in preparation of Guinea pepper samples. The seeds of guinea pepper (*Xylopia aethiopica)* were cleaned of stalks, unwholesome seeds, and extraneous materials using water to avoid interference with seed. The selected seeds after cleaning were washed with distilled water to remove dust and then spread on trays and oven dried at 65°C for 10h. The cleaned dried seeds were ground into powder using a laboratory homogenizer and stored in air tight containers prior to further use.

Guinea pepper seeds
↓
Sorting and Cleaning
↓
Washing
↓
Oven Drying (65°C; 10h)
↓
Milling
↓
Guinea pepper powder

Fig. 3: Flow chart for the processing of guinea pepper powder.

The method of Famobuwa *et al.* (2016) was used in preparation of Aidan powder with slight modifications. The fruits of aidan tree (*Tetrapleura tetraptera*) were cleaned of stalks and other extraneous materials using portable water to remove clinging soil. The selected seeds were washed with distilled water to remove dust and then spread on trays and oven dried at 65°C for 10h. The cleaned dried fruits were crushed into powder with a laboratory homogenizer and stored in airtight containers before usage.

Aidan fruits
↓
Sorting and Cleaning
↓
Washing
↓
Oven Drying (65°C; 10h)
↓
Milling
↓
Aidan fruit powder

Fig. 4: Flow chart for the processing of Aidan fruit powder

Mineral Analysis

This was done following the method described in the study of Abiola *et al.* (2017). About 2.0 g of the sample was ashed by putting the sample in a dish and heated in a furnace at 550 ^{o}C until all the carbon burnt away. The crucible plus ash was transferred to a desiccators to cool after which (20 ml) of 0.1M HCl solution was added to the content in the crucible to break up ash, it was latter filtered using filter paper into 100 ml volumetric flask and made up to the mark with distilled-deionized water. Atomic Absorption Spectrophotometer (Bulk scientific, 210VGP) was used for the analysis of the zinc and selenium composition of the samples.

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Vitamins Analysis

Determination of Vitamin C content

The ascorbic acid content of the samples was determined by the method of AOAC (2020). Ground spice (1 g each) were homogenized with 50 ml of distilled water for 3 min, rested for 3h, re-homogenized for another 2 min and filtered through filter paper. A 15mL volume of metaphosphoric acid/acetic acid solution was added and the mixture was stirred and then transferred to a 250-mL conical flask. The residue in the beaker was washed with 30mL of deionized water and combined with the sample solution. Titration was immediately done using 2,6-dichloroindophenol until the first appearance of pink color that persists for about 5 seconds. Ascorbic acid was used as a standard, and the concentration of ascorbic acid in the samples was calculated and expressed as mg/100 g of the dry spice sample. mg ascorbic acid / 100 g = C x V x (F/W). Where, C= mg ascorbic acid/ml,V= volume (ml) of 2,6-dichloroindophenol used, F= dilution factor, W= weight (g) of sample used.

Determination of Carotenoid Content

Carotenoids content was determined according to the method described by Krishnaiah *et al*. (2009). A measured weight of the samples was homogenized in methanol using a laboratory blender. A 1:10 (1%) mixture was used. The homogenate was filtered to obtain the initial crude extract, 20 ml of ether was added to the filtrate and mixed well and then treated with 20 ml of distilled water in a separating funnel. The ether layer was recovered and evaporated to dryness at low temperature (35-50ºC) in a vacuum dessicator. The dry extract was then saponified with 20 ml of ethanolic potassium hydroxide and left over in a dark cupboard. The next day, the carotenoid was taken up in 20 ml of ether and the washed with two portions of 20 ml distilled water. The carotenoid extract (ether layer) was dried in a dessicator and then treated with light petroleum (petroleum spirit) and allowed to stand overnight in a freezer (-10°c). The precipitated steroid was removed by centrifugation after 12hours and the carotenoid extract was evaporated to dryness in a weighed evaporation dish, cooled in a dessicator and weighed. The weight of carotenoid was determined and expressed as a percentage of the sample weight.

$$\text{Percentage carotenoid content} = \frac{\text{Weight of carotenoid extracted}}{\text{Weight of sample used}} \times 100$$

Determination of Vitamin E content

The determination was done spectrophotometrically using the modified standard method of AOAC (2000). 1.5g of samples, 1.5 ml of standard tocopherol, and 1.5 ml of water were pipette into three stoppered centrifuge tubes, respectively. Into all the centrifuge tubes, 1.5 ml of ethanol and 1.5 ml of xylene were added, properly mixed and centrifuged at 300 rpm. The xylene (1.0 ml) layer was then transferred into another stoppered tube. To each tube, 1.0 ml of dipyridyl reagent was added and mixed properly. The mixture (1.5 ml) was pipetted into a cuvette. The extinction was read at 460 nm. Ferric chloride solution (0.33 ml) was added to all the tubes and mixed properly. The red colour that developed was read after 15 min at 520 nm using a visible spectrophotometer.

Statistical Analysis

All measurements were carried out in triplicate. The data generated were analyzed using statistical program SPSS (version 23.0) and significant difference were compared by Analysis of Variance test (ANOVA) following Duncan's multiple range tests at the significance level of 5%.

III. Results and Discussion

Results of the analyzed micronutrient content of four indigenous aromatic spices in Nigeria are presented in Table 1. The vitamin C content of these spices ranged from 6.89 – 38.17mg/100g. Guinea pepper (GUP) had the highest vitamin C value while garlic bulb (GAR) had the lowest. The amount of vitamin C in the chosen spices varied significantly ($p<0.05$). The values found in this study are different from those that various researchers have reported for some of the studied spices while Akintola *et al*. (2015) showed a lower value of 1.01mg/100g for aidan fruits, Mardomi (2017) observed a greater vitamin C content of 31.00mg/100g for garlic bulbs. These results inconsistency may be due to differences in the raw materials' spices and preparation techniques.

Table 1: Micronutrient content of four indigenous Aromatic spices in Nigeria

Samples	Vitamin C (mg/100g)	Vitamin E (mg/100g)	Beta carotene (mg/100g)	Zinc (mg/100g)	Selenium (mg/100g)
SCL	$21.63^{b}\pm0.55$	$18.80^{d}\pm0.20$	$0.53^{c}\pm0.02$	$8.30^{c}\pm0.30$	$2.92^{c}\pm0.07$
GAR	$6.89^{d}\pm0.10$	$103.87^{b}\pm1.63$	$1.74^{a}\pm0.04$	$5.65^{d}\pm0.05$	$1.79^{d}\pm0.01$

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AID	$11.16^{c}\pm0.34$	$56.03^{c}\pm0.06$	$1.39^{b}\pm0.02$	$14.74^{a}\pm0.25$	$3.39^{a}\pm0.10$
GUP	$38.17^{a}\pm0.29$	$113.63^{a}\pm1.52$	$0.09^{d}\pm0.00$	$9.87^{b}\pm0.12$	$3.08^{b}\pm0.03$

Results are expressed as mean ±SD (n=3). Values with different superscripts within the columns are significantly different from each other at $p<0.05$.

Key: SCL: Scent leaves; GAR: Garlic bulb; AID: Aidan fruit; GUP: Guinea pepper**.**

Vitamin C is essential for protein metabolism, the immune system, wound healing, and iron absorption, all of which are necessary for fighting infections (Akintola *et al*., 2015). Additionally, it has the rare capacity to stop or at least significantly reduce the production of carcinogenic chemicals from dietary components (Igara *et al*., 2017). This table demonstrated that the high vitamin E content of garlic, aidan, and guinea pepper. Guinea pepper had the highest vitamin E concentration, at 113.63 mg per 100g, followed closely by garlic, at 103.87 mg per 100g, then Aidan, at 56.03 mg per 100g, and scent leaf, at 18.80 mg per 100g. This suggests that when these flavorful spices are employed to prepare food or medications, they may give the body this vitamin. Vitamin E is a potent lipid-soluble antioxidant necessary for preserving the integrity of cell membranes, mucous membranes, and skin by shielding them from dangerous oxygen-free radicals, claim Ndife *et al*. (2019).

The content of beta-carotene was generally low in all of the studied aromatic spices. The least valuable ingredient was guinea pepper (0.09 mg/100g), which was followed by fragrance leaf (0.53 mg/100g), aidan (1.39 mg/100g), and garlic (1.75 mg/100g). There was a significant difference in beta-carotene concentration ($p<0.05$) between the samples. Carotenoid beta-carotene is a crucial phytonutrient that benefits human health. Carotenoids' primary physiological role is as a precursor to vitamin A. (Nocolle *et al*., 2013). Zinc aids the synthesis of enzymes and blood clotting, enhances immunological performance, preserves the senses of taste and smell, keeps the skin healthy, and promotes proper growth and development (Akintola *et al*., 2015). Zinc concentrations obtained in this project work were higher than those reported by Alexander (2016) for scent leaf (2.00 mg/100g), Abiola *et al*. (2017) for garlic (1.69 mg/100g), and Adesina *et al*. (2016) for aidan (10.59 mg/100g). The variation could be because of environmental factors and processing methods. Zinc is an essential trace mineral, act as a natural defense against viruses, particularly those that cause respiratory tract illnesses (Uyoh *et al*., 2013). Zinc's significance in the growth and operation of the pituitary gland, the gonads, and the reproductive organs (George and Pamplana, 2004) also helps to explain why breastfeeding women employ these spices in preparation of their food in the south eastern Nigeria. The values for selenium composition of the aromatic spices are 1.79mg/100g, 2.92mg/100g, 3.08mg/100g and 3.39mg/100g for garlic, scent leaf, guinea pepper and aidan respectively. The results showed that significant difference ($p<0.05$) existed in their values. Selenium is an essential trace mineral that supports many bodily processes. It helps to improve cognition, immune system function and fertility. It also plays a significant role in thyroid hormone metabolism and protects the body from oxidative damage and infection (WHO, 2006).

IV. Conclusion

This study aimed to compare the essential vitamin (A, C, E) and mineral (zinc and selenium) content of four indigenous spices commonly consumed in Nigeria: Scent leaf, garlic, Aidan seed, and guinea pepper. Among the spices studied, Xylopia aethiopca (guinea pepper) exhibited the highest amounts of vitamin C (38.17 mg/100g) and vitamin E (113.63 mg/100g). while *Tetrapleura tetratera* demonstrated the highest concentrations of zinc (4.74 mg/g) and selenium (3.39 mg/g) among the spices analyzed. Allium Sativum (garlic) stood out for its high beta-carotene content, measuring 1.75 mg/g. These results shows the diverse nutritional profiles of the studied spices and their potential health benefits. Including these spices into the daily diet can provide additional essential vitamins and minerals, which can contribute to overall nutritional well-being. The limitation encountered was the seasonal differences in the growth of this spices as some tends to yield and give better result at time of this experiment compared to others.

V. Recommendation

The analysis's findings suggest encouraging increased production of these spices. Since these spices have significant nutritional potentials that protect against various diseases, its consumption should be encouraged. Further research and exploration of these indigenous spices can bring forth more light on their nutritional and medicinal properties, allowing for their optimal utilization in culinary practices and promoting a balanced and healthy diet.

References

1. Abiola, T. T., Amoo, I. A. and Ayoade, G. W. (2017). Evaluation of Nutritional Composition and Antioxidants Properties of Onion (Allium Cepa) and Garlic (Allium Sativum). The International Journal of Science & Technoledge 5(10): 1-7.
2. Adesina, S. K., Iwalewa, E. O. and Johnny, I. I. (2016). Tetrapleura tetraptera Taub- Ethnopharmacology, Chemistry, Medicinal and Nutritional Values A Review. British Journal of Pharmaceutical Research, 12(3): 1-22.

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3. Akintola, O. O, Bodede, A. I. and Ogunbanjo, O. R. (2015). Nutritional and medicinal importance of tetrapleura tetraptera fruits (aridan). African Journal of Science and Research, (4)6: 36-41.
4. Alexander, P. (2016). Phytochemical screening and mineral composition of the Leaves of Ocimum gratissimum (scent leaf). Int J Appl Sci Biotechnol, 4(2): 161-165.
5. Anumudu, C. K., Okolo, C. A., Ezembu, E. N., Anumudu, I. C., Opara, C. N., Omeje, F. I., Ikimi, C. G., Gbodo, E. E., Zige, D. V. Okpe, C. U. and Ekwueme, D. C. (2020). Biopreservative Potential of the Spices; Piper Guineense (Uziza), Xylopia Aethiopica (Uda) and Tetrapleura Tetraptera (Oshorisho) in Fresh Fruit Juices. Journal of Food Technology & Nutrition Science, 2(2): 1-6.
6. AOAC (2000). Official Method of Analysis of Association of Analytical Chemists International. 17th Edition, Horowitz, Maryland.
7. Awuchi, C. G., Igwe, V.S., Amagwula, I.O. and Echeta, C.K. (2020). Health Benefits of Micronutrients (Vitamins and Minerals) and their Associated Deficiency Diseases: A Systematic Review. International Journal of Food Sciences Vol. 3, Issue 1, (1) pp 1-32.
8. Blancquaert, D; De Steur, H; Gellynck, X; and Van Der Straeten, D (2017). "Metabolic engineering of micronutrients in crop plants". Annals of New York Academy of Sciences. 1390 (1): 59–73. doi:10.1111/nyas.13274.
9. Corvallis, OR (2018). "Minerals". Corvallis, OR: Micronutrient Information Center, Linus Pauling Institute, Oregon State University. 2018.
10. Chao, P. Y., Lin, J. A., Ye, J. C., Hwang, J. M., Ting, W. J., Huang, C. Y. and Liu, J. Y. (2017). Attenuation of oxidative stress-induced cell apoptosis in Schwann RSC96 cells by Ocimum gratissimum aqueous extract. International Journal of Medical Sciences, 14(8): 764-771.
11. Ekpo, I. A. Agbor, R. B. Osuagwu, A. N. Ekanem, B. E. Okpakao, E. C. and Urua I. S. (2012) Phytochemical and compatrative studies of the stem bark and root of Xylopia aethiopia aethiopica. World Journal of Biological Research 5(2): 41 – 44.
12. Essien, E. U., Izunwane, B. C., Aremu, C. Y. and Eka, O. U. (2014). Significance for humans of the nutrient contents of the dry fruit of Tetrapleura tetraptera. Plant Food Human Nutrition; 45(1): 47-51.
13. Famobuwa, O. E., Lajide, L., Owolabi, B. J., Osho, I. B. and Amuho, U. E. (2016). Antioxidant Activity of the Fruit and Stem Bark of Tetrapleura tetraptera Taub (Mimosaceae). British Journal of Pharmaceutical Research 9(3): 1-4.
14. Fetse, J. P., Kofie, W. and Adosraku, R. K. (2016). Ethnopharmacological Importance of Xylopia aethiopica (DUNAL) A. RICH (Annonaceae) - A Review. British Journal of Pharmaceutical Research 11(1): 1-21.
15. Gebreselema, G. and Mebrahtu, G. (2013). Medicinal values of garlic: A review. International Journal of Medicine and Medical Sciences; 5(9): 401-408.
16. George, D. and Pamplana-roger Mid, (2004). Encyclopedia of foods and their healing power: Review and herald publishing Mary Land USA., 1:412.
17. Herrera-Calderon, O.; Chacaltana-Ramos, L. J.; Huayanca-Gutiérrez, I. C.; Algarni, M. A.; Alqarni, M. and Batiha, G. E. (2021). Chemical Constituents, In Vitro Antioxidant Activity and In Silico Study on NADPH Oxidase of Allium sativum L. (Garlic) Essential Oil. Antioxidants, 10: 1844.
18. Ibrahim. A. N., Igwe, C. E., Asogwa, I. S., Agbaka, J. I. and Ajibo, Q. C. (2020). Influence of Ocimum gratissimum (Scent Leaf) on the Organoleptic Acceptability and Shelf Stability of Yoghurt. Asian Food Science Journal 16(1): 28-44.
19. Igara, C. E., Omoboyowa, D. A., Uchegbu, R. I. and Ahuchaogu, A. A. (2017). Phytochemical composition, proximate analysis and vitamin content of (Tetracarpidium conophorum) wall nut seed. Chemical Research Journal; 2(5): 1-8.
20. Imo, C., Yakubu, O. E., Imo, N. G., Udegbunam, I. S. and Onukwugha, O. J. (2018). Chemical composition of Xylopia aethiopica. American Journal of Physiology, Biochemistry and Pharmacology, 7(2): 48-53.
21. Imosemi, I. O. (2020). A review of the medicinal values, pharmacological actions, morphological effects and toxicity of ocimum gratissimum linn. European Journal of Pharmaceutical and Medical Research, 7(7): 29-40.
22. Krishnaiah, D., Devi, T., Bono, A. and Sarbatly, R. (2009). Studies on phytochemical constituents of six Malaysian medicinal plants. Journal of Medicinal Plant Resources; 3(2):67- 72.
23. Lanzotti, V.; Scala, F. and Bonanomi, G. (2014). Compounds from Allium species with cytotoxic and antimicrobial activity. Phytochem. Rev., 13: 769–791.
24. Mardomi, R. (2017). Determining the Chemical Compositions of Garlic Plant and its Existing Active Element. Journal of Applied Chemistry; 10(1): 63-66.
25. Mgbemena, N. M. and Amako, N. F. (2020). Comparative Analysis of the Phytochemicals, Proximate and Mineral Compositions of Scent Leaf (Ocimum gratissimum) and Bitter Leaf (Vernonia amygdalina) Leaves. International Journal of Biochemistry Research & Review 29(7): 1-9.
26. Muhammad A.and Idris S. I. (2019). Phytochemical Screening and Proximate Analysis of Garlic (Allium Sativum). Arc Org Inorg Chem Sci 4(1): 478-482.

27. Ndife, J., Nwaubani, O. and Aniekpeno, I. E. (2019). Effect of palm oil inclusion on the quality of garri produced from white and yellow cassava (Manihot esculenta cranz) roots. International Journal of Food Science and Nutrition, 4 (3), 180-185.
28. Nocolle, C., Cardinault, N., Aprikian, O., Busserolles, J., Grolier, P., Rock, E., Demigne, C., Mazur, A., Scalbert, A., Amouroux, P. and Remesy, C. (2013). Effect of carrot intake on cholesterol metabolism and antioxidant status in cholesterol fed rats. European Journal of Nutrition; 42: 254–261.
29. Nwangwa, E.K.(2012). Antifertility Effects of ethanolic extract of Xylopia aethiopica on male reproductive organ of Wistar rats. American Journal of Medicine and Medical Sciences. 2012;2(1):12-5.
30. Ogbunugafor, H. A., Ugochukwu, C. G. and Kyrian-Ogbonna, A. E. (2017). The role of spices in nutrition and health:a review of three popular spices used inSouthern Nigeria.Food Quality and Safety, 1(3): 171–185.
31. Ogueke,C. C., Nnadi,N. B., Owuamanam,C. I., Ojukwu,M., Nwachukwu, L. N., Ibeabuchi, C. J. and Bede,E. N. (2018). Preservative potentials of essential oils of three Nigerian spices in mixed fruit juice and their antioxidant capacity. African Journal of Biotechnology, 17(35): 1099-1110.
32. Oguoma, O. I., Ezeifeka, G. O., Adeleye, S. A., Oranusi, S. and Amadi, E. S.(2015). Antimicrobial activity, proximate and amino acids analysis of Tetrapleura tetraptera. Nigerian Journal of Microbiology, 27(1): 2709 – 2718.
33. Olaniran, A. F., Abiose, S. H. and Gbadamosi, S. O. (2019). Quality attributes and acceptability of ogi flour biofortified with garlic and ginger. J Health Sci., 7:101-109.
34. Petropoulos, S. A., Fernandes, A., Ntatsi, G., Petrotos, K., Barros, L. and Ferreira, I. C. (2018). Nutritional Value, Chemical Characterization and Bulb Morphology of Greek Garlic Landraces. Molecules, 23: 319: 1-14.
35. Udochukwu, U., Omeje, F. I., Uloma, I. S. and Oseiwe, F. D. (2015). Phytochemical analysis of Vernonia amygdalina and Ocimum gratissimum extracts on their antibacterial activity on some drug resistant bacteria. Journal of Research Communication 3(5): 225-235.
36. Upadhaya SD, Kim IH. Importance of micronutrients in bone health of monogastric animals and techniques to improve the bioavailability of micronutrient supplements - A review. Asian-Australas J Anim Sci. 2020 Dec;33(12):1885-1895. doi: 10.5713/ajas.19.0945. Epub 2020 Mar 12. PMID: 32164057; PMCID: PMC7649403.
37. Uyoh E.A., Ita, E.E. and Nwofia, G.E. (2013). Evaluation of Chemical Composition of Tetrapleura tetraptera (Schum and Thonn.) Taub. From Cross River State, Nigeria. International Journal of Medicinal and Aromatic Plants, 3(3): 386 – 394
38. WHO, (2006). Trace element in Human Nutrition and Health; Geneva, pp: 3-5, 72: 105-209.