International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 11 Nov. 2024, pp: 422-429 www.ijaem.net ISSN: 2395-5252

Proximate and Mineral Analyses of Onion (Allium Cepa) and Garlic (Alliumsativum)

[1]Iortile, M. T., [2]Burbwa, V.,[3]Akoso, V. N., [4]Okopi, P.A.,[1]Abah, C. N. and [1]Emmanuel, J. E.
[1]Department of Chemistry, Benue State University, Makurdi-Nigeria
[2]Department of Chemistry, Federal University of Health Sciences, Otukpo-Nigeria
[3]School of Science and Technology, National Institute for Nigerian Languages, Aba, Abia State, Nigeria
[4]Department of Environmental Science, National Open University of Nigeria, Abuja-Nigeria

Date of Submission: 15-11-2024 Date of Acceptance: 25-11-2024

ABSTRACT
Allium cepa (onion) and Allium sativum (garlic) are essential spices in the Allium family that offer significant nutritional and medicinal benefits for household and industrial uses. This study performed proximate and mineral analyses of the two spices using standard official methods of food analysis and Atomic Absorption Spectroscopy (AAS) respectively. Proximate analysis of onion and garlic gave the respective values (in percentages): moisture (74.467 ± 1.513 and 61.300 ± 3.148); ash (1.708 ± 0.088 and 3.282 ± 0.471); crude fibre (1.893 ± 0.050 and 2.234 ± 0.507); crude fat (1.198 ± 0.144 and 0.884 ± 0.015); protein (2.3613 ± 0.134 and 5.437 ± 0.131) and carbohydrate (18.402 ± 1.418 and 26.863 ± 3.048). From the mineral analysis, significant values were obtained for some essential elements (in mg/kg): Calcium (199.700 ± 0.300 and 168.475 ± 0.004); sodium (336.575 ± 0.014 and 52.950 ± 0.002); potassium (185.125 ± 0.005 and 246.325 ± 0.019) and magnesium (117.625 ± 0.003 and 161.975 ± 0.005) for onion and garlic respectively. The results from this study showed that, although garlic may have more potential, both spices are excellent supplements for human nutritional and medicinal needs.

Keyword: Onion; garlic; proximate analysis; mineral analysis; AAS

I. INTRODUCTION

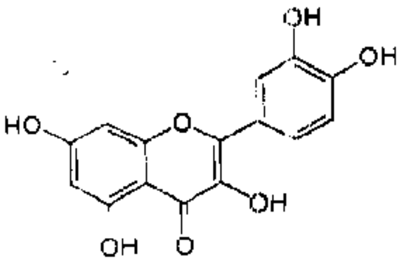
Natural food ingredients have nutritive and antioxidant properties which make them essential for food and medicine [1]. They are responsible for their unique flavours and tastes in foods. In fact, they are generally used to improve the sensory appeal of foods. Some of them are a good source of food preservatives, especially for industrially processed foods [2]. Spices range from onion, garlic, pepper, ginger, thyme, curry among others. Allium species is the most important genus of the Alliaceae family; the species is among the oldest and widely cultivated vegetables world over [3,4]. They differ in form of taste, but are related in biochemical and phytochemical content.

Alliums are revered because they possess antibacterial and antifungal activities and contain active antioxidants, sulphur and other numerous phenolic compounds. These natural chemicals are capable of fighting infections and healing the human body [5-9].

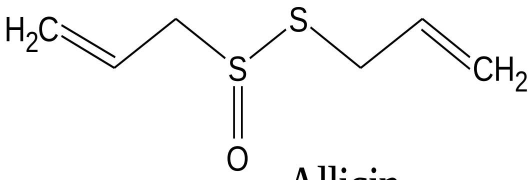
Onion A. cepa) and garlic (A. sativum) are the most regarded Allium species consumed around the world [1]. In Nigeria, these bulbous vegetables are grown mainly as food materials. Onion is consumed in its tender state, raw, ripe, pickled or in form of powder. The bulbs are also chopped and cooked in soups and stews recipes, fried or eaten raw. They can also be preserved in the form of pickles. Onion leaves are used to cook meals.Garlic is used mainly as a flavor enhancer in food. Considering the high rates of cancer and cardiovascular related diseases, it is considered an essential, inexpensive alternative natural alternative to expensive medicine if frequently consumed.

A. cepa and A sativum contain good doses of flavor, high moisture content, high carbohydrates and other essential nutrients as well as naturally occurring antioxidants [10]. The most biologically active compounds contained in onion and garlic are Quercetin and Allicin respectively [11].

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 11 Nov. 2024, pp: 422-429 www.ijaem.net ISSN: 2395-5252



Quercetin



Allicin

II. MATERIALS AND METHODS

Collection of samples

Fresh (onion) and A. sativum (garlic) bulbs were bought from building material market, Jos, Plateau State, Nigeria and were authenticated by a taxonomist from the Department of Biological Sciences, Benue State University, Makurdi.

Preparation of Sample

The raw onion and garlic bulbs were examined and separated by hand picking to remove any bad ones; those without any physical defect were selected for the analyses. The outer skin and ends of the onions and garlic bulbs were removed and washed with in running tap water to remove adhering debris and then deionized water. The samples were then spread to dry up the wash water. The samples were then sliced into chips using stainless steel knife and meshed using a mortar and pestle. The meshed samples were collected in airtight containers and preserved in refrigerator at 4^oC respective analyses [1].

Proximate analysis

Proximate analysis was carried out according to AOAC methods (2000) [12,13].

Moisture content determination

2g of each of the samples was weighed into a dried pre-weighed weighed crucible. The samples were then put into a moisture extraction oven at 105^oC and heated for 3h. The dried samples were put into desiccators, allowed to cool and reweighed. The process was repeated until constant weight was obtained. The difference in weight was calculated as percentage of the originals ample.

$$\%Moisture = \frac{w_2 - w_3}{w_2 - w_1} \text{ x } 100$$

W_1= weight of crucible; W_2 = weight of crucible + wet sample; W_3= weight of crucible + dried sample

Ash content determination

2g of each of the samples was weighed into crucible, heated in a moisture extraction oven for 3h at 100^oC before being transferred into a muffle furnace at 550^oC until it charred (turned white) and free of carbon. The sample was then removed from furnace, cooled in a desiccator to a room temperature and reweighed immediately. The weight of the residual ash was then calculated as ash content.

$$\text{Percentage Ash} = \frac{\text{Weight fo ash}}{\text{Weight of sample}} \text{ x } 100$$

Crude protein determination

The Kjeldahl method described by AOAC (2001) [14] was used for determination of crude protein through the following steps:

i. Digestion

Approximately 1g of the wet sample was weighed into the Kjeldahl flask. 7.5g of the Kjeldahl catalyst was added to the flask and 20mL of concentrated H_2SO_4 was added to the flask in the fume cupboard. The mixture was shaken gently to mix properly. The flask was clamped to a retort stand and placed in a heating mantle (the set-up was in a fume cupboard) and heated for 2h. After the interval, a clear green colour of digested sample was formed. The flask was unclamped and allowed to cool to room temperature.

About 50mL of distilled water was poured into the flask and shaken to digest the juice. The content was then poured into a volumetric flask. The content from the Kjeldahl flask were properly washed and the volume made up.

ii. Distillation

About 30mL of Boric acid was measured into a conical flask. The conical flask was placed in the distillation unit where the distillate would be collected. The distillate was then collected into the same flask containing the 30mL of 4% boric acid.

The digested sample was mixed by shaking. 10mL of the diluted digested juice was added to the distillation flask. 50mL of 40% NaOH was also added (black colour formed). 50mL of distilled water was also added. The distillation unit was run at 150 – 200°C for 1h. After the distillation, up to 200mL of the distillate was collected.

iii. Titration

0.1N of HCl was taken in a burette. A few drops of methyl red indicator were added to the conical flask containing a known volume of the distillate. The colour change was from transparent to yellow. The resulting solution was titrated to end point and the final burette reading was noted.
This process was done in triplicate for each sample. A blank was also done.

iv. Calculation

To calculate the percentage content, the following formula was used:

$$\%N = \frac{(\text{mL HCL sample} - \text{mL HCL blank}) \times 0.1 \times 14.01 \times 100}{1000 \times \text{weight of sample}}$$

$$\%\ \text{protein} = \%\ \text{N} \times 6.25$$

The value 6.25 is the conversion factor for most crude proteins.

Crude fibre determination

The following steps were adopted to determine the crude fibre of the samples:

i. Boiling in acid (H_2SO_4)

About 200 mL of 0.128 M H_2SO_4 was measured into a 500 mL conical flask. 2g of the homogenized sample was weighed and added to the acid solution in the flask with gentle shaking to mix. The sample was then placed on a hot plate and boiled for 30 min with periodic agitation. After the interval, the sample was filtered into an empty beaker using the cotton cloth and funnel. The conical flask was rinsed with warm water to rinse off all the acid which may interfere with boiling with NaOH. The residue was washed with more warm water.

i. Boiling in base (NaOH)

The residue was transferred into another 500 mL conical flask using a funnel. 200 mL of 0.313 M NaOH solution was added. The flask was shaken gently to mix. The flask containing the mixture was boiled for 30 min with periodic agitation.
After boiling, the sample was filtered using a cotton cloth and warm water was used to wash and remove the NaOH completely. The fibre was collected in a clean pre-weighed crucible.

ii. Drying fibre

The crucible was placed on a hot plate to remove excess water. The fibre was dried in an oven at 130 °C for 2 h. after the interval, the sample was cooled in a desiccator. The weight of the crucible with the fibre was recorded.

iii. Incineration of fibre

The crucible was placed in a muffle furnace and the fibre was burned at 500 °C for 2 h. After the incineration, the crucible containing the fibre was collected and cooled in a desiccator. The weight of the crucible with the fibre were taken.

iv. Calculation

The percentage crude fibre was calculated using the following equation:

$$\%\ \text{Crude fibre} = \frac{\text{Weight of fibre}}{\text{weight of sampl e}} \times 100$$

Fat content determination

2 g of the sample was loosely wrapped with a filter paper and put into the thimble which was filled to a clean round bottom flask, which had been cleaned, dried and weighed. The flask contained 120 ml n-hexane. The sample was heated with a heating mantle and allowed to reflux for 5 h. The heating was then stopped and the thimbles with the spent samples kept and later weighed. The difference in weight was received as mass of fat and is expressed in percentage of the sample. The percentage oil content is percentage fat thus:

$$\text{Percentage fat} = \frac{w_2 - w_1}{w_3} \times 100$$

W_1 = w eight of the empty extraction flask
W_2 = weight of the flask and oil extracted
W_3 = weight of the sample.

Carbohydrate content determination

The Nitrogen free method was used. The carbohydrate was calculated as weight by difference between 100 and the summation of other proximate parameters as Nitrogen Free Extract (NFE) percentage carbohydrate.
Percentage NFE = 100 - (M + P + F| + A + F_2)
Where;
M = Moisture; P = Protein; F, = Fat; A = Ash; F_2 = Crude fibre

Determination of mineral content of onion and garlic samples

The mineral analysis was performed at the Federal Ministry of Agriculture and RuralDevelopment, Zaria. 2 g sample was used. 50 mL of aquaregia was used for digestion and the final volume of 50 mL was made up for the digest and sent for AAS analysis. The results were calculated thus:

$$\text{Concentration (mg/kg)} = \frac{\text{actual conc (ppm) x vol (ml) of digested sample}}{\text{mass of sample (g)}}$$

III. RESULTS AND DISCUSSION

Results

The results of the proximate analyses of A. cepa and A. sativum are shown in Table 1. The results from the table show the proximate composition of the two bulbs on wet matter basis. Both bulbs have high moisture content. They also have higher carbohydrate and protein contents relative to the other parameters.

Table 1: Proximate analysis values for onion and garlic

Parameter	Value (%)	
Moisture	74.467 ± 1.513	61.300±3.148
Ash	1.708 ± 0.088	3.282 ±0.471
Crude fibre	1.893 ±0.050	2.234 ±0.507
Crude fat	1.I98±O.144	0.884±0.015
Protein	2.3613± 0.134	5.437±0.131

The results of the mineral analysis of both A. cepa and A. sativum are also shown in Table 2. The results show that micro-nutrients like sodium, magnesium, and potassium are important components of the allium bulbs and constitute a healthy portion of nutrients

Table 2: Results of mineral analysis of Acepa and A. sativum

Micro-nutrient	Onion (mg/kg)	Garlic (mg/kg)
Calcium	199.700 ±0.300	168.475 ±0.004
Copper	3.800 ±0.006	6.625 ±0.003
Iron	62.125 ±0.001	50.075 ±0.001
Sodium	336.575 ±0.014	374.575 ± 0.002
Manganese	31.975 ±0.001	52.950 ±0.002
Zinc	2.650 ±0.000	10.625 ±0.010
Potassium	185.125 ±0.005	246.325 ±0.019
Magnesium	117.625 ±0.003	161.975 ±0.005

*The values are mean ± standard deviation of triplicate analysis.

Discussion of Results

Results of proximate analysis of A. cepa and A. sativum

Moisture content

The allium bulbs contain appreciable amounts of moisture with onions containing more moisture (74.467 ± 1.513) than garlic (61.300 ± 3.148) on wet matter basis. Moisture content has a lot to do with a food product's characteristics, including its physical appearance (shape, color, etc.), texture, taste, weight (which can impact the cost) in addition to factors that affect the product's shelf-life, freshness, quality, and resistance to bacterial contamination.

Excess water in a food product can cause an increase in the rate of microbial growth, which cannot only spoil a product before it reaches the shelves but could also decrease the length of time it canstay fresh for. Therefore, the moisture content of these spices makes their preservation relatively challenging [15]. On the other hand, the moisture content in the spices also enhances, preserves the taste, flavour and nutrients in them.

The value obtained for moisture content in this study is lower than that reported by Lawal and Matazu [16] for white onion 89.2 %) and red onion (88.48 %); (86.67 %), but closer to values reported by Bhattacharjee, et al., [17] for onions from two different locations (82.90 and 82.77 %). The differences here are insignificant because the reported value is still high and indicates the high moisture content usually found in onion bulbs.

For garlic, the value obtained in this study (61.3%) is higher than the 53.77 reported by Devi and Brar [17], but slightly lower than the value (68.09 %) reported by Dalhat, et al., [9]. Again, all the values are within a close range and indicate that garlic has a better shelf-life than onions.

Ash content

Ash content is essential to a food's nutrition and longevity. The analysis of ash content in foods is simply the burning away of organic content, leaving inorganic minerals. This helps determine the amount and type of minerals in food; it is important because the amount of minerals can determine physiochemical properties of foods, as well as retard the growth of microorganisms. Therefore, mineral content is a vital component in a food's nutrition, quality and, like water, microbial viability.

The A. sativum spice had higher ash content (3.282 %) than the A. cepa spice. High ash content implies high mineral content in the spices. This means that garlic is likely to be a better source of minerals in diets than onions. Nutritionally, ash aids in the metabolism of protein, carbohydrate and fat [9]. The values obtained in this study for garlic and onion (Table 1) are slightly higher than those reported by Dalhat et al., 0.67 and 1.44 % respectively. Ali and Ibrahim [18] reported a higher value of ash content (5.85 %) in garlic. Abiola [1] also report comparably high values for both onions (5.58%) and garlic (3.71%). All these reports project garlic and onions to be good sources of ash among spices, with garlic having a better ash content than onions.

Crude fibre

Crude fibre helps in maintenance of normal peristaltic movement of the intestinal tract; hence, it facilitates digestion of food. Higher fibre content in onion makes it suitable for recommendation for patients who have problems with food digestion. Crude fibre has also been reported to help in prevention of cardiovascular disease because soluble fibre lowers levels of artery-clogging cholesterol in the blood stream [16].

Again, the value for crude fibre for garlic in this study is higher than that for onion, indicating that garlic may have a better potential at curing constipation and preventing cardiovascular diseases.

Crude fat

The values obtained from this study show that onion has higher crude fat content than garlic. This does not necessary make onion an oil spice, however. The effect of excess intake of crude fat has some well-established health implications especially for obese people. The consumption of excess amounts of fats has been recognized as the most important dietary factor aiding increased level of cholesterol. Besides the cholesterol implications due to high fat intake, obesity is a factor in the causation of disease [8]. In this regard, both spices have relatively low values of crude fat, with garlic having a significantly lower value and thus, with the potential of being a better alternative.

Crude protein

Protein is the building block and an essential component of cells. Proteins provide the body's required amino acids.

Crude protein content in this study was higher in garlic than in onions. This was also the case in a study by Dalhat, et al., [9]. This indicates that garlic could serve as an excellent source of protein in diets if consumed regularly in food. However, the protein values for both garlic and onions were significantly less than 20 %. According to Abiola, et al., [1], these are not excellent sources of protein since they have levels less than 20 %.

Carbohydrates

The composition of carbohydrates in the proximate analysis is the difference of the sum of all the other components from 100. From this evaluation, garlic had a higher value for protein than onions; although, onions also has a reasonable amount of carbohydrate content. Carbohydrates are usually a good source of energy to the body; therefore, the two spices would do well as carbohydrate supplements.

The composition of carbohydrates in the proximate analysis is the difference of the sum of all the other components from 100. From this evaluation, garlic had a higher value for protein than onions; although, onions also has a reasonable amount of carbohydrate content. Carbohydrates are usually a good source of energy to the body; therefore, the two spices would do well as carbohydrate supplements.

Results of the mineral composition of A. cepa and A. sativum

The mineral profile of the allium bulbs is presented in Table 2. The respective values Xfor the quantity or macro minerals in onion and garlic are respectively: potassium (185.125 mg/kg and 246.325 mg/kg), calcium (199.700 mg/kg and 168.475 mg/kg), magnesium (117.625 mg/kg and 161.975.975), and sodium (336.575 mg/kg and 374.575 mg/kg). These minerals are needed in larger amounts, their recommended daily intake is 100 mg or more, and so the values contained in these spices show that they are good mineral sources and should be consumed in diets. Potassium, magnesium and calcium are important in prevention and treatment of hypertension and their high intake may reduce coronary heart disease and stroke [19]. Again, sodium, potassium, calcium and magnesium all play a central role in the normal regulation of blood pressure [20]. They could also be valuable in improving immune system and preventing malnutrition related diseases. Mineral elements are required for normal growth activities of muscles and skeletal development (such as calcium), cellular activity and transport of oxygen (copper and iron), bone development and haemoglobin formation (calcium and zinc) chemical reaction in the body and intestinal absorption (magnesium), fluid balance and nerve transmission (sodium and potassium), as well as the regulation of acid-base balance (phosphorus). Iron is useful in prevention of anaemia and other related diseases [21], Manganese plays a crucial role in energy production and in supporting the immunesystem while zinc is also useful for protein synthesis, normal body development and recovery from illness [22],

For the trace elements, the values are: iron (62.123 mg/kg and 50.075 mg/kg), zinc (2.650 mg/kg and10.625 mg/kg), manganese (31.975 and mg/kg and 52.950 mg/kg), copper (3.800 mg/kg and 6.625 mg/kg) for onion and garlic respectively. These minerals are needed in minute quantities (Recommended dietary intake of less than 100 c-mg daily) for the proper functioning and regulation of the body. According to Andreini, et al. [23], some transition metals including iron, zinc, manganese and copper are essential for life through their function as both structural and catalytic cofactors of proteins. Zinc supplementation for children between three to five years reduces frequency and severity of diarrhoea and respiratory illnesses [24].

In comparison with other literature values, generally speaking the values obtained from this research for onions are similar to those reported by Edet, et al. [13]. They reported similar values for potassium (185.05 mg/kg) higher value for calcium (375.16 mg/kg) and manganese (213.65 mg/kg) and lower value for sodium (16.15 mg/kg) Abiola et al.[l] reported comparable values in onion and garlic respectively for calcium (289.69 and 270.72 mg/kg) potassium (90.25 and 83.70 mg/kg) and sodium (40.67 and 38.67 mg/kg). In a study reported by Ali and Ibrahim [19], the values obtained for garlic bulbs are comparably similar with those obtained from this study. For example, the value for potassium was 109.5 mg/kg), calcium (230.4 mg/kg). However, trace metals such as copper (0.5 mg/kg) and magnesium (30.9 mg/kg) compared low. These little discrepancies may be explained by the differences in soil fertility or the different cultivars of A. cepa and A. sativum used in the different studies.

From the foregoing, it is obxious that these spices offer excellent mineral nutrients to our diets. It is worth} of note however, that consumption of some of these minerals below the recommended amounts could lead to strong risk factors for diseases. For example, below normal dietary intake of magnesium has been identified as a strong risk factor for hypertension, cardiac arrythmias, ischemic heart disease, atherogenesis, and sudden cardiac death [10].

IV. CONCLUSION

In conclusion, this study has shown that A. cepa (onion) and A. sativum (garlic) are excellent sources of macro and micro nutrients and thus, can be healthily used for both nutritional and medicinal needs. The results from the research also show that garlic contains comparably higher amounts of minerals. Generally, the spices contain appreciable levels of proximate compounds and minerals that are readily available in raw or cooked forms; they could be consumed to supplement scarce or non-available sources of nutrients.

REFERENCES

[1] Abiola, T.T., Amoo, LA., and Ayaode, G.W. (2017). Evaluation of Nutritional

Composition and Antioxidants Properties of Onion (Allium Cepa) and Garlic (Allium Sativum). International Journal of Science Technoledge, 5:10.

[2] Ambuja S.R, Shivalkar Yadav K. and R. Prabha (2015). A review of Two wonder bulbs; Onion and Garlic. International Journal of Advanced Technology in Engineering and Science. 3.

[3] USDA (2014). United States Department of Agriculture USDA Plants. Classification.

[4] Bhagya, K.A, Raveendra, H.P., and Lalithya, Y.C. (2017). Mulibenificial Uses of Spices: A Brief Review. Acta Science Nutrition and Health. 1; 3-6.

[5] Campos, K.E., Diniz,, Y.S. Cataneo, A.C., Faine, L.A. Alves, M.J. and Novelli, E.L. (2003). Hypoglycaemic and antioxidant effects of onion, Allium cepa\ Dietary onion addition, antioxidant activity and hypoglycaemic effects on diabetic rats.

[6] Yashin, A., Yashin, Y., Xia, X., and Nemzer, B. (2017). Antioxidant Activity of Spices and Their Impact on Human Health: A Review. Antioxidants. 6; 1-18.

[7] Eleazu, C.O., Ikpeama, A.I., Amajor, J.U. (2012). Proximate composition, essential oils and energy value of 10 new varieties of ginger (zingiber officinale roscoe). International Journal of Biology', Pharmacy and Allied Science. 1:9

[8] Bhattacharjee, S., Sazzad, M.H., and Sultana, A. (2013). Analysis of theproximate composition and energy values of two varieties of onion (Allium cepa L.) of different origin: A comparative study. International Journal of Nutirition and Food Sciences. 2:5;246-253.

[9] Dalhat, F. A., Adefolake, and Musa, M. (2018). Nutritional Composition and Phytochemical Analysis of Aqueous Extract of Allum cepa (Onion) and Allum sativum (Garlic). Asian Food Sickened Journal. 3:4; 1-9.

[10] Abayomi, S.O.K., Fagbuaro, Y., and Fajemilehin, S. S. (2018). Chemical composition, phytochemical and mineral profile of garlic (Allium sativum).Journal of Bioscience and Biotechnology Discovery, 3:5; 105-109

[11] Bi, X., Lim, J., and Henry, C. J. (2017). Spices in the management of diabetes mellitus. Food Chem. 217, 281-293.

[12] Efiong, E.E., Akumba, L.P., Chukwu, E.C., Olusesan, A.I., and Obochi, G. (2020). Comparative qualitative phytochemical analysis of oil, juice and dry forms of garlic (Allium sativum) and different varieties of onions (Allium cepa) consumed in Makurdi metropolis. Int. J. Plant Physiol. Biochem.,Yl(\):9-\6.

[13] Edet, A., Eseyin, O., and Aniebiet, E. (2015). Anti-nutrients composition and mineral analysis of Allium cepa (onion) bulbs. African Journal of Pharmaceutical Pharmacology. 9:13;456-459.

[14] Tsiaganis. E.M.E.. Laskari. M.C. (2006). Fatty' acid composition of Allium species lipids. Journal Food Composition Analysis. 19; 620-627.

[15] Moore. S. (2020). Whj is moisture content in food important. Accessed from: https://www.news-medical.net/life-sciences/Why-is-Moisture-Content-Analysis- of-Food Important.aspx on November 9, 2020.

[16] Lawal, S.S., and Matazu, A. (2015). Comparative Studies of White and Red Allium cepa Cultivated in Sokoto , Nigeria. ChemSearch J., 6(2): 14-20.

[17] Devi, P.V., and Brar, J.K. (2018). Comparison of Proximate Composition and Mineral Concentration of Allium ampeloprasum (elephant garlic) and Allium sativum (garlic), Chern. Sci. Rev. Lett., 7(25):362—367.

[18] Ali, M,, and Ibrahim. l.S. (2019). Phytochemical Screening and Proximate Analysis of Garlic (Allium sativum). An Arch. Org. Inorg. Chern. Sci., 4(1):478—482.

[19] Akinwade, B. A., and Olatunde, S. J. (2015). Comparative Evaluation of the Mineral Profile and Selected Components of Onion and Garlic. International Food Research Journal, 22(1): 332 – 336.

[20] Valko, M., Leibfritz, D., Moncol, J., Cronin, M. T., and Mazur, M. (2007). Free radicals and antioxidants in normal physiological functions and human disease. International Journal of Biochemical Cell Biology, 39(1): 44-84.

[21] Oluemi, E. A., Akilua, A. A., Adenuya, A. A., and Adebayo, M. B. (2006). Migerial contents of some commonly consumed Nigerian foods. Science Focus, 11: 153 – 157.

[22] Muhammad, A., Dangoggo, S. M., Tsafe, a. I., Itodo, A. U., and Atiku, F. A. (2011).

Proximate, minerals and anti-nutritional factors of Gardenia aqualla (Gauden dutse) fruit pulp. Pakistan Journal of Nutrition, 10(6): 577-581.

[23] Andreini, C., Bertini, I., Cavallaro, G., Holliday, G. L. and Thomton, J. M. (2008). Metal ions in biological catalysis: from enzyme databases to general principles. Journal of Biological Inorganic Chemistry, 13: 1205 – 1218.

[24] Aggarwal, R., Sentz, J. and Miller, M. A. (2007). Role of zinc administration in prevention of childhood diarrhoea and respiratory illnesses: A meta-analysis. Pediatrics, 119(6): 1120-1130.