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Comparative Analysis of Mineral Content of Some Neglected Leafy Vegetables Consumed In Afikpo and Abakaliki Areas of Ebonyi State, Nigeria

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Abstract

Three neglected green leafy vegetables- *Pennsetum purpureum* (Elephant grass), *Colocasia esculenta* (Cocoyam leave), and *Ipomea aquatic* (water morning glory) were collected (n=3) from Afikpo and Abakaliki locations of Ebonyi State, Nigeria and were analyzed for the presence of Mg, Fe, Cu, Zn, Co and K, Na using Atomic Absorption Spectrophotometry and flame photometer respectively. The results showed K content of *Pennisetum purpureum* from Abakaliki was higher (9764.80 ± 135.80 mg/100 g), than that from Afikpo. While Cu content of *Ipomoea aquatic* from Afikpo location was lower (1.47 ± 0.52 mg/100 g) compared to that from Abakaliki, Co was not detected at all in all samples. The vegetables are exceptionally rich in the studied minerals when compared with the recommended dietary allowance (RDAs) values.

Keywords: Leafy, Minerals, Sample, Neglected, Vegetables.

Introduction

There are a number of vegetables that naturally have great economic importance but are not well utilized to meet the food demands. Wild vegetables are regarded as cheap sources of food for the marginal communities [1]. According to the Food and Agricultural Organization (FAO), approximately 5.4 million children and nearly 800,000 pregnant and breastfeeding women are at risk of acute malnutrition from six of the most affected states within the Northeast and Northwest regions of Nigeria [2]. Of this statistics, an alarming, 1.8 million children could suffer severe acute malnutrition and require critical nutrition treatment [3].

To apprehend the situation, interests have been centralized on the utilization of food plants, especially vegetables to meet nutrient needs [4]. Vegetables, being rich sources of vitamins and minerals form a major portion of the human diet, and are a cheaper source of nutrients [5]. Minerals are very essential for maintaining good health, and deficiencies of them can lead to various

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health problems like; weakness of bones, unhealthy red blood cell formation etc, [6, 7].

Recently some of these diseases like, diabetes, obesity, cancer, and cardiovascular diseases are manifesting in developing countries more than ever before and could be traced to inadequate consumption of fruits and vegetables [8]. If this trend continues, the world Health organization (WHO) projected that the percentage of people living with diabetes alone in developing countries will rise by 170% by the end of year 2025 [9].

Amongst the vegetables of interest, *Ipomoeae aquatica Forsk* is a semi aquatic, tropical plant grown as a leafy vegetable. It is found throughout the tropical and subtropical regions of the world. It belongs to the family of *Convolvulaceae* and is also known as water spinach or water morning glory [10]. *Ipomoea aquatica* grows in water or on moist soil. The stems are 2-3 meters (7-10 cm) or more long, rooting at the nodes and they are hollow and can float. In several parts of South Eastern Nigerian, this vegetable is used to make soup, pottage yam. It is popularly referred to as '*otele-piriri'* in Afikpo in Ebonyi State. *Pennisetum purpureum* (Schumach), commonly known as elephant grass or Napier grass belongs to the *Poaceae* (alt. *Gramineae*) family. It is called 'achara' by the Ibo speaking people of South Eastern Nigeria. It is generally used as an animal feed, or for ornamental and erosion control [11]. The dried matured shoots are used to make fences in Northern Nigeria. The matrixes of the matured shoots are used for preparing the special soup called 'ofe achara' by the people of Ebonyi State, Abia State, in South Eastern Nigeria. As noted by Nwosu 2011 [12] that although measures are being taken to boost food production by conventional agriculture, a lot of interest is currently being focused on the possibilities of exploiting the vast number of less familiar food plant resources.

Colocasia esculenta is widely cultivated across the world especially in the tropics. It is commonly known as Cocoyam, Elephant ear, Taro, etc. In Ebonyi state, Nigeria, both the corm and the leaf of cocoyam are consumable. The corm can be prepared in various ways and the leave as vegetable for soup majorly in the rural areas .Although a few studies have been carried out on the corm (root part); there is still very scanty information on the nutritional content of the leaves.

This work aims to compare the level of essential minerals such as Mg, K, Na, Cu, Zn, Fe, and Co in leaves of *Pennisetum purpureum*, *Ipomoea aquatica*, and *Colocasia esculenta* consumed by inhabitants of Abakaliki and Afikpo Areas of Ebonyi State, Nigeria.

Materials and Methods

Sample Collection and Preparation

Three samples each of the young leaves of *Colocasia esculenta, Ipomoeae aquatica and Pennsetum purpureum* were collected from two different zones in the State namely; Abakaliki and Afikpo.

The outer covering of *Colocasia esculenta* and *Pennisetum purpureum* was removed to obtain the innermost tender part of the vegetables. It was cut into smaller pieces and spread out on a laboratory bench for drying to take place. After drying, the samples were ground into powder.

Determination of the Mineral Content

The mineral contents of each of the samples were determined by atomic absorption spectrometry, flame photometry and spectrophotometry according to the methods of Fayek et al 2023, [13].

Exactly 0.5 g of the powdered sample was taken in a digesting glass tube. 12 cm^3 of HNO_3 was added to the food samples and the mixture was kept overnight at room temperature. Then 4.0 cm^3 perchloric acid ($HClO_4$) i.e. 3:1 of trioxonitrate and perchlorate acid respectively, was added to this mixture and was kept in the fumes block for digestion to take place. The temperature was increased gradually, starting from 50ºC and increasing up to 250-300ºC. The digestion is completed in about 70- 85 min, as indicated by the appearance of white fumes. The mixture was left to cool down, and the contents of the tubes were transferred to 100 cm^3 volumetric flasks and the volumes of the contents were made to 100 cm^3 with distilled water. The wet digested solution was transferred to plastic bottles labeled accurately and stored before being analysed for their mineral content.

Results and Discussion

The experimental results were expressed as the mean, and standard error of the mean of different replicates were also presented. Significance of differences between values were estimated using the student's T-test and compared among the groups using the analysis of variance (ANOVA). Differences were taken to be significant when $P < 0.05$ [14]. Tables designated as '(1 - 4)' show the mean of the results.

Result

Table 1: Mean of Mineral analysis of *Colocasia esculenta*

Location	Magnesium (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)	Iron (mg/100g)	Copper (mg/100g)	Zinc (mg/100g)
Afikpo	604.62±46.07[a]	5121.30±240.61[a]	320.38±264.52[a]	73.80±1.46[b]	2.22±0.24[a]	36.45±3.25[b]
Abakaliki	572.71±39.42[a]	4775.60±40.97[a]	884.51±27.16[b]	103.60±4.62[c]	2.27±0.48[a]	31.49±2.28[ab]

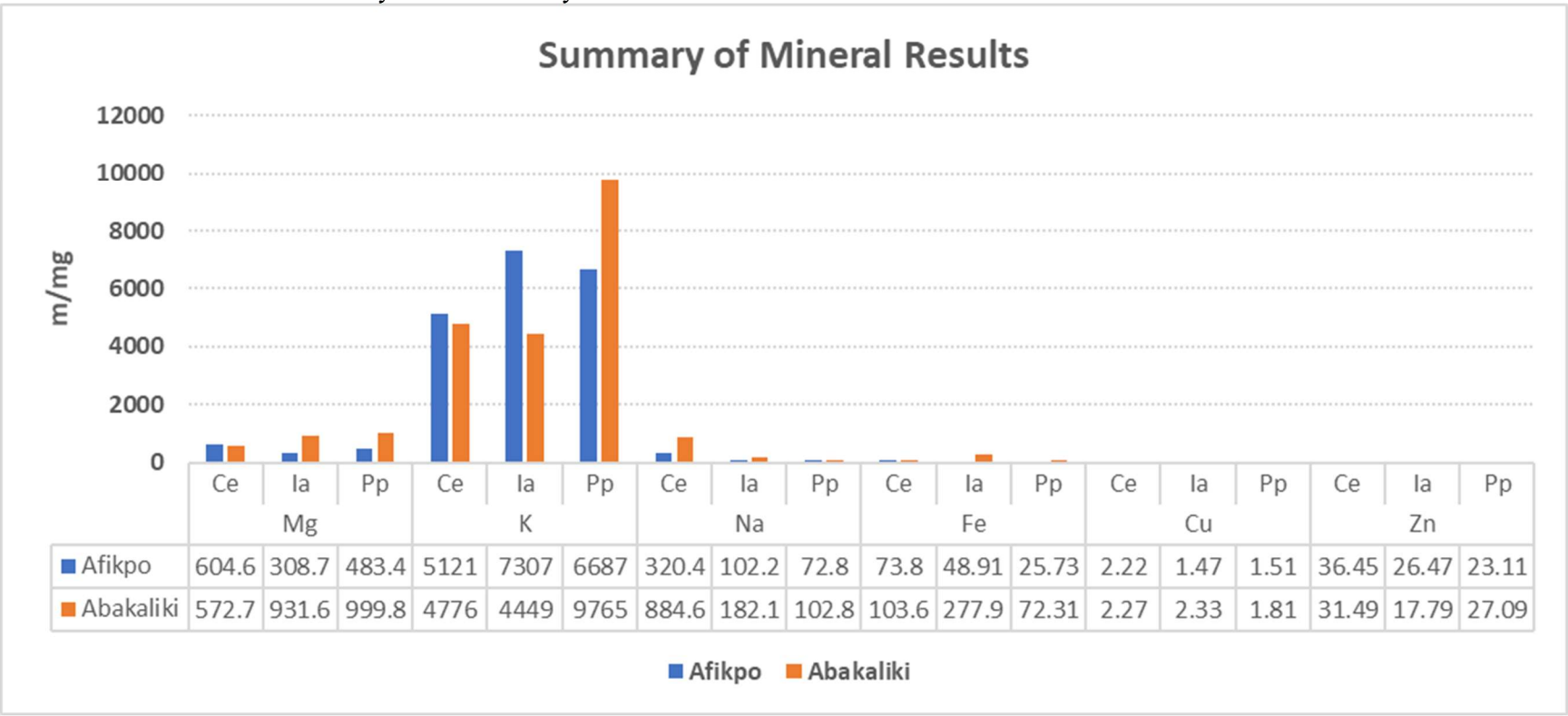
Table 2: Mean of Mineral analysis of *Ipomoea aquatic*

Location	Magnesium (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)	Iron (mg/100g)	Copper (mg/100g)	Zinc (mg/100g)
Afikpo	308.74±3.83[b]	7307.40±3.16[c]	102.20±0.29[a]	48.91±8.14[a]	1.47±0.52[a]	26.47±0.34[b]
Abakaliki	931.58±2.23[c]	4449.30±80.74[b]	182.07±19.76[b]	277.89±23.48[c]	2.33±0.24[a]	17.79±1.11[a]

Table 3: Mean of Mineral analysis of *Pennisetum Purpuerum*

Location	Magnesium (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)	Iron (mg/100g)	Copper (mg/100g)	Zinc (mg/100g)
Afikpo	483.36±20.89[a]	6686.70±491.30[b]	72.80±14.24[a]	25.73±1.79[a]	1.51±0.30[a]	23.11±2.38[a]
Abakaliki	999.83±51.20[c]	9764.80±135.80[c]	102.82±2.46[b]	72.31±9.71[c]	1.84±0.27[a]	27.09±3.21[a]

Table 4: Summary of Mineral analysis



	Mg			K			Na			Fe			Cu			Zn		
	Ce	Ia	Pp	Ce	Ia	Pp	Ce	Ia	Pp	Ce	Ia	Pp	Ce	Ia	Pp	Ce	Ia	Pp
Afikpo	604.6	308.7	483.4	5121	7307	6687	320.4	102.2	72.8	73.8	48.91	25.73	2.22	1.47	1.51	36.45	26.47	23.11
Abakaliki	572.7	931.6	999.8	4776	4449	9765	884.6	182.1	102.8	103.6	277.9	72.31	2.27	2.33	1.81	31.49	17.79	27.09

Magnesium

The three vegetables analysed were high in magnesium. *Colocasia esculenta* was moderately high, with a range of 572.71 – 892.42 mg/100g. *Ipomoea aquatica*, on the other, was low except for those sampled from the Abakaliki location, which was as high as 931.58 mg/100g. In terms of location, Abakaliki samples were the higher in Magnesium (572.71 – 999.83 mg/100g), compared to Afikpo samples which showed a significantly lower level (308.74 – 604.62 mg/100g). A significant level of magnesium is expected since it is a component of leave chlorophyll [15, 16]. These values are higher than that in *Ipomoea batatas* (79 – 107 mg/100g) [17]. Umar *et al*, 2007, [18] Reported that 310.64 mg/100g concentration of *Ipomoea aquatica* was consumed in Kebbi State, Nigeria. The values are within the RDA, especially for adults that require significant level of Magnesium

Potassium

The vegetables analysed contain a high amount of potassium. Among the three vegetables, *Pennisetum purpureum* sampled in Abakaliki location had higher (3,974.00 – 9,764.80 mg/100g) than the counterpart from Afikpo, followed by *Ipomoea aquatica* (3,324.90 – 7,307.40 mg/100g), while *Colocasia esculenta* was the least (4,775.60 – 5,910.00 mg/100g). In terms of the sampling location, Abakaliki samples showed the highest amount of potassium (4,449.60 – 9,764.80 mg/100g), Afikpo samples showed 5,121.30 – 7,307.00 mg/100g. The values highlighted here are higher than those reported by [18] (5,458.33 – 954.70 mg/100g) for *Ipomoea aquatica* grown in Kebbi State, Nigeria and much higher than *Ipomoea batata* leaves (750.00 – 4,953.49 mg/100g DW) grown in Ghana [17,19,20], but are within the range of that reported in some Nigerian leafy vegetables such as *Talinum trianglare* (8,000 mg/100g), *Crassocephalum biafrae* (6,500 mg/100g) and *Solanium nigrum* (6,700 mg/100g), *Celosia argentea* (5,200 mg/100g) and *Solanium aethiopicum* (5,000 mg/100g) as reported by Eze, 2018 [21].

Sodium

Colocasia esculenta showed the highest sodium concentration (320.35 – 884.5 mg/100g), *Ipomoea aquatica* showed 102.20 – 182.07 mg/100g and *Pennisetum purpureum* showed the least amount of sodium (72.80 – 131.20 mg/100g). On the area of location, Abakaliki samples showed the higher concentration of sodium (102.82 – 884.51 mg/100g), than those of Afikpo samples (72.80 – 320.38 mg/100g). Sodium is associated with potassium in the body in maintaining proper acid-base balance and nerve transmissions.

The concentration of sodium revealed for *Ipomoea aquatica* was within the range of that reported by [18]. The values were higher than those of *Ipomoea batatas* leaves [17,19]. Except for *Pennisetum purpureum* which showed higher sodium concentration, *Ipomoea aquatica* was within the range of the values reported in

Talinium trianglare (248.8 – 280.00 mg/100g) [20,21], *Telferia occidentalis* (229.10 mg/100g), *Amaranthus caudatus* (427.90 mg/100g) fall within the values reported by [22]. But *Amaranthus hybridus* (258.90 mg/100g) and *Vernonia amygdalina* (117.40 mg/100g) were also within the range of *Ipomoea aquatica* [22].

From the results, it was obvious that the concentration of potassium was far greater than that of sodium, as also evident from values in the available literature. The high concentration of potassium may be due to environmental factors resulting from the abundance of the mineral in the soil which could affect the mineral composition [23].

Iron

Pennisetum purpureum was significantly low in iron concentration (27.72 – 72.31 mg/100g) compared to other vegetables. *Ipomoea aquatica* was the highest in the concentration of iron (48.91 – 277.89 mg/100g). In terms of the sampling location, Abakaliki samples again showed higher concentration (72.31 – 277.89 mg/100g), than Afikpo samples which showed less amount of iron available in the vegetables analysed.

The importance of iron to human health cannot be overemphasized. According to the World Health Organisation (WHO), iron deficiency affects about 3.7 billion people and, out of which 2 billion people are anaemic [24]. The values obtained here were very encouraging, especially for the concentration of iron in *Ipomoea aquatica* and those other vegetables grown in the Abakaliki location compared to ones grown in Afikpo. The value falls within that obtained from *Ipomoea aquatica* grown in Kebbi State, Nigeria (210.30 mg/100g) as reported by [18]. The values were higher when compared with similar work done in Vietnam (41.27 mg/100g) reported [25]. *Ipomoea batatas* leaves grown in Ghana showed 36.69 – 147.87 mg/100g DW, as reported by [19].

Reports also show that green leafy vegetables grown in Sokoto state, Nigeria (110 – 325 mg/100g) [26]. It is important to state again that this factor is possibly due to the soil composition which invariably affects the mineral composition.

Copper

The concentration of copper was generally low. *Colocasia esculenta* showed the least amount of copper (1.73 – 2.22 mg/100g). *Ipomoea aquatica* showed 1.47 – 2.33 mg/100g, while *Pennisetum purpureum* was the highest (1.51 – 2.67 mg/100g). In terms of location, the vegetables sampled from Abakaliki (1.84 – 2.33 mg/100g) were higher compared to those sampled from Afikpo (1.47 – 2.22 mg/100g).

The values obtained were a little higher than that reported by [18] (0.36 mg/100g). However, [19] reported a higher range of copper content values in *Ipomea batatas* leaves (3.34 – 3.95 mg/100g). [27] reported very high levels of copper in *Trianthema portulacastrum* compared to the acceptable range set by WHO, which is 2-5 mg intake per day [28]. The value of copper obtained

for the vegetables analyzed is within the acceptable standard [29] reported that the consumption of copper in excess of 3 mg/l of drinking water results in gastrointestinal tract (GIT). Also, excess of copper in plants can lead to oxidative stress, inducing changes in the activity and content of some components of antioxidative pathways [29].

Zinc

The concentration of zinc in the vegetables analysed was a little higher than that of copper. It was highest in *Colocasia esculenta* (25.80 – 36.45 mg/100g), followed by *Ipomoea aquatica* (17.79 – 29.89 mg/100g) and the least was *Pennisetum purpureum* (23.11 – 27.89 mg/100g). Comparing the sampling locations, Afikpo samples were the higher in zinc content (23.11 – 36.45), than those collected from Abakaliki 17.79 – 31.49 mg/100g amount of zinc, respectively.

Zinc is important in the human diet. The positive impact of zinc supplementation on the growth of some stunted children and the prevalence of selected childhood diseases such as diarrhea, suggests that zinc deficiency is likely to be a significant public health problem, especially in developing countries like Nigeria [30, 31, 1]. It has been reported that according to FAO's food balance data, 20 % of the world population could be at risk of zinc deficiency. For example**,** adult men typically consume **11–16 mg/day,** and women **8–12 mg/day** [32]. This finding should stimulate the cultivation and consumption of large-scale vegetables, especially *Colocasia esculenta* and *Ipomoea aquatica*, which are grown in the Afikpo and Abakaliki areas. The concentration of zinc in the vegetables analysed was higher than that grown in Kebbi State (2.47 mg/100g) as reported [18].

Conclusion

The results generally show that *Ipomoea aquatica*, *Colocasia esculenta*, and *Pennisetum purpureum* are rich sources of important nutrients. The results show that *Pennisetum purpureum* collected from the Abakaliki location is richest in magnesium and potassium. *Colocasia esculenta,* also grown in Abakaliki, is a rich source of sodium. *Ipomoea aquatica,* also grown in Abakaliki, proved to be the richest source of iron. *Colocasia esculenta* grown in Afikpo location is considered a good source of zinc.

References

1. Olaniyi, M.B., Rufai, S.O., Olaniyi, A.A., Olawode, R.A., Hamzat, O.A., and Ogunbamowo, P.O., (2024) Ethno-Nutritional Uses of Wild Edible Vegetables in Ogun Waterside Rural Communities, Ogun State, Nigeria, *Journal of Applied Sciences and Environmental Management*, 28(10B), 3323-3328

2. Food Agriculture Organization of the United States (FAO), (2024). Nigerians projected to be food in secured in 2025.

3. Food and Agriculture Organization (FAO) of the United Nations, (2023), International Fund for Agricultural Development 1, United Children's fund. United Nation world food program, World Health Organization.

4. Harmoor, K.D., Hira, S., Mamta, P and Tarsem, S.D., (2024),Vegetables: Potential

Role For Nutritional Security; Journal of Plant Nutrition, 47(19), 3298-3315.

5. Jacob Sarfo, Elke Pawelzik & Gudrun B. Keding, (2022), Are processed vegetables and fruits able to reduce diet cost and address micro-nutrients deficiencies, Evidence from rural Tanzania. *Journal of Public Health Nutrition*s, 25(9); 2637 – 2650.

6. Chunli Wu, Yao Xiao & Yuexia Jiang (2023), Association of blood trace elements with bone mineral density: a population-based study in US adults; *Journal of Orthopedic Surgery and Research*; 18(827)

7. Pilar, V.M.; Garcia-Maldonado, E., Gallego-Narbon, A., Zapatera, B., Alcorta, A., & Martinez-Suarez, Miriam. (2024), Iron deficiency is associated with elevated parathormone levels, low vitamin D status, and risk of Bone loss in Omnivores and Plant-Based diets consumers; *International Journal of Molecular Sciences* 25(19); 10290

8. Okop, K.J, Ndayi, K, Tsolekile, L., Sanders, D., & Puoane, T. (2019), Low intake of commonly available fruits and vegetables in Socio-economically disadvantaged communities of South Africa: influence of affordability and sugary drink intake; *BMC Public Health;* 19:940

9. Smith, L., Lopez Sanchez, G.F., Veronese, N., Soysal, P.O., Barnett, Y., Keyes, H., Butler, L., Alien, P., Kostev, K., Jacob, L., Shin, J.I., & Koyanagi, A. (2022); Fruit and Vegetable intake and Non-Communicable Disease among Adults Aged ≥ 50 Years in low and Middle income countries; *Journal of Nutrition, Health and Aging*; 26(11):1003-1009

10. Mann, A., Gbate., M, & Umar, A. N. (2003). *Medicinal and Economic plants of Nupe Land*. Jube Evans Books and publications, P. 86.

11. Ewetola, E.A., Fanifosi, G.E., Ezekiel, A.A., Adetona, A.A., Oyewole, F.M., Onatoye, N.M., Idowu, I.T., & Akinniku, A.K. (2021); Farmers' awareness of the potential of vetiver grass for soil erosion control on Ogbomosho Agricultural Zone farmlands, South-western Nigeria; *Bulletin of the National Research Center*; 45:30

12. Nwosu, J.N. (2011). The effects of processing on the antinutritional properties of 'Oze' (*Bosqueia angolensis*) seed. *Journal of American Science,* 7(1), 1 – 6.

13. Fayek, N., Tawfik, W., Khalafallah, A, Hamed, S., Mousa, W. & Filkry, M., (2023), Evaluation of Heavy Metals Presence in Agricultural Sample of *Lactuca sativa* and *Trifolium alexandrinum* Using Picosecond Laser-Induced Breakdown Spectroscopy and Flame Atomic Absorption Spectroscopy in Banha and Giza Governorates, Egypt; *Minerals*; 13: 1300

14. Buderer, N.M., Brannan, G.D. (2024), Comparing the Means of Independent Groups: ANOVA, ANCOVA, MANOVA and MANCOVA; StatPearls Publishing ltd.

15. Ranteallo, Y., Ahmed, M., Syam, A., & Nilawati, A. (2023), Identification and quantification of minerals and Vitamins of purple potato (*ipomoea batatas*) leave; *Earth and Environmental Science*; 1755 - 1315

16. Kangton, S., Saurav, D., Shabiha, N. H., Gautam, K.H., Debajit, T., Arun, K.H. (2024) Chemical and Biochemical Characterization of ipomoea aquatic: genoprotective. Potential of inhibitory mechanism of its phytochemicals against α–amylase and α-glucosidase: *Frontiers in Nutrition* 21;10:1304903

17. Hongnan, S., Taihua, M., Lisha, X., Miao, Z., Jingwang, C.(2024), Sweet Potato (Ipomoea batatas L) leaves and

functional foods; Food Chemistry, 156;380-389.

18. Umar, K. J., Hassan L. G., Dangoggo S.M. & Ladan, M.J. (2007). Nutritional composition of water spinach leaves. *Journal of Applied Sciences*, 7, 803-809.

19. Adedokun, M.A, Ogundiran, M.A and Alatise, S.P (2019). Preliminary Assessment of Water Spinach (*Ipomoea aquatica*) and Morning Glory (*Ipomoea asarifolia*) Leaves Meals as Non-Conventional Fish Feed Stuffs, *International Journal of Zoology and Animal Biology;* 2(4): 000164

20. Okaka, A.N.C, Onu, P.N., Ibiam, U., Urako, A. J., & Aja, P.M., (2010); **Phytochemical Composition of *Talinum triangulare* (Water Leaf) Leaves,** *Pakistan Journal of Nutrition*; 9; (6):527-530 DOI: 10.3923/pjn.2010.527.530

21. Eze, C., Okafor, J., & Onuoha, C. (2018). Nutritional value and antinutritional factors in Telfairia occidentalis leaves. *African Journal of Traditional, Complementary and Alternative Medicines*, 15(3), 123–130. https://doi.org/10.4314/ajtcam.v15i3.4

22. Salawu, E. O., & Agbaje, G. O. (2022). Proximate, mineral and phytochemical composition of Amaranthus caudatus leaves from southwestern Nigeria. *Journal of Food Composition and Analysis*, 108, 104582. https://doi.org/10.1016/j.jfca.2022.104582

23. Naima. N., & Tanvir, A. C., (2020) Effects of Organic Wastes on the Growth and Nutritional Quality of Ipomoea aquatica. *Bangladesh Journal of Scientific Research;* . 7(1): 31-33.

24. World Health Organization. Global Anaemia Estimates, 2025 edition. Geneva: WHO; March 2025. Available from: https://www.who.int/data/gho/data/themes/topics/anaemia_in_women_and_children

25. Việt, D. N. & Phan, H. M. (2022). Nutrient composition of edible aquatic vegetables in the Mekong Delta, Vietnam. *Journal of Food Composition and Analysis*, 110, 104500. –.

26. Umar, K.J., Hassan, L.G., Dangoggo, S.M., Ladan, M.J., (2007). Nutritional Composition of Water Spinach (Ipomoea Aquatica Forsk) Leaves. Journal of Applied Sciences, 7:803-809**DOI:** 10.3923/jas.2007.803.809

27. Javid Hussain, Najeeb, U.R., Rehman, Abdul latif Khan., Mohammed Hamayun, S. Murtaza Hussain & Zabta Khan Shinwari. (2010). Proximate and essential Nutrients Evaluation of selected vegetables species from Kohat region, Parkistan. *Parkistan journal of botany,* 42 (4), 2847 – 2855

28. Naeem, K., Alia, S., Naima, T., & Nargis, J. (2016); **Nutritional composition, vitamins, minerals and toxic heavy metals analysis of *Trianthema portulacastrum* L., a wild edible plant from Peshawar, Khyber Pakhtunkhwa, Pakistan;** *African Journal of Biotechnology* Vol. 12(42), pp. 6079-6085; DOI:10.5897/AJB2013.12972

29. Guang, C., Jia L., Huimin, H., Ruiying, D. & Xu W., (2022); Physiological and Molecular Mechanisms of Plant Responses to Copper Stress; *International Journal of Molecular Science*, *23*(21), 12950; https://doi.org/10.3390/ijms232112950

30. Okafor,I.P., Akinyemi,O.T., Wika-Kobani, B.N., Olubodun, T., Eze, U.T., (2022); Childhood diarrhoea: a cross-sectional survey on maternal knowledge, hygienic practices and use of oral zinc for

home management in a Nigerian community; *Pan African Medical Journal*.**;42:123. doi: 10.11604/pamj.2022.42.123.33829**

31. Ogundele, O.A , Bello, O.E., Ogundele, T., Fagbemi, A.T., Fehintola,F.O., Osunmakinwa, O.O., (2023) Determinants of zinc utilisation in the management of diarrhoea among under-five children in Nigeria: a population-based, cross-sectional study *Transactions of The Royal Society of Tropical Medicine and Hygiene*, 117(9):655–662, https://doi.org/10.1093/trstmh/trad023

32. Wessells, K.R, Brown, K.H.,(2012) Estimating the Global Prevalence of Zinc Deficiency: Results Based on Zinc Availability in National Food Supplies and the Prevalence of Stunting. PLoS ONE 7(11): e50568. https://doi.org/10.1371/journal.pone.0050568.