

## Comparative Phytochemical and Antioxidant Assay of *Ipomoea aquatica* and *Telfairia occidentalis*

### Abstract

Some medicinal plants are known to possess antioxidant and nutritional properties. People living in the developing countries rely on the use of medicinal plants for treatment of several diseases. *Ipomoea aquatica* and *Telfairia occidentalis* have been reported to have several medicinal potentials, such as antioxidant activity. The aim was to determine and compare the antioxidant properties of the two medicinal plants, and to carry out elemental assay of the crude plants and phytochemical profiling of 70% methanol extracts. The experiment involved collection, extraction, chemical and elemental profiling and antioxidant assessment. The present study revealed the presence of minerals such as K, Fe, Zn, Se, Cu, Mg, Na, Mn, Ca, Cr, B and P in these medicinal plants. The HPLC analysis showed the presence of bioactive components including flavonoids, tannins and alkaloids. The extracts had an  $IC_{50}$  of 190  $\mu\text{g/ml}$  and 226.67  $\mu\text{g/ml}$  for *Ipomoea aquatica* and *Telfairia occidentalis* respectively in comparison to the standard drug ascorbic acid (616.67  $\mu\text{g/ml}$ ). These medicinal plants are more potent in scavenging DPPH radical than ascorbic acid.

Keywords; *Telfairia occidentalis*, *Ipomea aquatic*, polyphenols antioxidant, elemental analysis.

### 1. INTRODUCTION

*Telfairia occidentalis* Cucurbitaceae (Fluted pumpkin) is a nutraceutical commonly used by Nigerians as vegetable in preparations of delicacies and cuisines such as "Ogili" [1]. The leaves are medicinal because of the rich sources of mineral and secondary metabolites which are beneficial to human health [2, 3]. The aqueous extract of *T. occidentalis* had been reported to

reduce blood glucose level; to possess antimicrobial, anti-inflammatory, antioxidant, and analgesic properties and used in management of anaemia [3]. Other studies that have been carried out on the plant include; anti-convulsant, antidiabetic, renal protection and anticancer effect [3, 4, 5, 6].

*Ipomoea aquatica* Forsk (Convolvulaceae). It is a herbaceous perennial plant and is known commonly as Chinese water spinach, kangkong, swamp cabbage, morning glory, water convolvulus [7]. The plant is characterized by its fast growth, spreading along the ground or water surface, and is found in Asia, Africa and Australia [8]. *Ipomoea aquatica* are used for the treatment of diabetes, anticancer and genoprotective potential, antioxidant, anxiolytic effect and reported to contain alkaloids, tannins, and steroids [7, 9, 10, 11, 11, 2]. *Telfairia occidentalis* and *I. aquatica*, serve both culinary and medicinal purposes in various localities within Bayelsa State, Unlike *T. occidentalis* that is cultivated, *I. aquatica* (Figure 1) is naturally found growing in the wild while *T. occidentalis* is widely embraced and utilized, *I. aquatica* is less recognized and is specifically used in Ogbia Local Government Area, Bayelsa State, Nigeria as vegetable [12, 13]. Thus, the need to determine the chemical profiling, elemental analysis and which of the plant possesses better antioxidant property in comparison to the standard drug.



Figure 1: showing *I. aquatica* and *T. occidentalis*.

## 2. MATERIALS AND METHOD

### 2.1 Chemicals and Reagents

Methanol (JHD), 1,1-Diphenyl-2-picrylhydrazyl,

### 2.2 Equipment and Instrument

Rotary evaporator (Rotavap-Buchi R-200), Water bath (HH-420), Analytical balance (Ohaus Adventure Pro AV213), FS240AA Atomic Absorption Spectrophotometer (Agilent), UV-Vis Spectrophotometry (Jenway), BUCK M950 HPLC.

### 2.3 Collection and extraction of Plant materials

The tender shoots of *Ipomoea aquatica* and the leaves of *Telfairia occidentalis* were collected from a farm at Niger Delta University campus and from a local market, Amassoma, Bayelsa State, Nigeria in November 2023 respectively. The plants were identified by a Taxonomist, Faculty of Pharmacy, Niger Delta University; the Herbarium voucher number were assigned NDUP098 and NDUP034 for *Ipomoea aquatica* and *Telfairia occidentalis* respectively. From the

collected shoots, adulterated materials were removed and the leaves species were washed with a tap water.

## **2.4 Extraction**

The dried materials were chopped and made into a coarse powder. About 337.02g of coarse powder of *T. occidentalis* and 287.09g *I. aquatica* were macerated in 70% Methanol in a glass container with consistent stirring for 72h, filtered and marc re-macerated for another 72h. The filtrates were concentrated *invacuo* at 50°C to obtain crude extracts.

## **2.5 Elemental analysis**

Elemental analysis of crude leaves conducted using Agilent FS240AA Atomic Absorption Spectrophotometer according to the standard methods [15, 16, 17].

## **2.6 High Performance Liquid Chromatography**

The analysis was performed on a BUCK M950 HPLC equipped with a RESTEK 15 meter MXT-1 column (15m x 250um x 0.15um) was used. The concentration of the different bioactive compounds express in µg/g [18, 19, 20, 21].

## **2.7 Antioxidant activity**

### **1,1-Diphenyl-2- Picrylhydrazyl Radical Scavenging**

The extracts were screened at 10, 40, 160, 360, 640 and 1000 µg/mL while Vitamin C was used as the standard drug and absorbance was recorded at 516nm in UV-Visible spectrophotometer [22]. The percentages scavenging activity of samples were calculated using equation (1) and IC<sub>50</sub> was determined from the plot.

$$\% \text{ Scavenging activity} = \frac{\text{absorbance of control} - \text{absorbance of sample}}{\text{absorbance of control}} \times 100\% \dots\dots\dots(1)$$

### 3.0 RESULTS AND DISCUSSION

#### 3.1 Elemental assessment of *Ipomoea aquatica* and *Telfairia occidentalis*

. The results (Table 1.0), showed that *I. aquatica* constitute high concentration of these elements K, Zn, Mn, Ca, and P compared to *T. occidentalis*. *Telfairia occidentalis*, high concentration of elements Fe, Na, Se, Cu, Mg, Cr, and B than *I. aquatic*. It is obvious that plants accumulate essential elements for man and animals. The presence of Ca, Mg, Na, K, Cr, Cu, Fe, Mn, Zn, B, P, and S reflects their function as essential nutrients, often as co-factor activators in metal-ligand enzyme complexes [23]. Chromium, Cu and Zn are essential for hair growth and for increasing the rate of milk production by pregnant females [24, 25, 26, 27, 28].

The presence of high element concentrations in the plants under study gives a new insight into their potential use to compensate for element deficiencies in both man and animals. It is interesting to note that some of the medicinal plants used in folkloric medicine have high concentration of essential element. Mn, Fe, Cu, Zn etc. Zn is important in wound healing and also functions as an antioxidant. Mn essential for normal functioning of central nervous system and are a good anti-oxidant [27, 29].

**Table 1: Elemental compositions of *I. aquatic* and *T. occidentalis***

SN	Element	<i>Ipomea aquatic</i> (ppm)	<i>Telfaira occidentalis</i> (ppm)
1	Potassium	6.08±0.01	6.07±0.00
2	Iron	0.89±0.00	0.98±0.00
3	Zinc	0.66±0.01	0.43±0.00
4	Selenium	0.01±0.0	0.02±0.00
5	Copper	0.003±0.0	0.02±0.00
6	Manganese	0.476±0.0	0.29±0.01

7	Sodium	8.501±0.02	9.28±0.00
8	Magnesium	6.013±0.00	9.02±0.00
9	Calcium	9.405±0.00	8.12±0.00
10	Chromium	0.003±0.00	0.02±0.00
11	Boron	0.003±0.00	0.004±0.0
12	Phosphorus	12.29±0.00	9.07±0.00

Mean±SD

### 3.2 Phytochemical Constituents of *Ipomoea aquatic* and *Telfairia occidentalis*

The plant extracts constitute high concentration of flavonoids and phenolic compounds. Flavonoids are potent antioxidants agents that play essential role for the protection against human diseases. The leaves extracts of *Ipomoea aquatic* (Table 2) and *Telfairia occidentalis* (Table 3) contained flavonoids, tannins, alkaloids, and other phenolic compounds [30]. Fluted Pumpkin contains notable Quinine levels, its use in treating malaria traditionally seems justified. Some of the flavonoids detected were flavon-3-ol, kaempferol, naringenin, rutin, catechin, anthocyanins, proanthocyanidins while resveratrol is a stilbene derivative. The results of this research corroborate with other scientific findings that these medicinal plants could be a major sources of polyphenolic compounds.

*Ipomea aquatica* may have similarity with *T. occidentalis* (Figure 2.0) in terms of chemical constituents; resveratrol, kaempferol, ribalinidine and lunamarin are found in *Ipomea aquatica* and *T. occidentalis* while epihedrine, naringin, spartein, ellagic acid, quinine, naringenin and rutin are present in *T. occidentalis*, while catechin, flavonone, Flavan-3-ol, flavones, digitoxigenin, gallicocatechin, isoflavonoid are found in *I. aquatic* (Figure 1.0) However, anthocyanidine constituents include; Proanthocyanidine, delphinidine, pyranoanthocyanin, anthocyanidine and malvidine which are found in both *T. occidentalis* and *I. aquatic* as revealed by the HPLC profiling (Table 4). These Tannins and anthocyanin are polyphenols which are water soluble pigments and can be found in many plants. They also possess some biological

activities which include anti-inflammatory, vasorelaxant, cardioprotective and antioxidant properties [31].

Flavonoids are associated with activities such as anti-inflammatory, anti-pyretic, hypoglycemic, antifungal, antibacterial and antitumor [32, 33]. The protective activities of flavonoids (Rutin and kaempferol, Flavanones, epicatechin) are attributed to their ability to transfer electrons to free radicals. Antioxidant properties of these compounds have made them useful in the prevention of many degenerative diseases [34]. Other activities exhibited by these phytochemicals include; anticancer, cardio-protective, wound healing, antimicrobial, anti-inflammatory, anti-viral, hypoglycemic, anti-lipidemia anti-depressant and anti-allergic [14, 35, 36]. Naringenin; is abundantly found in citrus fruits and pigmented vegetables and have been beneficial in the management of cancer, liver injury, cardiovascular diseases, oxidative stress and osteoporosis [37]. Proanthocyanidins and anthocyanidins occur naturally in plants. Proanthocyanidins are considered condensed tannins. They are known for several biological activities such as anti-inflammatory, prevention of neurodegenerative diseases, diabetes and cancer which endeared proanthocyanidins to enter the natural product market as dietary supplement [38]. Alkaloids are another group of phytochemicals that enormously occur in plants. Their analgesic uses with the discovery of morphine and its derivatives are known. However, the presence of quinine, sparteine and ribalinidine in the leaves of *Ipomoea aquatic* and *Telfairia occidentalis*, must have been responsible for some outstanding activities in their ethnobotanical uses. These alkaloids have been documented to be effective in the management of cancer, malaria, microbes and protozoans. Ribalinidine, which is a strong antioxidant, has been reported for its strong radical scavenging property [39].

**Table 2: Phytochemicals Constituents identified in the leaves extract of *I. aquatic***

Constituents	Retention time (mins)	Concentration ( $\mu\text{g/g}$ )
Resveratrol	0.426	6.74 $\pm$ 0.001
Catechin	2.423	10.12 $\pm$ 0.00
Ribalinidine	5.506	12.39 $\pm$ 0.001
Flavonones	16.900	9.15 $\pm$ 0.004
Flavan-3-ol	18.013	10.39 $\pm$ 0.001
Flavone	23.483	17.28 $\pm$ 0.002
Digitoxigenin	24.916	7.75 $\pm$ 0.006
Lunamarine	32.563	33.63 $\pm$ 0.001
Gallocatechin	38.806	13.43 $\pm$ 0.004
Isoflavonoids	38.563	5.03 $\pm$ 0.001
Kaempferol	39.776	10.99 $\pm$ 1.062
Mean $\pm$ SD		

**Table 3: Phytochemical components identified in the extract of *T. occidentalis***

Constituents	Retention time (mins)	Concentration ( $\mu\text{g/g}$ )
Resveratrol	40.080	10.92 $\pm$ 0.000
Epihedrine	1.006	17.49 $\pm$ 0.001
Ribalinidine	4.100	13.21 $\pm$ 0.002
Ellagic acid	9.146	72.95 $\pm$ 0.001
Sparteine	12.016	8.25 $\pm$ 0.001
Naringin	14.310	39.15 $\pm$ 0.001
Quinine	25.570	144.36 $\pm$ 0.002
Lunamarin	20.116	1.15 $\pm$ 0.002
Naringenin	32.263	40.99 $\pm$ 0.001
Rutin	35.140	12.21 $\pm$ 0.002
Quinine	45.233	69.53 $\pm$ 0.001
Kaempferol	29.456	4.31 $\pm$ 0.001
Mean $\pm$ SD		

**Table 4: Phytochemical Constituents identified in methanol extracts of *Ipomea. aquatic* and *Telfairia occidentalis*.**

Constituents	Retention time (mins)	<i>Ipomea aquatic</i> (Conc $\mu\text{g/g}$ )	<i>Telfairia aquatic</i> (Conc $\mu\text{g/g}$ )
Proanthocyanides	6.376	46.35 $\pm$ 0.133	46.36 $\pm$ 0.002
Delphinidin	16.823	61.49 $\pm$ 0.001	56.48 $\pm$ 0.002
Pyranoanthocyanidines	22.353	6.81 $\pm$ 0.003	7.36 $\pm$ 0.002
Anthocyanidines	34.036	119.2 $\pm$ 0.003	110.3 $\pm$ 0.001
Malvidine	42.620	20.91 $\pm$ 0.002	16.39 $\pm$ 0.003

Mean±SD

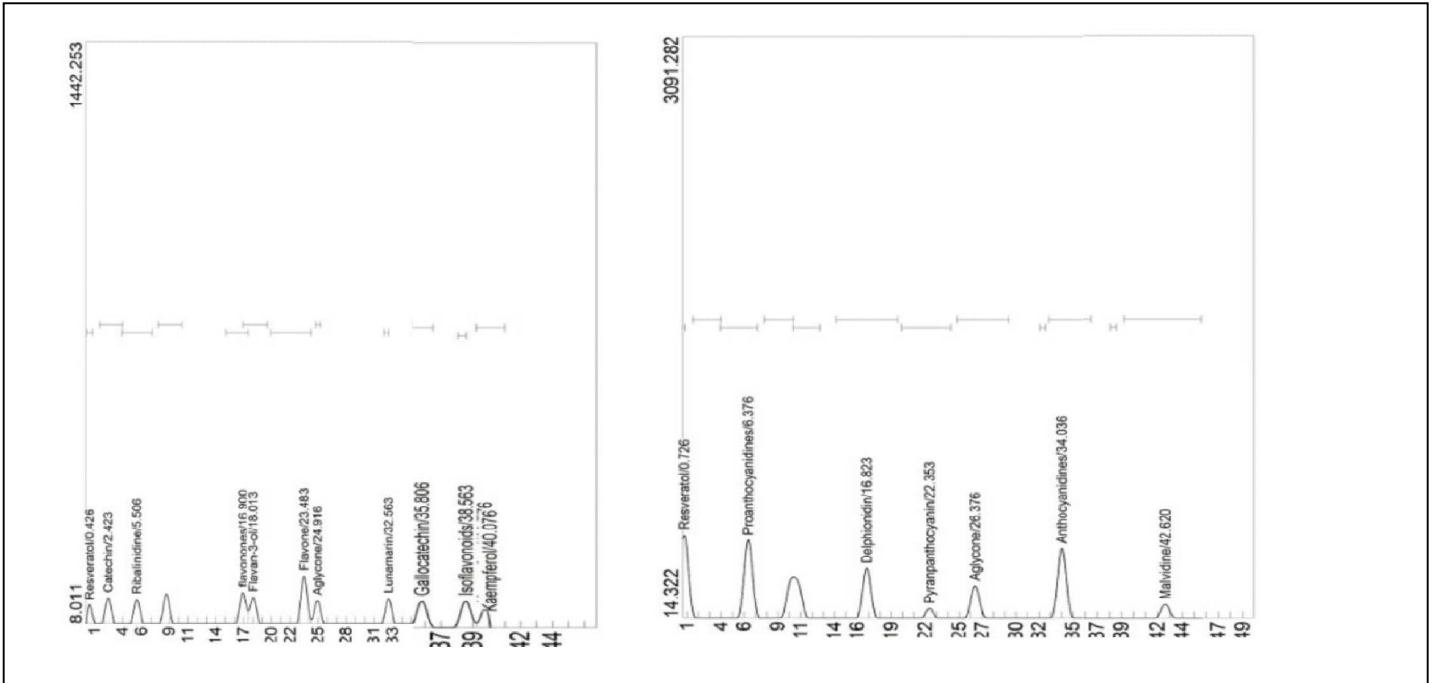


Figure 2: Chromatogram of the leaves of *I. aquatica* extract.

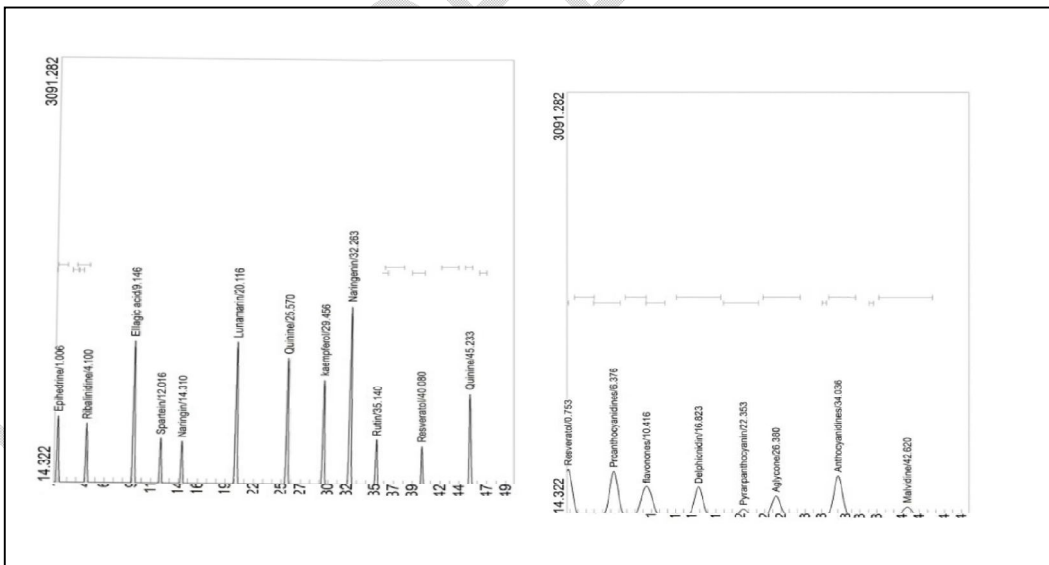
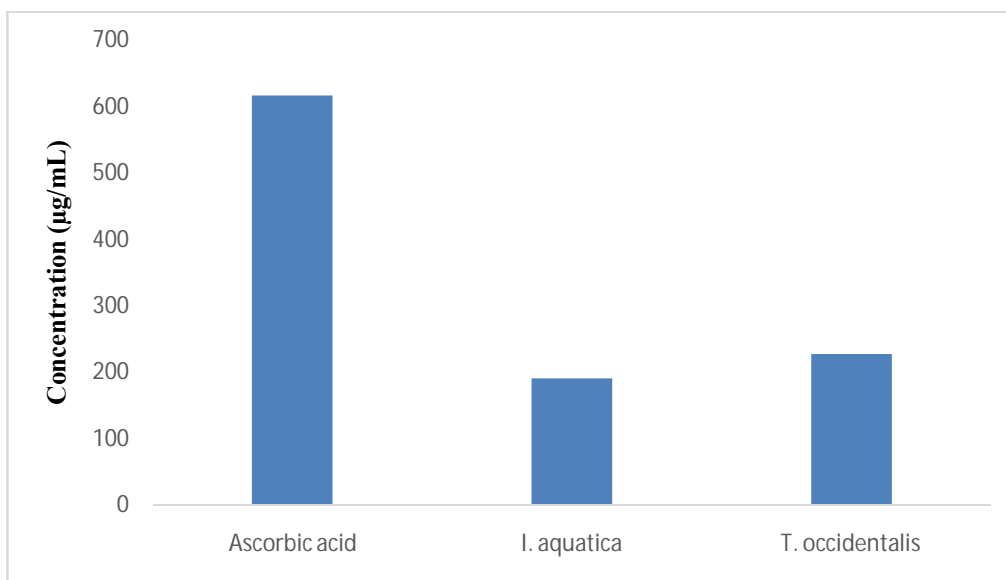


Figure 3: Chromatogram of the leaves extract of *T. occidentalis*

### 3.3 *In vitro* antioxidant activity of *Ipomoea aquatica* and *Telfairia occidentalis*

In the present study, it was observed that *I. aquatica* extract exhibited better scavenging activity when compared to *T. occidentalis* (IC<sub>50</sub> 190 µg/mL and 226.67 µg/mL), respectively as shown in Figure 4. The result of the antioxidant activity of *T. occidentalis* indicates that is less potent compared to findings reported by Nkereuwem et al., 2011, which showed that the methanol extract had an IC<sub>50</sub> of 31.25 µg/mL for *T. occidentalis* compared to 226.67 µg/mL from the investigation [40]. The effect could be due to geographical location, seasonal and chemical constituents [41]. The high scavenging activity of *I. aquatica* could be due to high phenolic content compared to *T. occidentalis*. Ogu et al., (2009) reported a strong relationship between phenolic content and antioxidant activity in selected fruits and vegetables [42]. *Ipomeaaquatica* had an IC<sub>50</sub> (190 µg/mL), compared to the study conducted by Saika et al., 2023 that *I.aquatic* had an IC<sub>50</sub> of 112 µg/mL which showed that is more potent compared to our findings [7]. James et al., (2009) reported the antioxidant effect (IC<sub>50</sub>) of the methanol extracts of leaves and stem of *I. aquatica* had 672.376 µg/mL and 33.188 µg/mL respectively [9]. The variation could be due to chemical constituents, seasonal and geographical location [43, 44].



The  $IC_{50}$  showed that *I. aquatica* (190 µg/mL) is more potent in terms of radical scavenging in DPPH model compared to *T. occidentalis* (226.67 µg/mL) and Ascorbic acid (616.66 µg/mL).

Figure 4:  $IC_{50}$  value for ascorbic acid, extracts of *I. aquatica*, and *T. occidentalis*

## CONCLUSION

Free radical scavenging activity of the plant extract through the antioxidation of the DPPH radical showed that *I. aquatica* is a potent source of antioxidant with low  $IC_{50}$  when compared with *T. occidentalis* and ascorbic acid.

### Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

## REFERENCES

1. Badifu, GIO. Food Potentials of Some Unconventional Oil seeds grown in Nigeria - a Brief Review. *Plant Foods for Human Nutrition*. 1993; 43(3): 211-24.
2. Akanbi WB, Adeboye CO, Togun AO, Ogunrinde JO, Adeyeye SA. Growth, herbage and seed yield and quality of *Telfairia occidentalis* as influenced by cassava peel compost and mineral fertilizer. *Agriculture Journal*. 2007; 2:588-95.
2. Aworunse, OS, Bello OA, Popoola JO, Obembe OO. Pharmacotherapeutic properties of *Telfaira occidentalis* Hook F: A systematic review. *Pharmacognosy Review*. 2018; 12: 238-249.
3. Okoye EI, Orakwue FC. The Chemical evaluation and antimicrobial screening of extracts from seed and leaves of *Telfaira occidentalis* fluted pumpkin. *Chemistry Research Journal*, 2019; 4(3): 98-104.
4. Osonuga IO, Faponle AS, Ezema EN, Adenowo TK, Adelegan AA. Effects of aqueous leaf extract of *Telfaira occidentalis* on haematological parameters and liver enzymes in male wistar rats 2020; 6(1): 44-50, doi: 0601-05-65.
5. Agu FU, Kalu, AA, Akunneh-Wariso C, Chinedu IB, Dimgba UC. Evaluation of the antidiabetic potential of methanol seed extract of *Telfaira occidentalis*. *GSC Biological and Pharmaceutical Sciences*. 2023; 24(03): 274-278.
6. Saika K, Dey S, Hazanika SN, Handique GH, Thakur D, Handique, AK. Chemical and Biochemical Characterization of *Ipomea aquatic*: genoprotective potential and inhibitory mechanism against  $\alpha$ -amylase and  $\alpha$ -glucosidase, *Frontiers in Nutrition*. 2023; 10.1304903. doi: 10.3389/fnut.2023.1304903.
7. Austin DF. Water spinach (*Ipomea Aquatica*, Convolvulacea). A food gone wild. *Ethnobotany Research and Applications*. 2007; 5, 123-146.
8. James O, Nnacheta OP, Aliyu UR. In vitro and in vivo studies on the antioxidative activities, membrane stabilization and cytoprotecting of water Spinach (*Ipomea aquatica* Forsk from Ibaji Ponds, Nigeria. *International Journal of PharmTech Research*, 2009; 1(3): 474-482.

9. Khan MJ, Saini V, Bhati VS, Karchuli MS, Kasture SB. Anxiolytic activity of *Ipomea aquatica* leaves. *European Journal of Experimental Biology*.2011; 1(1): 63-70.
10. Sasikala M, Mohan S, Wanakumari S, Nagarajan A.Evaluation of the role of Merromoside from *Ipomea aquatic* Forskalhydroalcoholic extract in the down regulation of ROS, Species in overcoming MDR in breast cancer. *Asian Pacific Journal of Cancer Prevention*. 2022; 23(11): 3657-3663.
11. Shah P, Awasthi H, Kunwar K, Kalauni SK. Phytochemical analysis and antioxidant activity of *ipomea aquatic* from Ghodaghodi wet land area, Nepal. *International Journal of Herbal Medicine*. 2022; 9(2): 23-27.
12. Eseyin OA, Sattar MA, Rathore HA. A review of the Pharmacological and Biological activities of the aerial parts of *Telfaira occidentalis*, Hook, F (Curcubitaceae). *Tropical Journal of Pharmaceutical Research*. 2014; 13(10): 1761-1769.
13. Roy A, Khan A, Ahmad I, Alghamdi S, Rajab BS, Babalghith AO, Alshahrani MY, Islam S, Islam MR. Flavonoid a Bioactive medicinal plants and its therapeutic application. *Biomed Research International*. 2022;1-9.<http://doi.org/10.1155/2022/5445291>.
14. Zafar M, Khan MA, Ahmad M, Jan G, Sultana S, Ullah K, Marwat SK, Ahmad F, Jabeen A, Nazir A, Abbasi, AM, Rehman ZU, Ullah Z. Elemental analysis of some medicinal plants used in traditional medicine by atomic absorption spectrophotometer (AAS). *Journal of Medicinal Plants Research*. 2010; 4(19): 1987-1990.
15. Anal J.M.H. Trace and essential elements analysis in some medicinal plants using graphite furnace-atomic absorption spectroscopy and its health concern. *Journal of Toxicology*. 2014; 99: 690758,doi: <http://dx.doi.org/10.1155/2014/690758>.
16. Anal J.M.H., Chase, P. Trace elements analysis in some medicinal plants using graphite furnace-atomic absorption spectroscopy. *Environmental Engineering Research*. 2016: 21(3): 247-255.
17. Avula B, Wang Y-H., Ali Z, Khan TA. Quantitative determination of chemical constituents from seeds of *Nigella sativa*, L using HPLC-UV and identification by LC-ESI-TOF. *Journal of AOAC International*.2010; 93(6): 1778-1787.

18. Wu T-Y, Chang F-R, Liou J-R, Lo I-W, Chung T, Lee L, Chi C, Du Y-C, Wong, M-H., Juo, S-H H, Lee, C-C., Wu, Y-C. (2016). Rapid HPLC quantification approach for detection of active constituents in modern combinatorial formular, San-Huang-Xie-Xin-Tang (SHXXT). *Frontiers in Pharmacology*, 7:374. Doi:10.3389/fphar.2016.00374.
19. Sharma G, Sharma V, Mishra T. Phytochemical analysis, high performance liquid chromatography and ex vivo antioxidant potential of a herbal fruit extract. *Asian Journal of Pharmaceutical and Clinical Research*. 2019; 12(2): 256-260.
20. Stanoeva JP, Stojichevski C, Bankova V, Stefova M. Phenolic fingerprint of Macedonian propolis. *Macedonian Journal of Chemistry and Chemical Engineering*. 2024; 43(1): 87-98.
21. Gyamfi MA, Yonamine M, AniyaY. Free radical scavenging activity of medicinal herb of Ghana: *Thonningiasanguinea* on experimentally induced liver injuries. *General Pharmacology*. 1999; 32:661–667.
22. Labhob QR, Al-SanafAE, Mohammed, N.Y, Abbas HJ, Ibrahim ZJ, Najim KM, Malik, ZA, Budaiwi ZK, Abdul-Jabbar ZH, Kadham M.J. Mineral and trace element, dietary sources, biological effects, deficiency and toxicity. A review. *Eurasian Chemical Communications*. 2023; 5: 536-555.
23. Ahmad M, Khan MA, Rashid U, Zafar M, Arshad M, Sultana S Quality assurance of herbal drug valerian by using chemotaxonomic markers. *AfricaJournalof Biotechnology*.2009; 8(6): 1148-1145.
24. Ahmad M, Khan MA, Zafar M, Hasan A, Sultana S, Shah GM, Tareen RB Chemotaxonomic authentication of Herbal Drug Chamomile. *Asian Journal of Chemistry*. 2009; 21(5): 3395-3410.
25. Abbasi AM, Khan MA, Ahmad M, Zafar M, Khan H, Muhammad N, Sultana S. Medicinal plants used for the treatment of jaundice and hepatitis based on socio-economic documentation. *African Journal Biotechnology*. 2009; 8(8): 1643-1650.
26. Sousa C, Moutinho C, Vinha AF, Matos C. Trace Mineral in human health: Iron, Zinc, Copper, Manganese and Fluorine. *International Journal of Science and Research Methodology*. 2019, 13(3): 57-80.

27. Akram M, Munir N, Daniyal M, Egbuna C, Gaman M, Onyekere PF, Olatunde A. Vitamins and Minerals: Types, sources and their functions In:Egbuna, C., Dable-Tupas, G (eds) Functional foods and Nutraceuticals, [https://doi.org/10.1007/978-3-030-42319-3\\_9](https://doi.org/10.1007/978-3-030-42319-3_9). Springer Nature Switzerland AG.2020; 149-172.
28. Jayasekara C, Mendis E, Kim S. Seafood in the human diet for better nutrition and health. Encyclopedia of Marine Biotechnology, John Wiley and Sons Ltd, 2020; 2939-2959.
29. Temitope OR, Olugbenga OO, Aisoni JE, Isyaku J, Shehu MY. Comparative study of the Physicochemical properties of male and Female fluted pumpkins (*Telfaira occidentalis*). Journal of Medical Research. 2020; 6(2):55-61.
30. Qi Q, Chu M, Yu X, Xie Y, Du Y, Liu X, Zhang Z, Shi J, Yan, N. Anthocyanins and Proanthocyanidins: Chemical Structures, Food Sources, Bioactivities and Product Development. Food Reviews International. 2023; 39(7): 4581-4609.
31. Gross, M. Flavonoids and cardiovascular disease. Pharmaceutical Biology. 2004; 42, 21-35.
32. Ferreyra, M.L.F., Rius, S., Casati, P. Flavonoids: Biosynthesis, biological functions and biotechnological application. Frontiers in Plant Science. 2012; 3(222): 1-15.
33. Theja I and Kuber BR. Recent Advances. Flavonoid Metabolism: An updated review in flavonoid metabolism: an updated review in flavonoid metabolism-Recent Advances and application in crop breeding, Muhammad, H., Abbas, K., Ahmad, A. 2023; doi:10.5772/intechopen.106243, ISBN, 978-1-80356-706-8.
34. Reygaert, W.C Green Tea Catechins: Their use in treating infectious diseases. Biomed Research International. 2018, Doi: <https://doi.org/10.1155/2018/9105261>.
35. Juca MM, Filho FMSC de Almeida JC, Mesquita DS, Bariga JRM, Ferreira DKC, Barbosa TM, Vasconcelos LC, Leal LKAM, Junior JERH, Vasconcelos S.M.M.. Flavonoids: Biological activities. Natural Product Research. 2018; 1-16 <https://doi.org/10.1080/14786419.2018.1493588>.
36. Kumar S. Naringenin present status and its future prospective. International Journal of Pharmaceutical & Phytopharmacological Research. 2015; 5(1): 18-26.

37. Nie Y, Sturzenbaum SR. Proanthocyanidine of natural origins: Molecular Mechanisms and implications for lipid disorder and aging associated diseases. *Advanced Nutrition* 2019; 10(3):464-478.
38. Marella A, Ali MR, Alam MT, Saha R, Tanwar O, Akhter M, Shaquiquzzman M, Alam MM. Pyrazolines: A biological review. *Mini Review. Medicinal Chemistry*. 2012; 13, 921.
39. Nkereuwem AO, Eseyin OA, Udobre SA, Ebong A. Evaluation of antioxidant activity and Chemical analysis of the leave of *Telfaira occidentalis*, *Nigerian Journal of Pharmaceutical and Applied Science Research*.2011; 1(1): 21-28.
40. Adesegun SA, Elechi NA and Coker HAB. Antioxidant activities of methanolic extracts of *Sapiumelliticum*. *Pakistan Journal of Biological Sciences*. 2008; 11: 453-47.
41. Ogu GI, Ezeadila JE, Ehiobu JM. Antioxidant and antimicrobial activities of *Dialiumguineense* (Willd) leaf extract. *Pharmacy and Pharmacology Research*2013; 1(1): 1-7.
42. Zainol MK Abd-Hamid A, Yusof S, Muse R. Antioxidant activity and total phenolic compounds of leaf, root and petiole of four accession of *Centella asiatica* (L) urban. *Food Chemistry*. 2003; 81;575-581.
43. Hamid AA, Aiyelaagbe OO, Usman LA, Ameen OM, Lawal A. Antioxidant its medicinal and pharmacological applications. *African Journal of Pure and Applied Chemistry*. 2010 4(8): 142-151.
44. Badifu, GIO. Food Potentials of Some Unconventional Oil seeds grown in Nigeria - a Brief Review. *Plant Foods for Human Nutrition*. 1993; 43(3): 211-24

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