DOI: 10.38061/idunas.1582691

IDUNAS	NATURAL & APPLIED SCIENCES JOURNAL	2025 Vol. 8 No. 1 (1-17)

Phytochemicals, Nutrients and Anti-Nutrients Composition of the Aqueous Roots and Stem Extracts of *Typha domingensis*

Research Article

Jabir Danyaya Aliyu[1*], Ibrahim Abubakar[2], Mustapha Sahabi[3], Zayyanu Abdullahi[1], Abdulhakim Zubairu[1], Abdulsalam Sahabi Umar[1], Fatima Ahmad[4]

[1]Biochemistry Unit, Department of Science Technology, Waziri Umaru Federal Polytechnic, Birnin Kebbi, Nigeria
[2]Department of Biology-Chemistry, Idris Koko Technical College, Farfaru, Sokoto, Nigeria
[3]Department of Biology, Shehu Shagari University of Education, Sokoto, Nigeria
[4]Chemistry Unit, Department of Science Technology, Waziri Umaru Federal Polytechnic, Birnin Kebbi, Nigeria

Author E-mail:
aliyujabir55@gmail.com
J. D. Aliyu ORCID ID: 0000-0003-0718-0107

*Correspondence to: Jabir Danyaya Aliyu, Biochemistry Unit, Department of Science Technology, Waziri Umaru Federal Polytechnic, Birnin Kebbi, Nigeria

DOI: 10.38061/idunas.1582691

Received: 14.11.2024.; Accepted: 14.01.2025

Abstract

Medicinal plants contain various phytoconstituents and have nutritional benefits, medicinal properties, and pharmacological activities. *Typha domingensis* has been used as a source of food and in the treatment of many diseases including wounds, anxiety, depression, and bleeding disorders. The aim of this study is to evaluate the phytochemicals, nutrients and anti-nutrients content of the aqueous roots and stem extracts of *T. domingensis*. Phytochemicals, proximate, minerals and anti-nutrients composition were determined using Association of Official Analytical Chemists (AOAC) and Atomic Absorption Spectrometric (AAS) methods. The results revealed that aqueous roots and stem extracts of *T. domingensis* demonstrated significant ($p< 0.05$) amounts of glycosides (8.50 and 22.05 %), saponins (5.32 and 6.01 %), alkaloids (2.87 and 6.80 %), flavonoids (2.81 and 5.63 %), cardiac glycosides (1.73 and 7.41 %), steroids (5.44 and 1.90 %), and tannins (2.29 and 2.50 %), respectively. A significant ($p< 0.05$) amounts moisture (55.30 and 28.21%), fiber (34.77 and 19.50 %), carbohydrates (25.99 and 20.29), ash (20.41 and 11.40 %), lipids (7.82and 5.06 %) and protein (4.96 and 2.88%) were found in the aqueous roots and stem extracts of *T. domingensis*, respectively. The aqueous roots and stem extracts of *T. domingensis* demonstrated higher significant ($p< 0.05$) levels of calcium, sodium, iron, potassium, magnesium, aluminium, zinc, copper, manganese, cobalt with trace amount of nickel, lead, and cadmium. However, the amount of the phytochemicals and the nutrients was significantly ($p< 0.05$) higher in the aqueous roots extract of *T. domingensis* compared to the stem extract. A trace amount of oxalate, tannins, phytate, and cyanide was found in the aqueous roots and stem extracts of *T. domingensis*. The aqueous roots and stem extracts of *T.*

Domingensis contain a significant amount of phytochemicals and nutrients which could be attributed to its nutritional value and medicinal properties.

Keywords: Anti-nutrients; Minerals; Nutrients; Phytochemicals; *Typha domingensis*

1. INTRODUCTION

Research interest in medicinal plants has been increased because of their availability, easy accessibility, phytoconstituents contents, nutritional benefits, medicinal properties, and pharmacological activities of their constituents. About 80% of the world's population relies on plants and herbs for remedies (Khan and Ahmad, 2019). It was estimated that 95% of the people in developing countries depend on plants and herbs for therapeutic uses (Khan and Ahmad, 2019). Plants and herbs are less expensive and more easily accessible and have few side effects. Plants have been used for treatment of many diseases in many local communities in the world which could be attributed to the presence of phytochemicals (Olivia *et al.,* 2021; Anand *et al.,* 2019). Nutrients and phytochemicals demonstrate vital biological and biochemical functions and pharmacological properties. Nutritional value of plants is determined by their nutrients and anti-nutrients contents (Abubakar *et al.,* 2022). Phytochemicals in plants are responsible for their medicinal uses and pharmacological activities. Anti-nutrients in plants reduce nutrients bioavailability by preventing the absorption of essential nutrients (Abubakar *et al.,* 2022). Many bioactive phytochemicals extracted from medicinal plants have been used for drugs discovery and development (Kumar *et al.,* 2021).

Typha domingensis is an aquatic plant that belongs to the family *Typhaceae* and the genus *Typha* consisting of many species (Pandey and Verma, 2018; Xu and Chang, 2017). *T. domingensis* is abundantly available in tropical and subtropical areas. The plant is commonly found in moist soil, swamps, marshes, lakeshores, roadsides, and manmade reservoirs (He *et al.,* 2015; CABI, 2013). Aquatic plants including *T. domingensis* have been used by animals for foods and nutrition (Elsken, 2020; Tham and Udén, 2013). *T. domingensis* has been used locally for management of wounds, anxiety, depression and neuro and bleeding disorders (Chai *et al.,* 2014; Qin and Sun, 2005). The stem part of the plant has diuretic and astringent properties. The leaves of the plant demonstrated analgesic, antioxidant, and diuretic activities (Lopes *et al.,* 2017). The roots of the plant exhibited anti-inflammatory, antioxidant, astringent, cytotoxic, and diuretic properties (Bandaranayake, 1998). Study showed that extracts of *T. domingensis* demonstrated wound healing properties in rat models (Akkol *et al.,* 2011). It has been reported that hydroethanolic extract of *T. domingensis* demonstrated spasmolytic, bronchodilator, and vasodilating properties (Imran *et al.,* 2020). Rootstocks and rhizomes of Typha species including *T. domingensis* have been consumed as a source of nutritious foods (Zeng *et al.,* 2020). *Typha* species are important source of powder flour which is used in the manufacture of many food products including bread, cakes, and biscuits (Aljazy *et al.,* 2021).

In Nigeria *T. domingensis* is found in the northern region of the country and it is locally called Kachalla or Geron tsuntsu in Hausa. Different parts of the *T. domingensis* have been used in many local communities in Nigeria as source of foods and fodder for livestock, and raw materials for making house screens, boats, andstuffing pillows. *T. domingensis* has been abundantly grown in Shagari dam, in Shagari local government area, Sokoto state, Nigeria. Many people especially local herbalists in and outside the Sokoto community use the *T. domingensis* from this dam as source of food and for treatment of certain diseases. This study aims at evaluating the phytochemicals, nutrients and anti-nutrients contents of the aqueous roots and stem extract of *T. domingensis*.

2. MATERIALS AND METHODS

2.1 Chemicals and Reagents

Chemicals and reagents including Folin-Denis reagent, Wagner's reagent, Baljet's reagent, ethyl acetate, ethanol, chloroform, HCl, H_2SO_4, NaOH, $FeCl_2$, $FeCl_3$, and NH_3 were used in this study. The levels of purity of the chemicals were of standards (≥ 95%) set by American Chemical Society (ACS) grade. The chemicals and reagents purchased were manufactured by Reidel-de Haem (Merck, Germany), Sigma-Aldrich (St. Louis, MO, USA), and BDH Chemical Limited Poole (England, UK).

2.3 Plant Samples

Fresh roots and stem of *T. domingensis* L. were obtained from Shagari dam, Shagari local government area, Sokoto state, Nigeria with help of local herbalists. The samples were collected in early January 2023 from a moist site of the dam. The plant samples were identified at Taxonomy Unit, Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto.

2.4 Preparation of the Samples Extract

The plant samples were thoroughly washed with distilled water, cut into pieces and then air dried at room temperature for 21 days. The dried samples were mechanically pulverized to fine powder using a grinding machine. The powdered samples were stored in a clean container at room temperature for further analysis. The extract preparation followed the method of Abubakar et al. (2021) with modifications. Five hundred grams (500 g) of each powdered sample was soaked in two liters of distilled water for three days with constant stirring at one-hour interval. Each sample extract was filtered using Whatman filter paper No 1 and concentrated using rotary evaporator under reduced pressure at 40°C for three hours. Each sample extract was weighed using analytical weighing balance and the percentage yield of samples extract was calculated. The weight and the percentage yield of the roots and stem extracts obtained was 34.2 g and 41.8 g and 6.8 % and 8.4 %, respectively. The samples extracts were stored in clean desiccators until further analysis.

2.5 Qualitative Phytochemical Screening

2.5.1 Test for Alkaloids

Qualitative determination of alkaloids in the aqueous roots and stem extracts of *T. domingensis* was carried out using Wagner's test according to the method described by Mosa et al. (2012), Abubakar et al. (2022; 2020) and Trease and Evans (1989). Each sample extract (3 mL) was added to the test tubes containing 3 mL of 1% HCl, heated for 20 minutes and then allowed to cool. The Wagner's reagent (1 mL) was added in drops into the test tube. The presence of alkaloids in the samples extract was observed by the formation of a reddish-brown precipitate.

2.5.2 Tests for Glycosides

Glycosides present in the aqueous roots and stem extracts of *T. domingensis* were qualitatively determined by Salkowski's test as described by Ibrahim et al. (2024) and Abubakar et al. (2022; 2020). Each sample extract (5 mL) was transferred into a test tube followed by the addition of 5 mL of 1 % H_2SO_4 solution, boiling for 15 minutes and then allowed to cool. The mixture was neutralized with 10% NaOH solution followed by addition of 5 mL of Fehling's solution A and B. The presence of glycosides was observed by the formation of brick red precipitate of reducing sugars.

2.5.3 Test for Tannins

Ferric chloride test was employed for qualitative determination of tannins in the aqueous roots and stem extracts of *T. domingensis* according to the method described by Trease and Evans (1989) and Ibrahim

et al. (2024). Each sample extract (1 mL) was treated with 2 mL of 5% $FeCl_3$ solution. Tannins in the samples extract was identified by the formation of black or blue-green colour.

2.5.4 Test for Saponins

The presence of saponins in the aqueous roots and stem extracts of *T. domingensis* was determined using Froth test according to the method described by Mosa et al. (2012), Abubakar et al. (2022; 2020) and Trease and Evans (1989). Each sample extract (3 mL) was added into the test tube containing 3 mL of distilled water. The test tubes were vigorously shaken for 30 sec and allowed to stand for 30 min at room temperature. The formation of stable persistent froth indicated the presence of saponins.

2.5.5 Test for Flavonoids

The presence of flavonoids in the aqueous roots and stem extracts of *T. domingensis* was evaluated using sodium hydroxide test as described by Mosa et al. (2012) and Ibrahim et al. (2024). Each sample extract (3 mL) was transferred into the test tubes and then 1 mL of 10% NaOH solution was added into the test tubes. Flavonoids in the samples extract were identified by the formation of an intense yellow colour which became colourless after the addition of dilute HCl solution.

2.5.6 Test for Steroids

The aqueous roots and stem extracts of *T. domingensis* were analyzed for the presence of steroids using the method of Trease and Evans (1989) and Ibrahim et al. (2024). Each sample extract (500 µL) was treated with 5 mL of chloroform and 5 mL of H_2SO_4 solution. The presence of steroids in the samples extract was observed by the formation of violet colour which changed to blue-green.

2.5.7 Test for Terpenoids

Terpenoids in the aqueous roots and stem extract of *T. domingensis* were Qualitative determined using the method of Trease and Evans (1989) and Ibrahim et al. (2024). Each sample extract was treated with 1 mL of ethanol and acetic anhydride followed by addition of 10 mL of concentrated H_2SO_4 solution. Formation of pink colour indicated the presence of terpenoids.

2.5.8 Test for Cardiac Glycosides

Qualitative determination of alkaloid cardiac glycosides in the aqueous roots and stem extracts of *T. domingensis* was performed by Keller-Killani test using the method of Mosa et al. (2012) and Trease and Evans (1989). The samples extracts (5 mL) were transferred into test tubes and then treated with 2 mL of glacial acetic acid containing one drop of $FeCl_2$ solution. One mile of concentrated H_2SO_4 solution was added into the test tubes. The formation of brown ring at the interface indicated the presence of deoxysugar, a characteristic of cardenolides. The presence of cardiac glycosides in the samples extract was observed by the appearance of violet colour below the brown ring.

2.5.9 Test for Anthraquinones

The experimental identification of anthraquinones in the aqueous roots and stem extracts of *T. domingensis* was carried out according to the method described by Trease and Evans (1989) with little modifications. The powdered samples (0.2 g) were transferred into the test tubes followed by addition of 10 cm^3 of chloroform and vigorous shaking for 5 minutes. Each extract was filtered using Whatman filter paper and each filtrate was treated with equal volume of ammonia and then shaken for 5 minutes. The presence of anthraquinones was observed by the formation of bright pink colour in the upper aqueous layer.

2.6 Quantitative Determination of Phytochemicals

2.6.1 Determination of Alkaloids

Alkaloids in the aqueous roots and stem extracts of *T. domingensis* were quantitatively determined using the method of Trease and Evans (1989) and Ibrahim et al. (2024). Five grams of the dried samples extracts were dissolved in 100 mL of methanol followed by evaporation of the solvent. The residues obtained were treated with 20 mL of 2 mM sulphuric acid and the contents were thoroughly mixed, and then partitioned with ether. The aqueous portions were basified with strong ammonia solution and then extracted with excess chloroform for several times. The extracts were concentrated to dryness and the final alkaloid residues were weighed. The alkaloids content was calculated using the following equation:

$$\text{Alkaloids Content (\%)} = \frac{\text{Weight of alkaloids residue}}{\text{Weight of extract}} \text{X } 100$$

2.6.2 Determination of Flavonoids

The quantitative determination of flavonoids in the aqueous roots and stem extracts of *T. domingensis* was conducted according to the method described by Harborne (1973) and Ibrahim et al. (2024). Each dried sample extract (5 mg) was added into a test tube containing 50 mL of 2M HCl solution and then heated at 100 °C for 25 min under reflux. The contents were cool and then filtered using Whatman filter paper. The mixture was treated with 50 mL of ethyl acetate solution, filtered using filter paper and then concentrated to dryness. The weight of dried flavonoids residues were measured using analytical weighing balance. The flavonoids content was obtained using the following formula:

$$\text{Flavonoids Content (\%)} = \frac{\text{Weight of flavonoids residue}}{\text{Weight of extract}} \text{X } 100$$

2.6.3 Determination of Tannins

The quantitative determination of tannins content in the aqueous roots and stem extracts of *T. domingensis* was carried out using the method of AOAC (1999) and Ibrahim et al. (2024). Tannic acid standard solution was obtained by dissolving 10 mg of tannic acid in 100 mL of distilled water. The preparation of tannic acid standards (0 – 2.5 ml aliquots) was performed in 25 mL volumetric flasks. Folin-Denis reagent (2.5 mL) and sodium carbonate solution (1.25 mL) were added into the flask and then the contents were made up to the mark. The contents were incubated at room temperature for 30 minutes and then the absorbance was measured using spectrophotometer at 760 nm wavelength. The dried powder extract (1 g) was boiled in 80 ml of water for 30 minutes. The tannin content in the samples extract was obtained from the tannic acid standard curve.

2.6.4 Determination of Glycosides

Each sample extract (10 mL) was transferred into a 250 ml conical flask containing 50 mL of chloroform and the contents were shaken for 60 minutes. The mixture was filtered using Whatman filter paper followed by addition of 10 mL of pyridine and 2 mL of 2% sodium nitroprusside with vigorous shaking for 10 minutes. Three mil of 20% NaOH was then added to develop a brownish yellow colour. The absorbance of sample and standard was measured spectrophotometerically at 510 nm wavelength. Glycosides content in percentage was obtained using the formula:

$$\text{lycosides} \quad \text{Content (\%)} = \frac{\text{A x A} \quad \text{x DF}}{\text{Weight of extract}} \text{X } 10000$$

Where; A =Absorbance of sample; AG = Average gradient; DF = Dilution factor

2.6.5 Determination of Saponins

The aqueous roots and stem extracts of *T. domingensis* were quantitatively analyzed for saponins content using the method of El-Olemyl et al. (1994) and Ibrahim et al. (2024). Five grams of each dried sample extract was transferred into 250 mL conical flasks followed by addition of 150 mL of 50% alcohol. The mixture was heated at 100ºC for 30 minutes and then filtered using Whatman filter paper. The charcoal (1 g) was added to the filtrate and the contents were boiled for 30 minutes. The hot mixture was filtered and then allowed to cool at room temperature. To achieve total saponins precipitation, 150 mL of acetone was added into the filtrate. The mixture was filtered, and the filter paper was immediately transferred into the desiccator containing anhydrous $CaCl_2$ solution. The saponins residues were dried in oven and then weighed using analytical weighing balance. Saponins content in the samples extract was obtained using the following formula:

$$\text{Saponins Content (\%)} = \frac{\text{Weight of saponins residue}}{\text{Weight of extract}} \text{X } 100$$

2.6.6 Determination of Steroids

Total steroids in the aqueous roots and stem extracts of *T. domingensis* were quantitative determined using the method of Evans (1996) and Ibrahim et al. (2024). One mile of each sample extract was treated with 2 mL of $H_2SO_4$and 2 mL of $FeCl_2$ solution. Potassium hexacynoferrate (III) solution (2 mL) was added into the mixture and then incubated at 70 °C for 3o minutes with constant shaking. The absorbance of the samples against the blank was read at 780 nm wavelength using spectrophotometer. The following formula was used to obtain the steroids content in the samples extracts.

Steroids Content (%) = Absorbance of sample × 100

2.6.7 Determination of Cardiac Glycosides

Quantitative estimation of cardiac glycosides in the aqueous roots and stem extracts of *T. domingensis* was conducted using the method of Solich et al. (1992) with little modifications Each sample extract (10 mL) was treated with 10 mL of the prepared Baljet's reagent (95 mL of 1% picric acid + 5 mL of 10% NaOH). The mixture was diluted with 20 mL of distilled water and then allowed to stand for 60 minutes for colour development. The absorbance of samples and standard was read at 495 nm using spectrophotometer. The standard curve was prepared at different concentrations (12.5-100 mg/L) and the cardiac glycosides concentration was obtained and expressed in percentage.

2.7 Proximate Analysis

The crude lipid, moisture, carbohydrate, crude protein, ash and fiber contents of the aqueous roots and stem extracts of *T. domingensis* were determined using the method of AOAC (2010). All the tests were carried out in triplicate and the results were analyzed and expressed in percentage as the mean and standard error of mean.

2.8 Determination of Minerals Content

Atomic absorption spectrophotometeric technique was employed for determination of concentration of Ca, Fe, Zn, Mg, Cu, Co, Mn, Ni, Cd, and Pb in the aqueous roots and stem extracts of *T. domingensis* using the method of AOAC (1990; 2005). The level of K, Na and Al in the aqueous roots and stem extracts of *T. domingensis* was determined by flame photometeric technique according to the method described by AOAC (1990; 2005).

2.9 Determination of Anti-nutrients Contents

The level of phytate in the aqueous roots and stem extracts of *T. domingensis* was estimated according to the method described by Reddy and Love (1999). The concentration of cyanide in the aqueous

roots and stem extract of *T. domingensis* was determined using the method of AOAC (1990). The aqueous roots and stem extract of *T. domingensis* was analyzed for oxalate content using the method described by Gupta et al. (2005). The AOAC (2005) method was employed for determination of tannins level in the aqueous roots and stem extract of *T. domingensis*.

2.10 Statistical Analysis

All the tests were carried out in triplicate and the results were expressed as mean ± standard error of mean. Statistical Package for Social Sciences (SPSS) Statistics version 22 software was used for data analysis. Differences among the average values were significantly computed using One-way analysis of variance (ANOVA) at confidence level (95%) and Tukey-Kramer multiple comparisons test. Significance was considered by two-tailed ($p< 0.05$) values.

3. RESULTS

3.1 Phytochemicals Composition of Aqueous Roots and Stem Extracts of *T. domingensis*

Table 1 shows the presence of phytochemical constituents in the aqueous roots and stem extracts of T. domingensis. Alkaloids, flavonoids, and cardiac glycosides were moderately and slightly present in the aqueous roots and stem extracts of *T. domingensis*, respectively. High and moderate amounts of glycosides were respectively observed in the aqueous roots and stem extracts of *T. domingensis*. All the extracts demonstrated moderate and slight amount of saponins and tannins, respectively. Anthraquinones and terpenoids were not detected in the extracts (Table 1).

Table 1. Qualitative Phytochemicals Screening of Aqueous Roots and Stem Extracts of *T. domingensis*

Phytochemical	Roots Extract	Stem Extract
Alkaloids	+	++
Glycosides	++	+++
Tannins	+	+
Saponins	++	++
Flavonoids	+	++
Steroids	++	+
Terpenoids	ND	ND
Cardiac glycosides	+	++
Anthraquinones	ND	ND

+++ = Highly present, ++ = Moderately present, + = Slightly present, ND = Not detected

The quantitative phytochemicals composition of aqueous roots and stem extracts of *T. domingensis* is shown in Table 2. Significant amounts of the phytochemicals was observed in the aqueous roots and stem extracts of *T. domingensis*. The aqueous roots extract of *T. domingensis* demonstrated higher and low significant ($p< 0.05$) amount of glycosides and cardiac glycosides, respectively. The aqueous stem extract of *T. domingensis* exhibited higher and low significant ($p< 0.05$) amount of glycosides and steroids, respectively. However, the aqueous stem extract of *T. domingensis* demonstrated higher significant ($p< 0.05$) amount of alkaloids, flavonoids, glycosides, and cardiac glycosides compared to the aqueous roots extract of *T. domingensis* (Table 2).

Table 2. Quantitative Phytochemicals Composition of Aqueous Roots and Stem Extracts of *T. domingensis*

Phytochemical	Composition (%) Roots Extract	Stem Extract
Alkaloids	2.87 ± 0.031	6.80 ± 0.023
Flavonoids	2.81 ± 0.023	5.63 ± 0.017
Tannins	2.29 ± 0.014	2.50 ± 0.018
Glycosides	8.50 ± 0.016	22.05 ± 0.043
Saponins	5.32 ± 0.138	6.01 ± 0.081
Steroids	5.44 ± 0.239	1.90 ± 0.020
Cardiac glycosides	1.73 ± 0.108	7.41 ± 0.031

Values are expressed as mean ± SEM (n = 3)

3.2 Proximate Composition of the Aqueous Roots and Stem Extract of *T. domingensis*

Figure 1 shows the proximate composition of the aqueous roots and stem extracts of *T. domingensis*. The aqueous roots and stem extracts of *T. domingensis* demonstrated higher (55.30 and 28.21%) and low (4.96 and 2.88%) significant ($p< 0.05$) amount of moisture and protein content, respectively. The amount of all the proximate parameters was significantly ($p< 0.05$) higher in the aqueous roots extract of *T. domingensis* compared to the stem extract of *T. domingensis* (Figure 1).

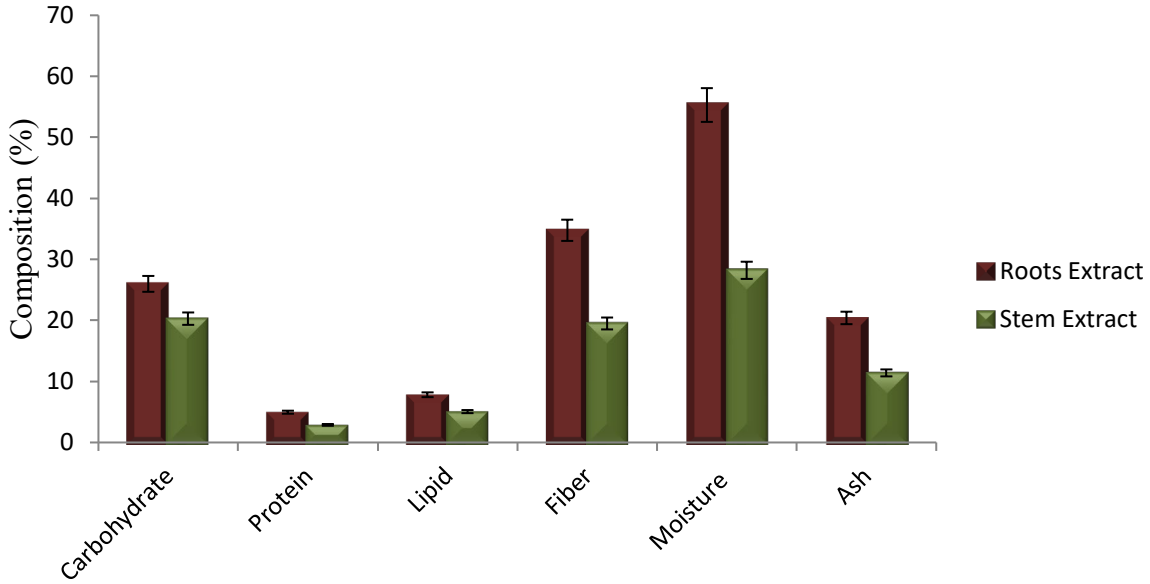

Figure 1. Proximate Composition of the Aqueous Roots and Stem Extracts of *T. domingensis*
Data are expressed as mean ± SEM (n = 3)

3.3 Minerals Composition of the Aqueous Roots and Stem Extracts of *T. domingensis*

Table 3 shows the minerals composition of the aqueous roots and stem extracts of *T. domingensis*. The aqueous roots and stem extracts of *T. domingensis* demonstrated higher significant ($p< 0.05$) levels of calcium, sodium, iron, potassium, and magnesium compared with the other minerals. The extracts contain moderate levels of aluminium, zinc, and copper. Also, trace level of nickel, manganese, cobalt, lead, and cadmium were observed in the extracts (Table 3). However, the aqueous roots extract of T. domingensis exhibited higher levels of calcium, sodium, iron, potassium, magnesium, aluminum, zinc, and copper compared to the stem extract (Table 3).

Table 3. Minerals Composition of the Aqueous Roots and Stem Extracts of *T. domingensis*

Element	**Concentration (mg/100g)**	
	Roots Extract	**Stem Extract**
Na	6.70 ± 0.069	4.80 ± 0.317
K	1.91 ± 0.040	1.23 ± 0.115
Ca	13.16 ± 0.069	8.65 ± 0.069
Fe	1.94 ± 0.023	2.81 ± 0.051
Zn	0.27 ± 0.028	0.14 ± 0.017
Mg	1.28 ± 0.017	1.04 ± 0.034
Cu	0.21 ± 0.028	0.13 ± 0.011
Al	0.91 ± 0.046	0.59 ± 0.034
Co	0.01 ± 0.003	0.02 ±0.004
Mn	0.03 ± 0.005	0.06 ± 0.023
Ni	0.09 ± 0.003	0.07 ± 0.004
Cd	0.02 ± 0.002	0.03 ± 0.001
Pb	0.02 ± 0.001	0.01 ± 0.001

Values are expressed as mean ± SEM (n = 3)

3.4 Anti-nutrients Composition of the Aqueous Roots and Stem Extracts of *T. domingensis*

The concentration of anti-nutrients in the aqueous roots and stem extracts of *T. domingensis* is shown in Figure 2. The aqueous roots and stem extracts of *T. domingensis* contain trace amount of oxalate, tannins, phytate, and cyanide. The aqueous roots extract of *T. domingensis* demonstrated high significant ($p< 0.05$) level of oxalate, tannins, phytate, and cyanide compared to the aqueous stem extract (Figure2).

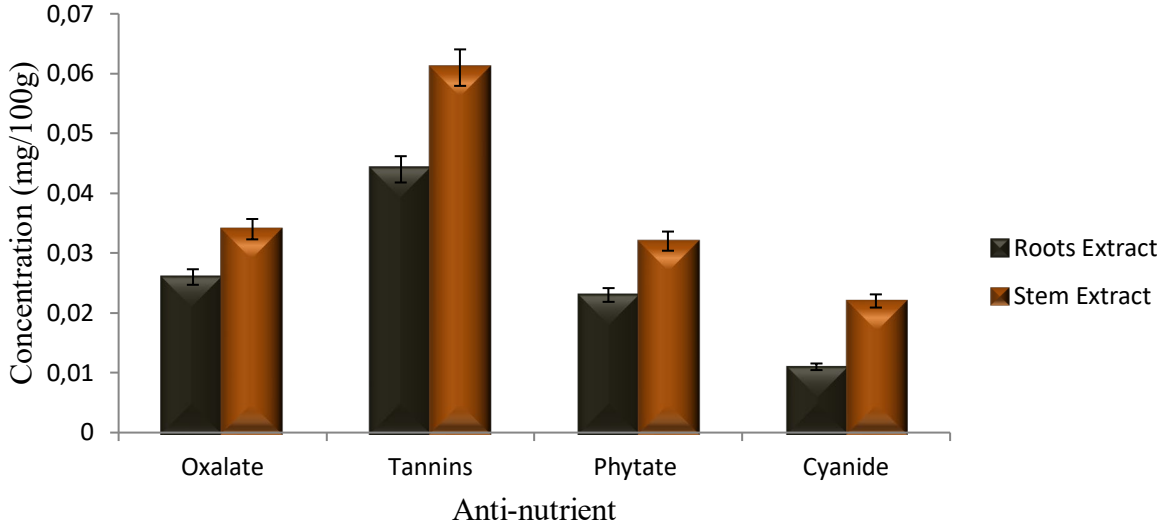

Figure 2. Anti-nutrients Composition of the Aqueous Roots and Stem Extracts of *T. domingensis* Values are expressed as mean ± SEM (n = 3)

4. DISCUSSION

The results of this study revealed that aqueous roots and stem extracts of *T. domingensis* contain significant amount of many phytochemicals. This finding aligns with the study by Ndanyi et al. (2021) who reported the presence of many phytochemicals in some selected plants. Phytochemicals from many medicinal plants demonstrate several pharmacological activities and medicinal properties (Oghenejobo *et al.,* 2017). Alkaloids from different plants extract demonstrated analgesic activity (Brewer, 2011). Study by Mamta et al. (2013) showed that tannins from many plants extracts demonstrated anti-inflammatory and anti-cancer activities. It has been reported that tannins isolated from many plants demonstrated wound healing and astringents properties, and anti-ulcer activities (Abubakar *et al.,* 2022; Kar, 2007). Steroids from various plants have been used for synthesis of sex hormones and steroidal drugs (Majeed *et al.,* 2004). Saponins serve as an important source of steroidal hormones and have blood cholesterol lowering properties (Kar, 2007). Study showed that plants flavonoids demonstrated antioxidant activity scavenging properties, anti-cancer, anti-malarial, antihypertensive and anti-ulcer activities (Ballard and Marostica, 2018). Plants cardiac glycosides have been used in the management of coronary heart diseases and their complications (Denwick, 2002).

This study revealed that the aqueous roots and stem extracts of *T. domingensis* contain high significant amount of moisture, fiber, carbohydrate, and ash content. A relevant study by Grosshans (2014) showed that fresh Typha species demonstrated high moisture content. Also it has been reported that *Typha angustifolia* contains high amount of ash (Gravalos, 2010). The high amount of moisture and carbohydrate in the plant extracts indicated that the plant extracts have short shelf life and high caloric value, respectively. Dietary fiber plays a vital role in lowering high risk of coronary heart diseases, obesity, diabetes and cancer (Lattimer and Haub, 2010). Minerals content of plants is determined by their ash content (Onwuka, 2005). High ash content is an indicator of essential minerals that play vital roles in blood coagulation and management of certain haematological disorders (Okaka, 2001). The high ash content of the plant extracts indicated that *T. domingensis* could be a vital source of minerals. However, this finding revealed that the aqueous roots and stem extracts of *T. domingensis* contain reasonable amount of proteins and lipids. Proteins are important source of nutrients in breast feeding and have many biological and biochemical

functions in synthesis and activities of enzymes and hormones (Wadhave *et al.,* 2014). Lipids are high energy nutrients and important source of fat-soluble vitamins that aids nutrients absorption (Ogbuagu *et al.,* 2011).

In this study the aqueous roots and stem extracts of *T. domingensis* demonstrated a high and low level of sodium and potassium, respectively. This finding is in agreement with the study by Grosshans (2014) who reported moderate and higher level of potassium and sodium in other Typha species. Sodium and potassium have many biological and biochemical functions which include regulation of acid-base balance, muscles contraction and nerve impulses transmission and maintenance of osmotic pressure and membrane potentials (Murray *et al.,* 2000). Potassium has an important role in the normal functioning of heart and skeletal muscle and regulation of many enzyme activities (Weaver, 2013). A significant amount of calcium, magnesium, zinc, iron, copper, manganese, and cobalt was found in the aqueous roots and stem extract of *T. domingensis* in the present study. Calcium plays an important role in regulation of vasodilatation and vascular contraction, nerve transmission, muscle function, hormonal secretion, and intracellular signaling (Catharine *et al.,* 2018). It is an important agent for blood clotting, formation of bone and teeth and function as co-factor in some enzymatic reactions (Abubakar *et al.,* 2022; Robert *et al.,* 2003). Magnesium plays a vital role in protein synthesis, release of muscle storage energy, formation of bones, maintenance of normal heart function and body temperature regulation (Akram *et al.,* 2020). It aids growth and integrity of bone, muscles and nerves functions, and regulation of the cardiac cycle (Allen and Sharma, 2019; Gragossian and Friede, 2019). Magnesium stimulates the activities of many enzymes (Vincente *et al.,* 2014). Zinc is an essential component of many enzymes and enables cell growth and proliferation, sexual maturity, and fertility (Akram *et al.,* 2020; Baltaci *et al.,* 2018). It plays a vital role in tissues formation, immune cell proliferation and maturation, wound repair, hair growth, signal transductor activation in postsynaptic neurons, regulation of oxidative stress, and gene expression (Baltaci *et al.,* 2018; Kimura and Kambe, 2016). Iron is a component of certain enzymes including those involves in oxidation-reduction reactions and proteins such as haemoglobin and myoglobin (Akram *et al.,* 2020). Iron regulate the activities of these enzymes and proteins including synthesis of hemoglobin, transport of oxygen, oxidative processes, cellular growth and catalytic reactions (Akram *et al.,* 2020; Yiannikourides and Latunde-Dada, 2019). Copper is a component of some enzymes including ferro-oxidase, catalase, cytochrome oxidase and tyrosinase and has an important role in bone formation and hematopoiesis (Leone *et al.,* 2006). It is required for red blood cell formation and contributes to the iron absorption in the gastrointestinal tract (Akram *et al.,* 2020). Manganese is essential for the activities of certain enzymes which include succinate dehydrogenase, arginase, and glucosyltransferase (Zeece, 2020; Tuschl *et al.,* 2013). It is required for the synthesis of chondroitin sulphate which is required for cartilage formation (Tuschl *et al.,* 2013). Cobalt serves an important function in the formation of vitamin B12 (Akram *et al.,* 2020). However, a very little amount of lead, nickel and cadmium observed in the samples extracts. These heavy metals demonstrate toxic effects on many organs and tissues in the body.

Results of this study showed that aqueous roots and stem extracts of *T. domingensis* contain very low amount of phytates, oxalate, tannins, and saponins. Anti-nutritional factors produce many adverse effects in food substances including reduction intake, digestion, and utilization of nutrients. Phytates present in diets can affect the bioavailability of minerals, solubility, functionality and digestibility of proteins and carbohydrates (Salunkhe *et al.,* 1990). Phytates can interfere with the absorption of many important minerals such as iron, zinc, magnesium and calcium (Masum *et al.,* 2011). This leads to high level of insoluble salts which are poorly absorbed by the gastrointestinal tract consequently reducing the bioavailability of minerals. Phytates also inhibit digestive enzymes like pepsin, trypsin and amylase (Kumar *et al.,* 2010). High levels of insoluble calcium oxalate in the kidneys form calcium oxalate crystals which contribute to the formation of kidney stones (Nachbar *et al.,* 2000). Oxalate hinders the absorption of

calcium ion resulting to unavailability of the calcium for various functions in the body (Unuofin *et al.,* 2017; Ola and Oboh, 2000). It has been reported that high levels of oxalate in foods causes irritation in the mouth and the lining of the gut (Gemede and Ratta, 2014). Tannins demonstrated anti-nutritional effects due to their capability to impair the digestion of many nutrients and preventing the body from absorbing essential bioavailable compounds (Hendek and Ertop, 2018). Tannins produce many adverse effects in food substances such as inhibiting the activities of many enzymes, decreasing the protein quality of foods and interfering with dietary iron absorption (Felix and Mello, 2000). Study showed that tannins could be responsible for decreased feed intake, growth rate, feed efficiency and protein digestibility in animals (Aletor, 2005). High concentration of tannins in diets might cause decrease in microbial enzyme activities including cellulose and intestinal digestion (Aletor, 2005). Saponins can impair the protein digestion, uptake vitamins and minerals in the gut, as well as lead to the development of a leaky gut (Johnson *et al.,* 1986). Saponins have been reported to reduce the bioavailability of nutrients and decrease activities various enzymes including trypsin and chymotrypsin (Liener, 2003). Also, it has been reported that saponins demonstrated strong hypocholesterolemic effect (Ikewuchi, 2012).

5. CONCLUSION

The aqueous roots and stem extracts of *T. domingensis* demonstrated significant amounts of various phytochemicals, essential minerals, and proximate parameters. The presence of these essential nutrients and the phytoconstituents in the plant samples extracts justified that roots and stem of *T. domingensis* have nutritional value and medicinal properties.

REFERENCES

1. Abubakar, I., Aliyu, J.D., Abdullahi, Z., Zubairu, Z., Umar, A.S., Ahmad, F. (2022). Phytochemical screening, nutritional and anti-nutritional composition of aqueous rhizome extract of *Curcuma longa*, IOSR *Journal of Biotechnology and Biochemistry*, 8(2), 01–09.
2. Abubakar, I., Muhammad, H. Y., Shuaibu, Y. B. and Abubakar, M. G. (2020). Anti-ulcer activity of methanol extract of the leaves of *Hannoa klaineana* in rats. *Journal of Phytopharmacology*, 9(4), 258–264.https://doi.org/10.31254/phyto.2020.9408
3. Abubakar, I., Muhammad, H.Y., Shuaibu,Y.B,, Abubakar, M.G., Hassan, S.W. (2021). Anti-ulcerogenic activity of the fractions of methanol leaves extract of *Hannoa klaineana* in Wistar rats. *International Journal of Pharma and Biosciences*, 12(2), 27–40. http://dx.doi.org/10.22376/ijpbs.2021.12.2.p27-40
4. Akkol, E. K., et al. (2011). The potential role of female flowers inflorescence of *T. domingensis* Pers. in wound management. *Journal of Ethnopharmacology*, 133(3), 1027–1032.
5. Akram, M. N. Munir, M. Daniyal, C. Egbuna, M.-A. Găman, P. F. Onyekere, A. Olatunde, (2020). Vitamins and minerals: Types, sources and their functions. Springer Nature Switzerland AG 2020 C. Egbuna, G. Dable-Tupas (eds.), *Functional Foods and Nutraceuticals*, 9, 149–172. https://doi.org/10.1007/978-3-030-42319-3_9
6. Aletor, V.A. (2005). Anti-nutritional factors as nature's paradox in food and nutrition securities. Inaugural lecture series 15, delivered at the Federal University of Technology, Akure (FUTA)

7. Aljazy, N.A.S., Abdulstar, A.R., Alrakabi, J.M.F. (2021). Analytical study of phytochemicals and antioxidant activity of pollen (*T. domingensis* Pers.) extracted from the papyrus plant and its use in cake enrichment. *Al-Qadisiyah Journal of Agricultural Science*, 11, 126–136. doi:10.33794/qjas.2021.132392.1017
8. Allen, M.J., Sharma, S. (2019). Magnesium. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK519036/
9. Ameen, O.A., Hamid, A.A., Yusuf, Q., Njoku, O.G., Oseni, T.O., Jamiu, W. (2021). Quantitative and qualitative assessment of phytochemicals in methanolic extracts of hurricane weed (*Phyllanthus amarus* Schumach. & Thonn) plant. Journal of Applied Science and Environmental Management. 25(2), 159–165.
10. Anand, U., Jacobo-Herrera, N., Altemimi, A., Lakhssassi, N. (2019). A comprehensive review on medicinal plants as antimicrobial therapeutics: Potential Avenues of Biocompatible Drug Discovery. Metabolites, 9, Article 258. https://doi.org/10.3390/metabo9110258
11. Association of Official Analytical Chemists (AOAC) (1990). Official methods of analysis. 15th Edn., Washington DC, USA. AOAC.
12. Association of Official Analytical Chemists (AOAC). (1999) Official Methods of Analysis of AOAC International. Food Composition, Additives, Natural Contaminants. 16th Edition, AOAC International, Gaithersburg, MD, USA, 35-47.
13. Association of Official Analytical Chemists (AOAC). (2005). Official methods of analysis. Food composition, additives and natural contaminants. Aldric, RC 15th edn. Association of Official Analytical Chemists Inc. USA.
14. Association of Official Analytical Chemists (AOAC). (2010). Official Methods of Analysis. Association of Official Analytical Chemists. (18th Edition). Gaithersburg, USA.
15. Ballard, C.R., Maróstica, M.R. (2018). Health benefits of flavonoids. In Bioactive Compounds: Health Benefits and Potential Applications; Segura-Campos, M.R., Ed.; Elsevier Inc.: Amsterdam. The Netherlands, 185–201. http://doi.org/10.1016/B978-0-12-8147740.00010-4
16. Baltaci, A.K., Yuce, K., Mogulkoc, R. (2018). Zinc metabolism and metallothioneins, *Biology and Trace Elements Research*, 183, 22–31.
17. Bandaranayake, W.M. (1998). Traditional and medicinal uses of mangroves. Mangroves and Salt Marshes, 2(3), 133–148. doi:10.1023/A:1009988607044.
18. Brewer, M.S. (2011). Natural antioxidants: Sources, compounds, mechanism of action and potential applications, Comparative Reviews in Food Science and Food Safety, 10(4), 221–247.
19. Catharine, R.H.B., Christine, L.T., Ann, L.Y, (2018), Dietary reference intakes for vitamin D and calcium. *Food Nutrition Board*, 356, 1053–1061.
20. Center for Agriculture and Bioscience International (2013). Steven Hall. In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc on 3 April 2016.
21. Chai, T., Mohan, M., Ong , H., Wong, F. (2014). Antioxidant, iron-chelating and anti-glucosidase activities of *Typha domingensis* Pers (Typhaceae). *Tropical Journal of Pharmaceutical Research*, 13(1), 67–72.

22. Denwick, P.M. (2002). Natural Products: A Biosynthetic Approach, 2nd ed. John Wiley and Sons Ltd, England.
23. El-Olemyl, M.M., Fraid, J.A., Abdulfattah, A.A. (1994). Experimental photochemistry. A laboratory manual Afifi, Abdel Fattah, A comp., IV King Saud university press, UK, pp 1-134.
24. Elsken, K. (2020). Studies Consider Use of Aquatic Plants to Feed Livestock. Retrieved from https://www.southcentralfloridalife.com on 28/10/2021
25. Evans, W.C. (1996). Commerce and production: principles related to the commercial production, quality and standardization of natural products. In: Trease GE & Evans WC (Editors), Pharmacognosy. 14th edn. Saunders, London.
26. Felix, J.P., Mello, D. (2000). Farm Animal Metabolism and Nutrition. United Kingdom: CABI.
27. Gemede, H.F., Ratta, N. (2014). Antinutritional factors in plant foods: Potential health benefits and adverse effects. IJNFS, 3(4), 284–289. http://doi.org/10.11648/j.ijnfs.20140304.18
28. Gragossian, A., Friede, R. (2019). Hypomagnesemia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-. Available from: https://www.ncbi.nlm. nih.gov/books/NBK500003/
29. Gravalos, I., Kateris, D., Xyradakis, P., Gialamas, T., Loutridis, S., Augousti, A., Tsiropoulos, Z. (2010). A study on calorific energy values of biomass residue pellets for heating purposes. In Proceedings on Forest Engineering: Meeting the Needs of the Society and the Environment, Padova, Italy (Vol. 1114)
30. Grosshans, R.E. (2014). Cattail (*Typha* Spp.) Biomass Harvesting for Nutrient Capture and Sustainable Bioenergy for Integrated Watershed Management.
31. Gupta, S., Lakshmia, A.J., Manjunathb, M.N., Prakash, J. (2005). Analysis of nutrient and anti-nutrient content of underutilized green leafy vegetables. *LWT-Food Science and Technology*, 38, 339–345. http://doi.org/10.1016/j.lwt.2004.06.012
32. Harborne, J.B. (1973). Phytochemical methods: A Guide to Modern Techniques of plant Analysis. Chapman and Hall Ltd, London. pp. 279.
33. He, D., Simoneit, B.R.T., Jara, B., Jaffé, R. (2015). Gas chromatography mass spectrometry based profiling of alkyl coumarates and ferulates in two species of cattail (*T. domingensis* P., and Typha latifolia L.). *Phytochemistry Letters*, 13, 91–98. doi:10.1016/j.phytol.2015.05.010.
34. Hendek, M., Ertop, M. (2018). Bektaş enhancement of bioavailable micronutrients and reduction of antinutrients in foods with some processes. *Food Heal*, 4(3), 159–165.
35. Ibrahim, I.B., Abubakar, I., Ibrahim, S., Adiya, Z.S., Buhari, H.B., Shehu, S.R. (2024). Phytochemicals screening, proximate composition and anti-oxidants analysis of Italian *Citrus paradisi* Fruits. *Journal of Tropical Pharmacy and Chemistry*, 8(1), 2087–7099. https://doi.org/10.25026/jtpc.v8i1.629
36. Ikewuchi, C.C. (2012). Hypocholesterolemic effect of an aqueous extract of the leaves of *Sansevieria senegambica* Baker on plasma lipid profile and atherogenic indices of rats fed egg yolk supplemented diet. *EXCLI J.*, 11, 346–356.
37. Imran, I., Javed, T., Jabeen, A. (1998). Synthesis, characterization and docking studies of amide ligands as anti-leishmanial

agents. *Pakistan Journal of Pharmaceutical Sciences*, 33(1), 385–392.

38. Johnson, I.T., Gee, J.M., Price, K., Curl, C., Fenwick, G.R. (1986). Influence of saponins on gut permeability and active nutrient transport in vitro. *Journal of Nutrition*, 116(11), 2270–2277.
39. Kar, A. (2007). Pharmacognosy and Pharmabiotechnology (Revised- Expanded Second Edition). New Age International Limited Publishers, New Delhi, pp 332-360.
40. Khan, M.S., Ahmad, I. (2019). New Look to Phytomedicine . Elsevier. Herbal medicine: current trends and future prospects; pp. 3–13.
41. Kimura, T., Kambe, T. (2016). The functions of metallothionein and ZIP and ZnT transporters: an overview and perspective. *International Journal of Molecular Science*, 17, 336.
42. Kumar, M., Prakash, S., Kumari, N. (2021). Beneficial role of antioxidant secondary metabolites from medicinal plants in maintaining oral health. *Antioxidants*, 10 (7), 1061. doi:10.3390/antiox10071061.
43. Kumar, V., Sinha, A.K., Makkar, H.P.S. (2010). Dietary roles of phytate and phytase in human nutrition: A review. *Food Chemistry*, 945–959.
44. Lattimer, J.M., Haub, M.D. (2010). Effects of dietary fiber and its components on metabolic health. *Nutrients*, 2(12), 1266–1289. doi:10.3390/nu2121266
45. Leone, N., Courbon, D., Ducimetiere, P., Zureik, M. (2006). Zinc, copper, and magnesium and risks for all-cause, cancer, and cardiovascular mortality. *Epidemiology*, 17(3), 308–314.
46. Liener, I.E. (2003). Phytohemagglutinins: Their nutritional significance. *Journal of Agriculture and Food Chemistry*, 22, 17.
47. Lopes, A., Rodrigues, M.J., Pereira, C., (2016). Natural products from extreme marine environments: searching for potential industrial uses within extremophile plants. *Industrial Crops and Products*, 94, 299–307. doi:10.1016/j.indcrop.2016.08.040.
48. Majeed, M., Vladimir, B., Murray, F. (2004). Turmeric and the healing curcuminoids: Their amazing antioxidant properties and protective powers, New Canaan CT: Keats Pub.
49. Mamta, S., Jyoti, S., Rajeev, N., Dharmendra, S., Abhishek, G. (2013). Phytochemistry of medicinal plants, *Journal of Pharmacognosy and Phytochemistry*, 1(6), 168–182.
50. Masum, A.S., Akond, M.G., Crawford, H., Berthold, J., Talukder, Z.I., Hossain K. (2011). Minerals (Zn, Fe, Ca and Mg) and antinutrient (Phytic acid) constituents in common bean. *American Journal of Food Technology*, 6(3), 235–243.
51. Mosa, E.O., Elhadi, M.A., Mahgoub, S.E. (2012). Preliminary phytochemical evaluation and seed proximate analysis of Surib (Sesbanialeptocarpa DC.) *SJMS*, 7(4), 29-34.
52. Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2000). Harper's Biochemistry, 25th Edition, McGraw-Hill, Health Profession Division, USA.
53. Nachbar, M.S., Oppenheim, J.D., Thomas, J.O. (2000). Lectins in the US diet: Isolation and characterization of a lectin from the tomato (Lycopersicon). *Journal of Biology and Chemistry*, 255, 2056.
54. Ndanyi, M. K., Kamau, D., Karanja, S. (2021). Phytochemical screening and acute oral toxicity study of Myrica Salicifolia (Bayberry) root extracts. *Journal of Pharmacy and Biological Sciences*, 16, 1–5. https://doi.org/10.9790/3008-1602010105
55. Ogbuagu, M.N., Odoemelam, S.A., Ano, A. (2011). The chemical composition of an under-utilized tropical african seed:

Adenanthera pavonina. *Journal of Chemical Society of Nigeria*, 36(1), 23–28.

56. Oghenejobo, M., Opajobi, O. A., Bethel, O.U.S. (2017). Antibacterial evaluation, phytochemical screening and ascorbic acid assay of turmeric (Curcuma longa). *MOJ Bioequiv Availability*, 4 (2), 232–239.
57. Okaka, J.A. (2001). Food Composition, Spoilage and Shelf Life Extension. Ocy. Academic Publishers, pp. 54-56.
58. Ola, F.L., Oboh, G. (2000). Anti-nutritional factors in nutritional quality of plant foods. *Journal of Technology*, 4, 1–3.
59. Olivia, N. U., Goodness, U. C., Obinna, O. M. (2021). Phytochemical profiling and GC-MS analysis of aqueous methanol fraction of *Hibiscus asper* leaves. *Future Journal of Pharmaceutical Sciences*, 7(1), 208–214. https://doi.org/10.1186/s43094-021-00208-4
60. Onwuka, G.l. (2005). Food analysis and instrumentation. Theory and practice. 1st edition, Naphthali Prints Nigeria, pp 1-129.
61. Pandey, A., Verma, R. (2018). Taxonomical and pharmacological status of Typha: a review. *Annal of Plant Science*, 7, 2101–2106. doi:10.21746/aps.2018.7.3.2
62. Qin, F., Sun, H.X. (2005). Immunosuppressive activity of *Pollen typhae* ethanol extract on the immune responses in mice. *Journal of Ethnopharmacology*, 102(3), 424 – 429.
63. Reddy, M.B., Love, M. (1999). The impacts of food processing on the nutritional quality of vitamins and minerals. *Advance Experiments on Medicine and Biology*, 459, 99–106. http://doi.org/10.1007/978-1-4615-4853-9_7
64. Robert, K.M., Daryl, K.G., Peter, A.M. Victor, W.R. (2003). Harper's Illustrated Biochemistry. In Benders and Mayes Vitamins and Minerals, Lange Medical Books/McGraw-Hill, Medical Publishing Division, New York.496.
65. Salunkhe, D.K., Chavan, J.K., Kaden, S.S. (1990). Dietary tannins: Consequences and remedies. CRC Press, Boca Roton, FL.
66. Solich, P., Sedliakova, V., Karlicek, R. (1992). Spectrophotometric determination of cardiac glycosides by flow-injection analysis. *Anal Chim Acta*, 269(2), 199–203.
67. Tham, H. T. and Udén, P. (2013). Effect of water hyacinth (*Eichhornia crassipes*) silage on intake and nutrient digestibility in cattle fed rice straw and cottonseed cake. *Asian - Australasian Journal of Animal Sciences*, 26(5), 646.
68. Trease, G.E., Evans, W.C. (1989). Pharmacognosy. 13th Edition, Bailere Traiadal, London, p.69.
69. Tuschl, K., Mills, P.B., Clayton, P.T. (2013). Manganese and the brain. *International Review Neurobiology*, 110, 277–312.
70. Unuofin, J.O., Otunola, G.A., Afolayan, A.J. (2017). Essential oil composition, nutrient and anti-nutrient analysis of *Vernonia mespilifolia* Less. *Research Journal of Botony*, 12(2), 38–45. https://doi.org/10.3923/rjb.2017.38.45
71. Vincente, A.R., Manganaris, G.A., Ortiz, C.M., Sozzi, G.O., Crisosto, C.H. (2014). Nutritional quality of fruits and vegetables, Postharvest Handling: A Systems Approach, 69–122.
72. Wadhave, A.A., Jadhav, A.I., Arsul, V.A. (2014). Plant proteins applications: A review. *WJPPS*, 3(3), 702–712.
73. Weaver, C.M. (2013). Potassium and health. *Advance Nutrition*, 4(3), 368S–377S.
74. Xu, Z., Chang, L. (2017). Identification and control of common weeds: Springer. Typhaceae; 3, 725–731.
75. Yiannikourides, A., Latunde-Dada, G.O. (2019). A Short review of iron metabolism

and pathophysiology of iron disorders. *Medicines*, 6(3), 85-100. http://doi.org/10.3390/medicines6030085

76. Zeece, M. (2020). Vitamins and minerals, Introduction to the Chemistry of Food, 163–212.
77. Zeng, G., Wu, Z., Cao, W., Wang, Y., Deng, X., Zhou, Y. (2020). Identification of antinociceptive constituents from the pollen of *Typha angustifolia* L. Using effect-directed fractionation. *Natural Products Research*, 34, 1041–1045. doi:10.1080/14786419.2018.1539979