PHYTOCHEMICALS, NUTRITIONAL AND ANTI-NUTRITIONAL COMPOSITION OF ETHANOL LEAVES EXTRACT OF *ELEUSINE INDICA*

Ibrahim Abubakar[1,*], Shehu Ibrahim[2], Nusaiba Lawan Ahmad[3]

[1]Department of Biology-Chemistry, Idris Koko Technical College, Farfaru, Sokoto, Nigeria
[2]Department of Chemistry, Shehu Shagari University of Education, Sokoto, Nigeria
[3]Biochemistry Unit, Department of Science Technology, Waziri Umaru Federal Polytechnic, Birnin Kebbi, Nigeria
[*] Corresponding author e-mail: ibrahimabubakarsok@gmail.com

Abstract

Eleusine indica has been consumed for nutrition and management of many diseases including epilepsy, diarrhea, infections, dysentery, influenza, and hypertension. This study aimed at evaluating the phytochemicals, nutrients and anti-nutrients composition of ethanol leaves extract of *E. indica*. Phytochemicals, proximate, and anti-nutrients content of the extract were determined using AOAC method. The levels of minerals in the extract were estimated using atomic absorption spectrophotometeric method (AAS) and flame photometeric technique. The extract displayed significant ($p < 0.05$) amount of steroids (78.75 %), flavonoids (52.10 **%**), terpenoids (44.14 %), tannins (40.25 %), alkaloids (26.13 %), saponin (34.76 %) and phenols (36.00 %). The significant ($p < 0.05$) amount of crude protein, crude fat, crude fiber, ash, moisture content, and carbohydrate observed in the extract was 7.43 %, 6.17 %, 24.60 %, 15.40 %, 13.50 %, and 35.50 %, respectively. The extract contains significant ($p < 0.05$) amount of magnesium (9.33 mg/100g), sodium (2.66 mg/100g), potassium (3.00 mg/100g), calcium (7.33 mg/100g), iron (4.68 mg/100g), zinc (8.89 mg/100g), and copper (5.48 mg/100g). However, low level of oxalate (2.36 mg/100g), alkaloid (1.42 mg/100g), saponin (3.27 mg/100g), phytate (3.30 mg/100g), and tannin (1.70 mg/100g) was detected in the extract. The ethanol leaves extract of *Eleusine indica* displayed significant amount of phytochemicals, proximate nutrients, and minerals suggesting their nutritional and therapeutic properties.
Keywords: Anti-nutrients, *Eleusine indica*, Minerals, Nutrients, Phytochemicals

Introduction

Demand for food and medicine, has been increasing due to the rapid population of people in the world. Inadequate of nutrients rich foods remains a major public health challenge causing a number of deaths especially in African countries. Insufficient quality plants-based foods cause adverse health effects, economic, and environmental impacts. About 45 % of all deaths among children under the age of five is associated with insufficient nutrients rich foods (UNICEF 2019). In 2024, report showed that 2.6 billion people could not afford a healthy diet and about 673 million people in the world that is approximately 8.3 % of the world population were suffered with excessive hunger (UNICEF 2025). Nutrients or foods rich nutrients are required for several physiological and biochemical processes. Foods rich nutrients aid physiological functions required for developing human body system (Onireti and Ikujenlola 2020). Nutrients enhance growth and development of tissues and regulation of metabolic activities in the body (Alexander and Eli 2025). More than ten million people are malnourishing due to excessive

Received 5 December 2025; Revised 21 January 2026 Accepted 18 February 2026;
Published Online 20 February 2026; Published 1 April 2026

This work is licensed under a Creative Commons Attribution 4.0 International License.
Copyright: © 2026 by the authors

hunger worldwide (WFP 2025). Malnutrition results due to lack or inadequate of micronutrient and macronutrient rich diets (WHO 2024). It is predicted that by 2050 the population of people in the world will approximately reach 8 billion and demand for foods will be major concern (Saerens et al. 2021).
Natural products particularly plants and herbs have been consumed for nutrition and remedies. About eighty percent of the world's population depends on plants for foods and remedies (Khan and Ahmad 2019, Abubakar et al. 2024, Abubakaret al. 2025). Plant based foods enhance dietary diversity and nutritional intake in local and resource limited communities (Rumicha et al. 2025). Plants and herbs displayed several nutritional and medicinal properties due to their nutrients contents and phytoconstituents (Abubakar et al. 2024, Abubakar et al. 2025). Plants and their products serve many biological functions and exhibited different pharmacological activities (Abubakar et al. 2025). Medicinal plants constitute different bioactive compounds that have important application in pharmaceutics and pharmaceutical industries for drug synthesis (Abubakar et al. 2022, Abubakaret al. 2025).
Phytochemicals are bioactive compounds produced in plants and characterized by low molecular weight (Chihomvu et al. 2024). They are secondary metabolites produce in plants where they serve significant roles including attracting pollinators and defending against herbivores (Thirumurugan et al. 2018, Chaachouay and Zidane 2023). Plants derived from phytochemicals exhibit protective effect against a number of diseases including cancer, coronary heart disease, neurological disorders, diabetes, hypertension, inflammation, infections, and gastrointestinal diseases (Prakash et al. 2012). They displayed a significant potential in the regulation of epigenome and produced very low toxic effect when consumed over a long period of time (Ramírez-Alarcón et al. 2021). Phytochemicals demonstrate significant pharmacological activities including antioxidant, anti-inflammatory, antimicrobial and anticancer activities (Rodríguez-Negrete et al. 2024, Janja 2025). Anti-nutritional factors are chemical compounds produced in food that reduce bioavailability of nutrients by decreasing the absorption of essential nutrients (Abubakar et al. 2022). Anti-nutrients produce adverse health effects on human and animal health (Abubakar et al. 2025). Anti-nutritional factors inhibit the utilization of nutrients, particularly proteins, vitamins, and minerals, thereby reducing nutritional benefits and value of foods (Fekadu et al. 2013, Tadessea et al. 2025).
Eleusine indica, commonly known as Goose grass is a diploid plant that belongs to the family Poaceae (Ettebong and Bassey 2017). The plant is widely available in tropical and subtropical countries. *E. indica* has been used in traditional treatment of many disorders including microbial infections, sprained muscle, coughing blood, and insects poisoning (Zakri et al. 2021). Fresh leaves of the plant have been used in treatment of diarrhea, dysentery, epilepsy, influenza, hypertension, and oliguria (Sagnia et al. 2014, Iberahim et al. 2015, Tutor and Chichioco-Hernandez 2018). The roots of the plant have been used in the local treatment of snake bites (Upasani et al. 2018). Aqueous extract made from infusing aerial parts of *E. indica* has been used for treatment of flu-related symptoms (Piah 2020). *E. indica* demonstrates significant anti-inflammatory, antioxidant, antimicrobial, hepatoprotective, anti-plasmodial, anti-diabetic, and anti-cancer activities (Nas et al. 2020, Shatakshi et al. 2025). In Nigeria, *E. indica* is locally called Gbegi or Gbaji in Yoruba, and Ciyawan daji in Hausa.The plant has been used in many local communities in Nigeria for the treatment of malaria, diabetes, gastrointestinal disorders and microbial infections.

Materials and Methods

Chemicals and Reagents

All the experiments were conducted using the analytical graded chemicals and reagents manufactured by Sigma-Aldrich based in St. Louis, MO, USA and Guangdong Chemical Reagent Engineering based in Guangdong, China.

Plant Sample

Fresh leaves of *Eleusine indica* were collected from *Gwadangwaji* village in Birnin Kebbi, Kebbi State, Nigeria. The samples were identified and transported to Biochemistry Laboratory, Department of Science Laboratory Technology, Waziri Umaru Federal Polytechnic Birnin Kebbi, Kebbi State, Nigeria for analyses.

Plant Extract

The plant leaves were washed thoroughly with distilled water and shed dried for seven days at room temperature. The dried samples were grounded to fine powder using motar and pestle. Extraction of the plant sample was done according to the method described by Abubakar et al. (2021). The powder sample (500 g) was extracted in 1 L of ethanol for 72 hours with shaken at one hour interval. The extract was filtered through a Whatman filter paper No 1 and then concentrated to dryness. The extract was weighed (154.7 g) and the percentage yield (30.94 %) was calculated and recorded. The extract was stored in the refrigerator at 4 ^{o}C for further analysis.

Qualitative Phytochemicals Analysis

The qualitative and quantitative determination phytochemicals of composition of the extract was conducted according to the standard methods described by AOAC (1999), Trease and Evans (1989), Harborne (1973), Mosa et al. (2012), Abubakar et al. (2020), and Ibrahim et al. (2024).

Alkaloids

The presence of alkaloids in the ethanol leaves extract of *E. indica* was detected using Wagner's test as described by Trease and Evans (1989) and Abubakar et al. (2020). The extract was treated with 3 mL of 1 % HCl solution in a test tube which was heated for 20 minutes and then allowed to cool at room temperature. The content was treated with 1 mL of Wagner's reagent in drops resulting to the formation of reddish-brown precipitate indicating that alkaloids were present in the extract.

Flavonoids

Flavonoids present in the extract were identified by NaOH test according to the method described by Mosa et al. (2012) and Ibrahim et al. (2024). Ten percent sodium hydroxide solution (1 mL) was added into a test tube containing 3 mL of the extract. Flavonoids in the extract were detected by formation of deep yellow precipitate which upon addition of HCl became colourless.

Tannins

Ferric chloride test was used for qualitative determination of tannins in the extract according to the method of Trease and Evans (1989) and Ibrahim et al. (2024). The extract (1 mL) was treated with 2 mL of 5 % $FeCl_2$ solution. The formation of black or blue-green colour indicated the present of tannins in the extract.

Saponins

Saponins in the extract were qualitatively estimated using Froth test as described by Mosa et al. (2012) and Abubakar et al. (2022). The extract (3 mL) was transferred into a test tube followed by addition of 3 mL of distilled water. The contents in the test tube were shaken for 30 sec and settled for 30 minutes. The presence of saponins in the extract was observed by formation of stable persistent froth.

Steroids

The identification test for steroid in the extract was carried out using the method of Trease and Evans (1989) and Ibrahim et al. (2024). The extract (500 µL) was transferred into the test tube followed by addition of chloroform (5 mL) and H_2SO_4 (5 mL) solution. The violet colour later blue-green indicating that steroids were present in the extract.

Terpenoids

The screening of terpenoids in the extract was done according to the method described by Trease and Evans (1989) and Abubakar et al. (2020). The ethanol (1 mL) and acetic anhydride (1 mL) was added into the test tube containing extract. The mixture was treated with 10 mL of H_2SO_4 solution. The present of terpenoids was detected by development of pink color.

Test for Phenols

The extract was screen for the presence of phenols employing the method of Trease and Evans (1989) and Abubakar et al. (2022). Five miles of the extract was transferred in a test tube followed by addition of ethanol (5 mL) and ferric chloride (5 mL) resulting to the formation of ink blue color indicating the presence of phenols.

Quantitative Estimation of Phytochemicals

Alkaloids

The amount of alkaloids in the extract was estimated using according to the method described by Trease and Evans (1989) and Ibrahim et al. (2024). The dried extract (5 g) was treated with 100 mL of methanol and then evaporated in rotary evaporator. Twenty miles of 2 mM H_2SO_4 was added into the content, shaked vigorously, and then treated with ether. The upper phase of the solution was treated with NH_3 solution and followed by extraction with chloroform. The extract containing alkaloids was dried in oven and then weighed. The alkaloids content was obtained using the formula below:

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

Flavonoids

Flavonoids present in the extract were quantitatively determined using the method of Harborne (1973) and Ibrahim et al. (2024). The extract (5 mg) was treated with 50 mL of 2M HCl solution followed by boiling for half hour. The mixture was allowed to cool and then filtered using Whatman filter paper. The ethylacetate solution (50 mL) was added to the filtrated. The mixture was filtered and then concentrated to dryness. The flavonoids residue was weighed and the flavonoids content was calculated using the following equation:

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

Tannins

Spectrophotometric method described by AOAC (1999) was employed for quantitative analysis of tannins in the extract. Ten milligram of tannic acid was dissolved in 100 mL of distilled water. The solution was used for preparation of tannic acid standards (0 – 2.5 mL) in 25 mL volumetric flasks. The extract (1 g) was boiled in 80 mL of distilled water for half hour. The contents were treated with 2.5 mL of Folin-Ciocalteu reagent and 1.25 mL of sodium carbonate solution and then incubated at room temperature for half hour. The absorbance was read spectrophotometerically at 760 nm wavelength. The tannic acid standard curve was constructed and the tannin content in the extract was obtained from the standard curve.

Saponins

Saponins present in the extract were quantitatively determined using the method of El-Olemyl et al. (1994) and Ibrahim et al. (2024). The extract (5 g) was treated with 150 mL of 50 % ethanol, boiled for half hour and then filtered using Whatman filter paper. The filtrate was treated with 1 g of charcoal, boiled for half hour, filtered and then cooled at room temperature. The filtrate was treated with 150 mL of acetone, filtered and the residue was immediately taken into the desiccator containing anhydrous $CaCl_2$ solution. The solution was dried in oven, weighed and the saponins content in was calculated using the equation below:

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

Steroids

The steroids content of the extract was evaluated using the method of Trease and Evans (1989) and Ibrahim et al. (2024). The extract (1 mL) was transferred into a test tube followed by addition of 2 mL of H_2SO_4 and $FeCl_2$ solution. The mixture was treated with 2 mL of potassium hexacynoferrate (III) solution and then incubated at 70 °C for half hour. The absorbance of the extract was measured spectrophotometerically at 780 nm wavelength. The steroids content was calculated using the following equation:

Steroids Content (%) = Absorbance of extract × 100

Proximate Analysis

Moisture

Oven-drying method was employed for determination of moisture content of the extract as described by Miroslav and Vladimir (1999) and Aliyu et al. (2026). A crucible was clean, dried, weighed (W_1) and then heated. One gram of the extract (W_2) was transferred into the weighed preheated crucible. The crucible containing the extract was heated in an oven at 125 °C for 3 hours until a consistent weight was obtained. The content was allowed to cool and then weighed (W_3). The moisture content of the extract was calculated using the following equation:

$$\text{Moisture content (\%)} = \frac{W_3 - W_1}{W_2} \text{ x } 100$$

Crude protein

The crude protein content of the extract was estimated using Kjeldahl method as described by Chen et al. (2006). The dried extract (2 g) was digested in a digesting tube containing mixture of sulfuric acid, potassium sulfate, copper sulfate, and selenium for four hours. The digested material was treated with boric acid and sodium hydroxide for nitrogen distillation. The distillate material was titrated with 0.05 N H_2SO_4 solution. The crude protein content was obtained using the following equation:

$$\text{Protein (\%)} = \frac{\text{Titre value x 14 x Volume x Normality x 6.25}}{\text{Conc. of solution x 1000 x weight of sample}} \text{ x } 100$$

Ash

The ash content of the extract was estimated using the method described by AOAC (2010) and Aliyu et al. (2025). A clean empty crucible was weighed (W_1) and then heated in an oven at 105 ˚C for 1 hour. One gram of the extract (W_2) was taken to the crucible and then heated in a muffle furnace at 600 ˚C for 1 hour. The crucible was allowed to cool at room temperature and then weighed (W_3). The ash content was calculated using the formula below:

$$\text{Ash content (\%)} = \frac{W_3 - W_1}{W_2} \text{ x } 100$$

Crude Fiber

The crude fiber content of the extract was determined by weight difference as described by Olszewska et al. (2001). The extract (1 g) was treated with 100 mL of 1.25 % H_2SO_4 and then with 100 mL of 1.25 % NaOH solution. The mixture was filtered, washed with distilled water, dried in oven and then ashed in the furnace at 550 ºC for 60 minutes. The fiber content was calculated using the following formula:

$$\text{Fiber (\%)} = \frac{\text{Weight of crucible} + \text{Weight of sample} - \text{ Weight of crucible}}{\text{Weight of sample}} \text{ x } 100$$

Crude lipids

The dried extract was weighed (4 g) and transferred into a separate extraction thimble and extracted with 200 mL of petroleum ether at temperature 60 – 80 ºC for 8 hours. The extract was dried in oven at 103 ºC to evaporate the solvent. The extract was allowed to cool and then weighed. The fat content of the extract was calculated using the formula below:

$$\text{Fat (\%)} = \frac{\text{Weight of thimble before extraction} - \text{Weight of thimble after extraction}}{\text{Weight of sample}} \text{ x } 100$$

Carbohydrate

The carbohydrate content of the extract was determined by difference method using the equation below:

Carbohydrates = 100 – (Protein + Fat + Ash + Moisture)

Estimation of Minerals Content

The quantitative estimation of level of magnesium, calcium, iron, zinc, and copper in the extract was performed using atomic absorption spectrophotometeric (AAS) method as described by AOAC (1990) and Abubakar et al. (2025). Flame photometeric technique was employed for the determination of concentration of sodium and potassium in the extract using the method of AOAC (1990; 2005). The plant sample was burn in a muffle furnace and then digested using nitric acid. The digested sample was extracted with methanol and then analyzed by atomic absorption spectrophotometeric and/or flame photometeric technique.

Determination of Anti-nutrients Contents

The quantitative estimation of alkaloid, saponin, oxalate, phytate, and tannin level in the extract using the method of Harborne (1984), and Abubakar et al. (2025).

Oxalate

Titration technique was employed for estimation of oxalate in the extract as described by Gupta et al. (2005) and Onwuka (2005). Two gram of the extract was dissolved in 190 mL of deionized followed by addition of 10 mL of 6M HCl. The solution was digested at 100 ºC for 60 minutes, cooled and filtered using filter paper. The filtrate was precipitated with NH_4OH and then treated with 10 mL of 20 % H_2SO_4 solution. The solution was titrated with 0.05 M potassium permanganate. The oxalate content was obtained using the following formula:

$$\text{Oxalate (\%)} = \frac{\text{T x Vme x DF x 105}}{\text{ME x MF}} \text{ x } 100$$

Where; T is titre value of $KMnO_7$, Vme is volume-mass equivalent (1 mL of $KMnO_7$ = 0.00225), DF is dilution factor, ME is molar equivalent of $KMnO_7$, MF is mass of the sample.

Tannins

Spectrophotometric method described by AOAC (1999) was employed for quantitative analysis of tannins in the extract. Ten milligram of tannic acid was dissolved in 100 mL of distilled water. The solution was used for preparation of tannic acid standards (0 – 2.5 mL) in 25 mL volumetric flasks. The extract (1 g) was boiled in 80 mL of distilled water for half hour. The contents were treated with 2.5 mL of Folin-Ciocalteu reagent and 1.25 mL of sodium carbonate solution and then incubated at room temperature for half hour. The absorbance was read spectrophotometerically at 760 nm wavelength. The tannic acid standard curve was constructed and the tannin content in the extract was obtained from the standard curve.

Alkaloids

The amount of alkaloids in the extract was estimated using according to the method described by Trease and Evans (1989) and Ibrahim et al. (2024). The dried extract (5 g) was treated with 100 mL of methanol and then evaporated in rotary evaporator. Twenty miles of 2 mM H_2SO_4 was added into the content, shaked vigorously, and then treated with ether. The upper phase of the solution was treated with NH_3 solution and followed by extraction with chloroform. The extract containing alkaloids was dried in oven and then weighed. The alkaloids content was obtained using the formula below:

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

Phytate

The phytate content of the extract was estimated using the method of Lucas and Markakas (1975) and Reddy and Love (1999). Two gram of the extract was treated with 100 mL of 2%

HCl and then filtered using Whatman No. 1 filter paper. The filtrate (50 mL) was treated with 10 mL of distilled water to adjust the pH of the solution followed by addition of 10 mL of 0.3 % ammonium thiocyanate solution. The solution was titrated with standard Iron II Chloride solution containing 0.00195 g Iron/mL until a yellow colour persisting up to five minutes. The phytate content was obtained using the following equation:

Phytate (%) = Titre value × 0.00195 g × 1.19 × 100

Saponins

Saponins present in the extract were quantitatively determined using the method of El-Olemyl et al. (1994) and Ibrahim et al. (2024). The extract (5 g) was treated with 150 mL of 50 % ethanol, boiled for half hour and then filtered using Whatman filter paper. The filtrate was treated with 1 g of charcoal, boiled for half hour, filtered and then cooled at room temperature. The filtrate was treated with 150 mL of acetone, filtered and the residue was immediately taken into the desiccator containing anhydrous $CaCl_2$ solution. The solution was dried in oven, weighed and the saponins content in was calculated using the equation below:

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

Statistical Analysis

All the experimental analyses were repeated three times. The results were expressed as mean ± SEM. The data were analyzed using Statistical Package for Social Sciences (SPSS) Statistics version 22 software was used for the data analysis. One-way analysis of variance (ANOVA) was employed for determining the significant differences among the average values at95 % confidence level using Dunnett multiple comparison test. Two-tailed (p<0.05) were considered significant.

Results

Photochemicals Composition of Ethanol Leaves Extract of *Eleusine indica*

Table 1 shows the qualitative phytochemicals composition of ethanol leaves extract of *Eleusine indica.* The extract displayed the presence of high amount of flavonoids and steroids. Moderate amount of tannins and terpenoids were detected in the extract. Alkaloids, saponins, and phenols were slightly present in the extract (Table 1).

Table 1. Qualitative Phytochemicals Composition of Ethanol Leaves Extract of *Eleusine indica*

Phytochemical	Extract
Alkaloids	+
Flavonoids	+++
Saponins	+
Tannins	++
Phenols	+
Steroids	+++
Terpeniods	++

High (+++), Moderate (++), Fair (+)

Figure 1 shows the quantitative phytochemicals composition of ethanol leaves extract of *Eleusine indica*. The extract showed the presence of high significant ($p < 0.05$) amount of steroids (78.75 %) and flavonoids (52.10 **%**). The extract showed the presence of moderate significant ($p < 0.05$) amount of terpenoids (44.14 %) and tannins (40.25 %). Low amount of alkaloids (26.13 %), saponin (34.76%) and phenols (36.00 %) were found in extract (Figure 1).

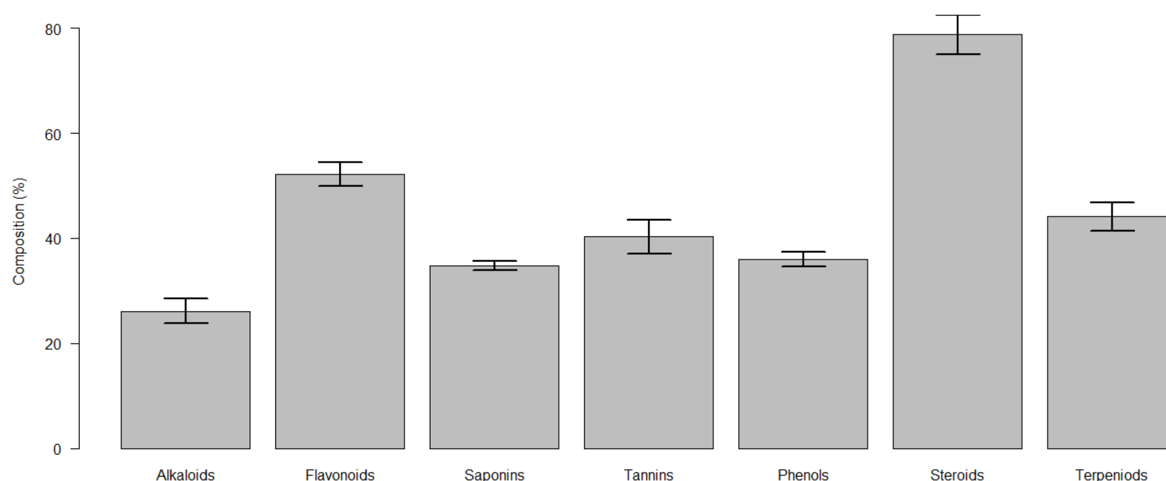

Figure 1. Quantitative Phytochemicals Composition of Ethanol Leaves Extract of *Eleusine indica*
Results are expressed as mean ± SEM (n = 3).

Proximate Composition of Ethanol Leaves Extract of *Eleusine indica*
The proximate composition of ethanol leaves extract of *Eleusine indica* is presented in Figure 2. The significant ($p < 0.05$) amount of crude protein, crude fat, crude fiber, ash, moisture content, and carbohydrate found in the extract was 7.43 %, 6.17 %, 24.60 %, 15.40 %, 13.50 %, and 35.50 %, respectively.

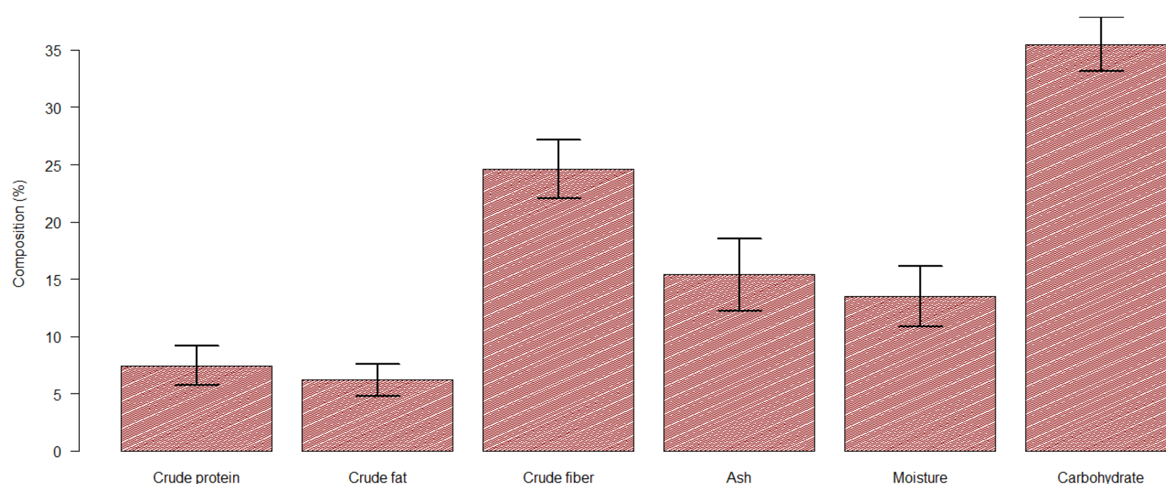

Figure2. Proximate Composition of Ethanol Leaves Extract of *Eleusine indica*
Values are expressed as mean ± SEM (n = 3).

Minerals Content of Ethanol Leaves Extract of *Eleusine indica*

Figure 3 shows the minerals content of ethanol leaves extract of *Eleusine indica*. The extract contains more significant ($p < 0.05$) amount of magnesium (9.33 mg/100g), sodium (2.66 mg/100g), potassium (3.00 mg/100g), calcium (7.33 mg/100g), iron (4.68 mg/100g), zinc (8.89 mg/100g), and copper (5.48mg/100g) (Figure 3).

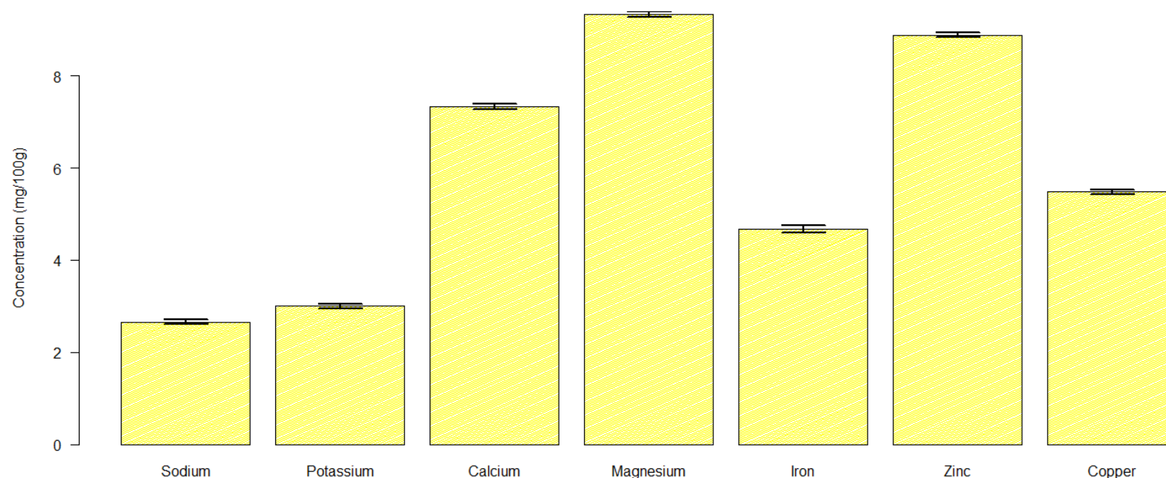

Figure 3. Minerals Content of Ethanol Leaves Extract of *Eleusine indica*
Data are expressed as mean ± SEM (n = 3).

Figure 4 shows the anti-nutrients content of ethanol leaves extract of *Eleusine indica*. The result showed the level of alkaloid, saponin, oxalate, phytate, and tannin in the extract was 1.42 mg/100g, 3.27 mg/100g, 2.36 mg/100g, 3.30 mg/100g, and 1.70 mg/100g, respectively.

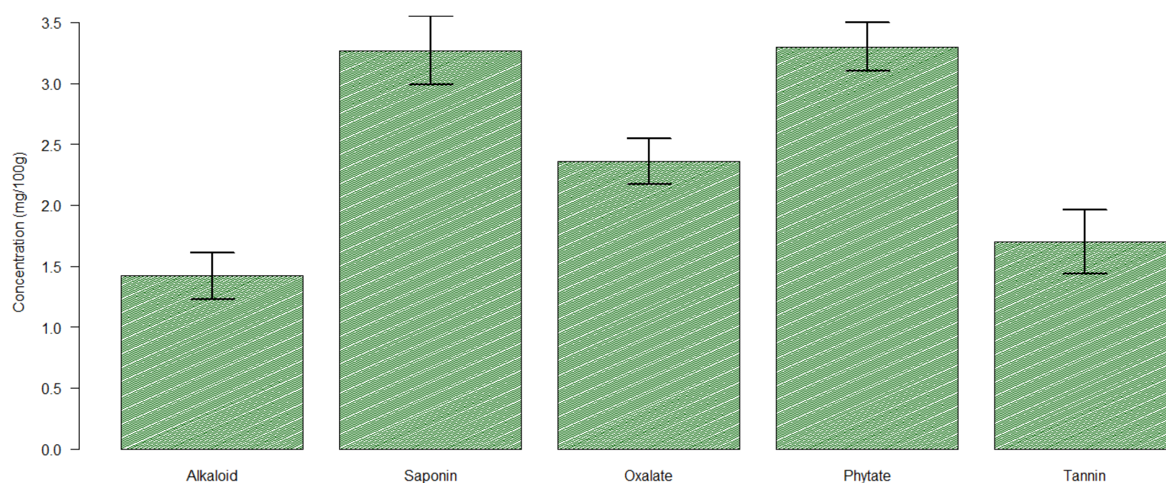

Figure 4. Anti-nutrients Content of Ethanol Leaves Extract of *Eleusine indica*
Results are given as mean ± SEM (n = 3).

Discussion

In this study, the ethanol leaves extract of *Eleusine indica* contain significant amount ofsteroids, flavonoids, tannins, alkaloids, saponins, and phenols. Result of this study is in agreement with

the result of similar study which revealed the presence of flavonoids, alkaloids, phenolics, terpenoids, saponins, and glycosides in *E. indica* (Shatakshi et al. 2025). This finding agrees with the result of the relevant study which showed that *E. indica* leaves contain significant amount of the phytochemicals alkaloids, flavonoids, steroids, glycosides, and saponins (Jone et al. 2023). Relevant studies revealed that *E. indica* contains saponins which contributed to its medicinal properties (Dorota et al. 2017, Shatakshi et al. 2025). Similar finding showed that *Eleusine indica* contain various phytochemicals such as phenols, anthraquinones, triterpenes, steroids, tannins, flavonoids, and alkaloids (Ette et al. 2020).

Phytochemicals from different plants extracts displayed a number of pharmacological activities (Oghenejobo et al. 2017). *E. indica* contains different phytochemicals that are responsible for its pharmacological activities (Shatakshi et al. 2025). Tannins in plants extracts exhibited astringents properties, anti-ulcer and analgesic activities (Abubakar et al. 2022). Saponins isolated from the plants extracts have been used in pharmaceutical industries as emulsifiers, foaming agents, and adjuvants in vaccines (Timilsena et al. 2023). Saponins have been documented to possess antifungal, antibacterial, and anti-inflammatory activities (Shatakshi et al. 2025). Alkaloids from the plants extracts exhibited various pharmacological activities including antimicrobial and anti-inflammatory activities (Joanna 2019, Shatakshi et al. 2025). Alkaloids have potential for treating diseases associated with nervous system (Owheruo et al. 2018). Flavonoids have been reported with anti-inflammatory and anti-cancer activities (Mutha et al. 2021). Flavonoids exhibited significant antioxidant activities and used in neutralizing poisons in the body (Edo et al. 2023). Plants flavonoids have potential for reducing risk of chronic heart disorders. Flavonoids such as quercetin displayed anti-oxidants activities by neutralizing free radicals and preventing oxidative cells and tissues damage (Shatakshi et al. 2025).

In the present study, higher moisture content, protein, crude lipid, crude fiber, carbohydrate and ash contents were observed in the ethanol leaves extract of *E. indica*. Higher moisture content in plants enhances growth and development of spoilage microorganisms and the activities of hydrolytic enzymes (Keyata et al. 2020). Dietary fibre serves important function in human health by enhancing water retention capacity during gastrointestinal transit (Roboul et al. 2017). Lipid serves as major source of high energy metabolites and fat-soluble vitamins that have important roles in biochemical reactions (Abubakar et al. 2025). Crude fibre facilitates the production of bulkier and softer stools (Roboul et al. 2017). Dietary fiber improves the digestion of foods, enhances the absorption of foods in the large intestine, stimulates peristalsis, and prevents constipation (Ogungbenle and Omosola 2015). High-fiber diets have potential to reduce risk of many chronic diseases including diabetes, obesity, coronary heart disease, hypertension, and colon cancer (Ikewuchi and Ikewuchi 2008, Tadessea et al. 2025). Proteins enhance tissues development and promote replacement of damaged tissues in the body (Tadessea et al. 2025). Proteins consist of amino acids, which are required for building and maintaining body tissues (Olufunso et al. 2019). Ash content of food substances is an indicator of minerals content of plants based foods (Abubakar et al. 2025).

The current finding indicated that ethanol leaves extract of *Eluesine indica* contain significant amount of sodium, potassium, magnesium, calcium, zinc, copper, and iron. The K^+/Na^+ ratio is a vital index for high blood pressure and coronary heart diseases (Morrissey et al. 2020). Magnesium serves important function in protein metabolism, regulation of cardiovascular system, energy release from muscle, bones formation, and regulation of body temperature (Allen and Sharma 2019, Gragossian and Friede 2019, Akram et al. 2020). Copper plays a vital role in formation of red blood cell and absorption of iron in gastrointestinal tract (Akram et al. 2020). Calcium is a vital agent for blood clotting, bone and teeth development (Abubakar et al. 2022, Aliyu et al. 2025). Other functions of calcium in the body include regulation of vasodilatation and vascular contraction, impulse transmission, muscle contraction, intracellular

signaling, and hormones synthesis (Catharine et al. 2018). Zinc serves many biological functions including cell growth and development, sexual maturity, fertility, and tissues formation (Baltaci et al. 2018, Akram et al. 2020). It also serves significant function in pain relief, proliferation and maturation of immune cells, hair development, regulation of oxidative stress, activation of signal transduction, and gene expression (Kimura and Kambe 2016, Baltaci et al. 2018, Aliyu et al. 2025).Copper plays a vital role in bone formation, hematopoiesis and serves as cofactor of enzymes particularly catalase, ferro-oxidase, tyrosinase and cytochrome oxidase (Abubakar et al. 2025). Iron is an essential component of haemoglobin, a pigment responsible for transportation of oxygen in the blood (Akram et al. 2020). It regulates the activities of many enzymes and proteins involve in oxidation reduction reactions, hemoglobin synthesis, oxygen transport, cellular growth and development (Yiannikourides and Latunde-Dada 2019, Akram et al. 2020).

In this finding, a reasonable amount of phytates, oxalate, tannins, and saponins was observed in the ethanol leaves extract of *Eluesine indica*. Anti-nutritional factors decrease the absorption, digestion, and utilization of nutrients in foods and their products (Aliyu et al. 2025). Phytates bind essential minerals to form insoluble complexes that decrease the bioavailability of minerals by inhibiting their absorption in the digestive tract (Chen and Xu 2023). Phytic acid inhibits the activities of digestive enzymes resulting to decrease in nutrients absorption (Smeriglio et al. 2017). Oxalate inhibits the absorption of Ca^{+} leading to limited amount of calcium for different roles in the body (Unuofin et al. 2017). It binds to plasma Ca^{+} to yield calcium-oxalate complexes that accumulate to kidney stones (Unuofin et al. 2017, Joye 2019). Oxalates bind minerals to form oxalate salts causing serious adverse health effects (López-Moreno et al. 2022).

Tannin combines with protein to form protein-tannin complexes responsible for inhibition of activities of certain digestive enzymes resulting to proteins deficiency (Joye 2019). Tannins hinder the absorption and digestion of nutrients (Yegrem et al. 2021). They bind to proteins, carbohydrates, and minerals to form complexes that preventing their digestion and absorption (Filho et al. 2017). Tannins inhibit the activities of digestive enzymes leading to decrease in digestion of nutrients (Rani and Kumar 2020). Saponin inhibits the digestion of proteins and absorption of minerals in the gut resulting to leaky gut formation (Barky et al. 2017). Saponins inhibit the absorption of glucose and volatile fatty acids (Yegrem et al. 2021). Over stimulation of immune response by saponins causes autoimmune reactions or enhances inflammatory conditions (Sharma et al. 2023). Saponins have been reported to bind minerals to form insoluble complexes which reduce their bioavailability (Sandeep and Ghosh 2020). Prolong binding of saponins with minerals can leads to anemic condition (Abdelrahman and Jogaiah 2020). Saponins inhibit the activities of proteolytic enzymes such as trypsin and chymotrypsin that catalyze the breakdown of dietary proteins into amino acids (da Silva et al. 2021). Alkaloids have been associated with rapid heartbeat, paralysis and in fatal case (Veer et al. 2021). Alkaloids disrupt signal transmission in nervous system (Veer et al. 2021). Alkaloids inhibited the activity of cholinesterase causing certain neurological disorders (Veer et al. 2021).

Conclusions

The ethanol leaves extract of *Eleusine indica* contain significant amount of proximate components and minerals content. Thus, *E. indica* contain essential nutrients required for tissues development and normal health maintenance. However, the plant extract demonstrated significant amount of phytochemicals suggesting its medicinal properties.

Conflict of Interest

No conflict of interest declared by the authors.

References

Abdelrahman M, Jogaiah S. 2020. Isolation and characterization of triterpenoid and steroidal saponins, in bioactive molecules in plant defense. Cham: Springer International Publishing. 20: 59–78. https://doi.org/10.1007/978-3-030-61149-1_6.
Abubakar I, Abubakar MG, Aliyu JD, Ibrahim S, Abdullahi Z, Zubairu A, Sahabi AU. 2024. Analgesic effect of ethylacetate fraction of the methanol leaves extract of *Hannoa klaineana* in rats. Journal of Bioscience and Biotechnology. 13(2): 155–161. https://doi.org/10.69085/jbb20242155.
Abubakar I, Aliyu JD, Mohammed AG,Ibrahim IB, Said SS, Umar SF. 2025. Evaluation of phytochemicals, nutritional and anti-nutritional composition of the aqueous extracts of white and red onions bulbs. Biology, Medicine, and Natural Product Chemistry. 14(1): 443–450. https://doi.org/10.14421/biomedich.2025.141.443-450.
Abubakar I, Danyaya JA, Abdullahi Z, Zubairu A, Sahabi AU, 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. https://doi.org/10.9790/264X-08020109.
Abubakar I, Muhammad HY, Shuaibu YB, Abubakar MG, Hassan SW. 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://doi.org/10.22376/ijpbs.2021.12.2.p27-40.
Abubakar I, Muhammad HY, Shuaibu YB, Abubakar MG. 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.
Akram MN, Munir M, Daniyal C, Egbuna MA, Găman PF, Onyekere A, Olatunde A. 2020. Vitamins and minerals: Types, sources and their functions. Springer Nature Switzerland AG 2020 C. Egbuna, G. DableTupas (eds.), Functional Foods and Nutraceuticals. 9: 149–172. https://doi.org/10.1007/978-3-030-423193_9.
Alexander DP, Eli ZW. 2025. Assessment of anti-nutritional factors and amino acid profiles in Rice-Africa yam bean flour blends. Journal of Materials and Environmental Science. 16(4): 614 – 625.
Aliyu JD, Abubakar I, Abdullahi Z, Musa S. 2026. Application of activated carbon derived from *Typha domingensis* in industrial wastewater treatment. Journal of Bioresources and Environmental Sciences. https://doi.org/10.61435/jbes.2026.20003.
Aliyu JD, Abubakar I, Sahabi M, Abdullahi Z, Zubairu A, Sahabi AU, Ahmad F. 2025. Phytochemicals, nutrients and anti-nutrients composition of the aqueous roots and stem extracts of *Typha domingensis*. Natural and Applied Sciences Journal. 8(1): 1–17. https://doi.org/10.38061/idunas.1582691.
Allen MJ, Sharma S. 2019. Magnesium. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK519036/.
AOAC. 1990. Official Methods. Minerals, Official Methods of analysis, Washington, DC, USA. AOAC.
AOAC. 1999. Official Methods of Analysis, 15th edn. Association of Official Analytical Chemists, Arlington, VA.
AOAC. 2010. Official Methods. Minerals, Official Methods of analysis, Washington, DC, USA. AOAC.
Baltaci AK, Yuce K, Mogulkoc R. 2018. Zinc metabolism and metallothioneins. Biology and Trace Elements Research. 183: 22–31.

Barky A, Hussein S, Alm-Eldeen Y. 2017. Saponins and their potential role in diabetes mellitus. Diabetes Manag (Lond).7(1): 14858.
Catharine RHB, Christine LT, Ann LY. 2018, Dietary reference intakes for vitamin D and calcium. Food Nutrition Board. 356: 1053–1061.
Chaachouay N, Zidane L. 2023. *Atractylis gummifera* (Stemless Atractylis). Exploring poisonous plants. Boca Raton, FL, USA: CRC Press.
Cheema ZA, Farooq M, Wahid A. 2018. Allelopathic potential of *Eleusine indica* on the germination of associated crops. Agricultural Sciences. 9(3): 105–113.
Chen Q, Zhao J, Huang X, Zhang H, Liu M. 2006. Simultaneous determination of total polyphenols and caffeine contents of green tea by near-infrared reflectance spectroscopy. Microchemical Journal. 83 (1): 42–47.
Chen W, Xu D. 2023. Phytic acid and its interactions in food components, health benefits, and applications: A comprehensive review. Trends Food Science and Technology. 441: 104201. https://doi.org/10.1016/j.tifs.2023.104201.
Chihomvu P, Ganesan A, Gibbons S, Woollard K, Hayes MA. 2024. Phytochemicals in drug discovery-A confluence of tradition and innovation. International Journal of Molecular Science. 25(16): 8792. https://doi.org/10.3390/ijms25168792.
da Silva Y, Magedans V, Phillips MA. 2021. Fett-Neto AG. Production of plant bioactive triterpenoid saponins: from metabolites to genes and back, Phytochemistry Reviews, 20(2): 461–482. https://doi:10.1007/s11101-020-09722-4.
Dorota K, Joanna B, Izabela W, Hubert A, Charalampos P, Mirko B, Ljiljana B, Bolin Z. 2017. Saponin-based, biological-active surfactants from plants. https://doi:10.5772/68062.
Edo GI, Ugbune U, Onoharigho FO, Ezekiel GO, Agbo JJ. 2023. Antioxidant activities of *Reissantia indica* willd. (mopane paddle-pod) and nephroprotective effect on paracetamol-induced nephrotoxicity in male wistar rats. Nutrire. 48: 26. https://doi.org/10.1186/s41110-023-00214-x.
El-Olemyl MM, Fraid JA, Abdulfattah AA. 1994. Experimental photochemistry. A laboratory manual Afifi, Abdel Fattah, A comp., IV King Saud university press, UK. p. 1-134.
Ette OE, Peace M, Ubulom E, Daniel O. (2020). A Systematic review on *Eleucine indica* (L.) Gaertn.): From ethnomedicinal uses to pharmacological activities. Journal of Medicinal Plants Studies. 8(4): 262 – 274.
Ettebong EO, Bassey AI. 2017. Plants Studies. Journal of Medicine. 5: 99.
Filho AM, Pirozi MR, Borges JT, Pinheiro HM, Sant'Ana JB, Chaves JS. 2017. Coimbra, Quinoa: nutritional, functional, and anti-nutritional aspects, Critical Review of Food Science and Nutrition. 57(8): 1618–1630. https://doi.org/10.1080/10408398.2014.1001811.
Gragossian A, Friede R. 2019. Hypomagnesemia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019. https://www.ncbi.nlm. nih.gov/books/NBK500003/.
Gupta S, Lakshmia AJ, Manjunath MN, 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.
Harborne JB. 1973. Phytochemical methods: A guide to modern Techniques of plant Analysis. Chapman and Hall Ltd, London. pp. 279.
Harborne JB. 1984. Phytochemical Methods. Chapman and Hall London: New York.
Iberahim R, Wan Ahmad Y, Ibrahim N. 2015. Phytochemistry, cytotoxicity and antiviral activity of *Eleusine indica* (sambau), AIP. Conference Proceedings. 1678:030013. http://dx.doi.org/10.1063/1.4931234.
Ibrahim IB, Abubakar I, Ibrahim S, Adiya ZSG, Buhari HB, Shehu SR. 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.

Ikewuchi C, Ikewuchi C. 2008. Chemical Profile of *Pleurotus tuberregium* (Fr) Sing's Sclerotia. Available, http://www.akamaiuniversity.us/PJST.htm.
Janja B. 2025. Phytochemical profiling and biological activities of medicinal plants: A comprehensive review. Journal of Pharmacognosis and Natural Products. 11: 341.
Joanna K. 2019. Introductory Chapter: Alkaloids - Their Importance in Nature and for Human Life. https://doi:10.5772/intechopen.85400.
Jone BM, Ajith SS, Jameer SA. 2023. Phytochemical screening and biological activities of *Eleusine indica* leaf extract. Biological Forum – An International Journal. 15(3): 444 – 449.
Joye I. 2019. Protein digestibility of cereal products. Foods. 8(6):199.
Keyata EO, Tola YB, Bultosa G, Forsido SF. 2020. Proximate, mineral, and antinutrient compositions of underutilized plants of Ethiopia: Figl (*Raphanus sativus* L.), Girgir (*Eruca sativa* L) and Karkade (*Hibiscus sabdariffa*): Implications for in-vitro mineral bioavailability. Food Research International. 137: 109724. https://doi.org/10.1016/j.foodres.2020.109724.
Khan MS, Ahmad I. 2019. New look to phytomedicine. Elsevier. Herbal medicine: current trends and future prospects. p. 3–13.
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.
Kumar M, Prakash S, Kumari N. 2021. Beneficial role of antioxidant secondary metabolites from medicinal plants in maintaining oral health. Antioxidants. 10(7): 1061. https://doi:10.3390/antiox10071061.
López-Moreno M, Garcés-Rimón M, Miguel M. 2022. Anti-nutrients: Lectins, goitrogens, phytates and oxalates, friends or foe?, Journal of Functional Foods. 89: 104938. https://doi.org/10.1016/j.jff.2022.104938Antinutrients.
Lucas G, Markakas M. 1975. Phytic acid and other phosphorus compounds of bean (*Phaseolus vulgaris*). Journal of Agriculture and Education Chemistry. 23: 13–15.
Miroslav R, Vladimir NB. 1999. Practical environmental analysis. Royal Society of Chemistry, UK.
Morrissey E, Giltinan M, Kehoe L, Nugent AP, McNulty, BA, Flynn A. 2020. Sodium and potassium intakes and their ratio in adults (18–90 y): Findings from the Irish National Adult Nutrition Survey. Nutrients.12(4):938. http://doi.org/10.3390/nu12040938.
Mosa EO, Elhadi MA, Mahgoub SE. 2012. Preliminary phytochemical evaluation and seed proximate analysis of Surib (*Sesbania leptocarpa* DC.) SJMS. 7(4): 2934.
Mutha RE, Tatiya AU, Surana SJ. 2021. Flavonoids as natural phenolic compounds and their role in therapeutics: an overview. Future Journal of Pharmaceutical Sciences. 7: 25. https://doi.org/10.1186/s43094-020-00161-8.
Nas JSB, Dangeros SE, Chen PDR, Dimapilis RC, Gonzales DJG, Hamja FJA. 2020. Evaluation of anticancer potential of *Eleusine indica* methanolic leaf extract through Ras- and Wnt-related pathways using transgenic Caenorhabditis elegans strains. Journal of Pharmacy Negative Results. 11: 42 – 46.
Oghenejobo M, Opajobi OA, Bethel OUS. 2017. Antibacterial evaluation, phytochemical screening and ascorbic acid assay of turmeric (*Curcuma longa*). MOJ Bioequiv Availability. 4(2): 232–239.
Ogungbenle H, Omosola S. 2015. The comparative assessment of nutritive values of dry Nigerian okra (*Abelmoschus esculentus*) fruit and oil. International Journal of Food Science, Nutrition, and Engineering. 1: 8–14. https://doi.org/10.5923/j.food.20150501.02.
Olszewska M, Głowacki R, Wolbiš M. 2001. Quantitative determination of flavonoids in the flowers. Acta Pol. Pharmacy. 58 (3): 199–203.
Olufunso OO, Abioye VF, Sanusi RA. 2019. Proximate and mineral composition of maize (*Zea mays*) grown in different locations of Nigeria. Journal of Food Science and Technology. 56(4): 1930 – 1936.

Onireti FM, Ikujenlola AV. 2020. Nutrients, antinutrients and amino acids profile of malted quality protein maize (*Zea mays* L.) based ready-to-eat breakfast cereal fortified with vegetable biomaterials. Croatian Journal of Food Science and Technology 12 (2): 258–267. https://doi.org/10.17508/CJFST.2020.12.2.15.

Onwuka GI. 2005. Food analysis and instrumentation theory and practice. Naphthali prints. Lagos, p.142-143.

Owheruo JO, Ifesan BOT, Kolawole AO. 2018. Physicochemical properties of malted finger millet (*Eleusine coracana*) and pearl millet (*Pennisetum glaucum*). Food Science Nutrition. 7(2): 476 – 482.

Piah D. 2020. Direct communication with Nenek Piah, a traditional practitioner from ethnic Kadasan/Dusun at Keningau, Sabah (Pers. Comm).

Prakash D, Gupta C, Sharma G. 2012. Importance of phytochemicals in nutraceuticals. Journal of Chinese Medicine Research and Development. 1(3): 70 – 78.

Ramírez-Alarcón K, Victoriano M, Mardones L, Villagran M, Al-Harrasi A, Al-Rawahi A, Cruz-Martins N, Sharifi-Rad J, Martorell M. 2021. Phytochemicals as potential epidrugs in Type 2 diabetes mellitus. Front Endocrinol (Lausanne). 12: 656978.

Rani A, Kumar V. 2020. Translational genomics and breeding in soybean, Accelerated plant breeding. 3: 343–367. Springer.

Reboul E. 2017. Vitamin E and the nervous system. In Vitamin E: Chemistry and nutritional benefits. Nova Science Publishers. p. 109 – 124.

Reddy MB, 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.

Rodríguez-Negrete EV, Morales-González Á, Madrigal-Santillán EO, Sánchez-Reyes K, Álvarez-González I, Madrigal-Bujaidar E. 2024. Phytochemicals and their usefulness in the maintenance of health. Plants (Basel). 13(4): 523. https://doi.org/10.3390/plants13040523.

Rumicha TD, Belew S, Hasen G, Teka TA, Forsido SF. 2025. Food, feed, and phytochemical uses of wild edible plants: A systematic review. Food Science and Nutrition. 13: e70454. https://doi.org/1 0.1002/fsn3.70454.

Saerens W, Smetana S, Van Campenhout L, Lammers V, Heinz V. 2021. Life Cycle Assessment of Burger Patties Produced With Extruded Meat Substitutes. Journal of Cleaner Production. 306: 127177.

Sagnia B, Fedeli D, Casetti R, Montesano C, Falcioni G, Colizzi V. 2014. Antioxidant and antiinflammatory activities of extracts from *Cassia alata*, *Eleusine indica*, *Eremomastax speciosa*, *Carica papaya* and *Polyscias fulva* medicinal plants collected in Cameroon. PLoS One. 9(8): 110.

Sandeep N, Ghosh S. 2020. Triterpenoids: Structural diversity, biosynthetic pathway, and bioactivity, 67: 411–461. https://doi.org/10.1016/B978-0-12-819483-6.00012-6.

Sharma K, Ramandeep K, Satish K, Kumar R, Sharma S, Vikas K. 2023. Saponins: A concise review on food related aspects, applications and health implications. Food Chemistry Advances. 2:100191. https://doi.org/10.1016/j.focha.2023.100191.

Shatakshi M, Versha U, Rupinder K, Chandrika B, Kanchan C, Hitendra K, Prerana B, Krishan Pal Singh R, Naveen K. 2025. A Comprehensive Review Of *Eleusine Indica* (Goosegrass): phytochemical composition, morphology, and anatomy. International Journal of Environmental Sciences. 11(6): 2229 – 7359. https://theaspd.com/index.php.

Smeriglio A, Barreca D, Bellocco E, Trombetta D. 2017. Proanthocyanidins and hydrolysable tannins: occurrence, dietary intake and pharmacological effects. British Journal of Pharmacology. 174 (11): 1244–1262. https://doi.org/10.1111/bph.13630.

Tadesse D, Masresha G, Lulekalc E, Getachewd P, Belaynehe T. 2025. Proximate, mineral, and anti-nutrient compositions of selected wild edible plants consumed in Northwestern Ethiopia. Measurement: Food 19: 100243. https://doi.org/10.1016/j.meafoo.2025.100243.
Thirumurugan D, Cholarajan A, Raja SS, Vijayakumar R. 2018. An introductory chapter: secondary metabolites. Secondary metabolites-sources and applications. p. 3 – 21.
Timilsena YP, Phosanam A, Stockmann R. 2023. Perspectives on Saponins: Food functionality and applications. International Journal of Molecular Science. 24(17): 13538. https://doi.org/10.3390/ijms241713538.
Trease GE, Evans WC. 1989. Pharmacognosy. 13th Edition, Bailere Traiadal, London, pp. 69.
Tutor JT, Chichioco-Hernandez CL. 2018. Angiotensin Converting Enzyme Inhibition of Fractions from *Eleusine indica* Leaf Extracts. Pharmacognosis Journal. 10(1): 25 – 28.
UNICEF 2019. Companion to breastfeeding after 6 months. Retrieved from http://www.unicef.org/programme/breastfeeding/food.htm.
UNICEF. The State of Food Security and Nutrition in the World. 2025. Addressing High Food Price Inflation for Food Security and Nutrition. August 8, 2025.
Unuofin JO, Otunola GA, Afolayan AJ. 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.
Upasani MS, Upasani SV, Beldar VG, Beldar GC, Gujarathi PP. 2018. Infrequent use of medicinal plants from India in snakebite treatment. Integrated Medical Research. 7: 926.
Veer SJ, Pawar VS, Kambale RE. 2021. Antinutritional factors in foods. The Pharma Innovation Journal. 10(7): 01 – 04. www.thepharmajournal.com.
WFP. 2025. Food Security in WAEMU: Current Challenges and a Way Forward.
WHO World Health Organization 2024. Fact Sheets: Malnutrition. https://www.who.int/newsroom/fact-sheets/detail/malnutrition.
Yegrem L. 2021. Nutritional composition, anti-nutritional factors, and utilization trends of Ethiopian chickpea (*Cicer arietinum* L.), International Journal of Food Science. 5570753. https://doi.org/10.1155/2021/5570753.
Yiannikourides A, Latunde-Dada GO. 2019. A Short review of iron metabolism and pathophysiology of iron disorders. Medicines. 6(3): 85-100. http://doi.org/10.3390/medicines6030085.
Zakri ZHM, Suleiman M, Shean Y, Ngaini N, Maili Z, Salim F. 2021. *Eleusine Indica* for food and medicine. Journal of Agrobiotechnology. 12: 68–87.