J. Chem. Soc. Nigeria, Vol. 50, No. 2, pp 279 – 294 [2025]

PHYTOCHEMICAL, PROXIMATE, VITAMIN AND MINERAL COMPOSITION OF CRUDE EXTRACT OF *ZANTHOXYLUM ZANTHOXYLOIDES* STEM BARK.

N. N. EZEANI

Department of Biochemistry, Ebonyi State University, Abakaliki, Nigeria.
Corresponding Author: nk.ezeani@yahoo.com

ABSTRACT

Zanthoxylum zanthoxyloides, a member of the Rutaceae family, is renowned for its extensive traditional medicinal applications, including the treatment of infections, pain, inflammation, gastrointestinal disorders, and parasitic diseases. Despite its widespread use, there is a need to further explore its rich phytochemical, proximate, vitamin, and mineral composition to scientifically validate its therapeutic and nutritional potential. This study analyzed the crude extract of *Zanthoxylum zanthoxyloides* stem bark using standard methods, and revealed significant concentrations of bioactive compounds such as phenols (853.49 ± 2.86 mg/100 g), flavonoids (748.95 ± 0.32 mg/100 g), tannins (729.36 ± 1.89 mg/100 g), alkaloids (517.79 ± 1.56 mg/100 g), and glycosides (332.37 ± 1.64 mg/100 g), which are known for their potent antioxidant, anti-inflammatory, and antimicrobial properties. Proximate analysis demonstrated a rich nutritional profile with carbohydrates (81.81 ± 0.01 mg/100 g), protein (5.70 mg/100 g), fiber (2.22 mg/100 g), and low-fat content (1.03 mg/100 g), positioning it as a potential dietary resource. The vitamin profile included Vitamin A (0.69 mg/100 g), Vitamin C (0.34 mg/100 g), and essential B-complex vitamins, including B_1, B_2, B_3, B_6, and B_{12}, which are crucial for energy metabolism, immune support, and overall well-being. Mineral analysis highlighted sodium (190.46 mg/100 g), potassium (142.13 ± 1.01 mg/100 g), magnesium (183.06 ± 0.01 mg/100 g), calcium (181.49 mg/100 g), and trace elements like iron and zinc, reinforcing its potential in combating micronutrient deficiencies. These findings provide comprehensive scientific validation for the traditional applications of *Zanthoxylum zanthoxyloides*, highlighting its utility in nutraceutical and pharmaceutical industries. Further investigations are recommended to explore its pharmacological properties, safety profile, and therapeutic efficacy in clinical applications.

Keywords: *Zanthoxylum zanthoxyloides*, phytochemicals, proximate analysis, vitamins, minerals, traditional medicine, nutritional value, medicinal properties.

INTRODUCTION

Plants are a treasure trove of essential nutrients, including fiber, vitamins, and minerals, which play a vital role in maintaining overall health. Additionally, they are rich in antioxidants that help shield cells from damage and lower the risk of chronic diseases like heart disease, diabetes, and certain cancers [1,2,3]. The importance of plant-based nutrition has gained significant attention in recent years, with many individuals adopting plant-based diets to reap their numerous health benefits [4]. A well-rounded diet rich in fruits, vegetables, whole grains, and legumes can

ISSN 0795 - 22066

significantly reduce the risk of chronic diseases, promote healthy weight management, and support overall health and well-being [5].

The utilization of plants for medicinal, nutritional, and spiritual purposes has a rich history that spans ancient civilizations. Our forebears heavily relied on plants for survival, and their extensive knowledge of plant properties and uses was carefully passed down through generations [6]. In ancient times, plants were employed to treat a vast array of ailments, including wounds, infections, digestive issues, and mental health concerns (7]. Beyond their medicinal properties, plants have also served as a vital source of nutrition throughout human history. Fruits, vegetables, grains, and legumes have provided essential nutrients, including vitamins, minerals, and macronutrients, necessary for human sustenance [8].

Traditional Plants are an abundant source of proximate nutrients, which are crucial for maintaining optimal human health and well-being. These essential nutrients, found in plants, encompass carbohydrates, proteins, fats, fiber, vitamins, and minerals (9]. Carbohydrates serve as the primary energy source in plants, occurring in various forms such as starches, sugars, and fibers. Certain plant varieties, including potatoes, sweet potatoes, and corn, are particularly rich in carbohydrates [10]. Although present in smaller quantities compared to carbohydrates, proteins are also found in plants. Legumes, such as beans, lentils, and peas, are notable for their high protein content. While present in limited amounts, fats in plants still provide a vital source of energy (11]. Certain plant varieties, including nuts, seeds, and avocados, are dense in fatty acids. Another vital nutrient found in plants is fiber, which plays a pivotal role in maintaining a healthy gut. Plant-based foods such as whole grains, fruits, and vegetables are particularly rich in fiber [12]. Vitamins and minerals are also abundant in plants, and they are essential for maintaining optimal health. Leafy greens, citrus fruits, and whole grains are exemplary sources of vitamins and minerals [12]. For instance, spinach is an excellent source of iron, while oranges are replete with vitamin C. In addition to these essential nutrients, plants also harbor a diverse array of phytochemicals, which are bioactive compounds that have been shown to confer health benefits. For example, plants like tomatoes and bell peppers contain lycopene, a potent antioxidant that has been extensively studied (13].

The medicinal power of plants lies in phytochemical constituents that cause definite pharmacological action on human body [14]. Phytochemical is a natural compound that occur in plants such as medicinal plants, vegetables and

ISSN 0795 - 22066

fruits, that work with nutrients and fibers to act against diseases or more specifically to protect against diseases (15]. Some of the most significant bioactive phytochemicals are alkaloids, flavonoids, tannins, saponins, glycosides, phenolic compounds and many more. These natural compounds form the foundation of modern prescription drugs as we know today [16].

Zanthoxylum zanthoxyloides is a spiny, deciduous shrub (meaning it has separate male and female plants) of the *Rutaceae* family, found in Africa (precisely west Africa) [17]. The leaves are pinnate or trifoliate, alternately arranged, and often bear spines on the leaf margins and petioles, though some varieties may be spineless [18]. Its small, aromatic flowers are typically arranged in panicles, with male flowers containing four stamens and female flowers possessing up to five carpels [18]. The fruits are follicles that split open when ripe to release shiny black seeds. This species thrives in diverse habitats such as savannahs, thickets, coastal dunes, and dry forests, often growing on termite mounds or in degraded soils [19]. It can grow up to 12–16 meters tall and features a spiny trunk that sheds its woody thorns as the tree matures [17].

Zanthoxylum zanthoxyloides is well-known for its extensive medicinal and nutritional properties [18]. Various parts of the plant, including its roots, bark, and leaves, are utilized in traditional medicine due to their rich content of bioactive compounds such as alkaloids, flavonoids, tannins, and saponins [17], which exhibit antioxidant, anti-inflammatory, antimicrobial, and antidiabetic activities [18,17]. *Zanthoxylum zanthoxyloides* has been traditionally used to address infections, pain, inflammation, gastrointestinal disorders, parasitic diseases, and several other health conditions [19,18], [17].

Understanding the phytochemical, proximate, vitamin, and mineral composition of *Zanthoxylum zanthoxyloides* will help uncover the specific bioactive components responsible for its therapeutic and nutritional effects, offering insights into its diverse applications. The plant's versatile uses, coupled with its potential to provide essential nutrients and bioactive compounds, make it an important candidate for scientific exploration. However, despite its broad traditional use, there is a need for detailed studies to comprehensively assess its composition and validate its applications. This study aims to bridge this gap by scientifically substantiating the traditional uses of *Zanthoxylum zanthoxyloides* and exploring its potential in modern medicine and nutrition, building a strong foundation for its integration into contemporary healthcare solutions.

ISSN 0795 - 22066

MATERIALS AND METHOD

Plant collection and extraction

The plant material used in this study was *Zanthoxylum zanthoxyloides* stem bark, sourced from Ishieke-Idembia Village in Ebonyi Local Government Area of Ebonyi State in South-Eastern Nigeria. The plant was classified and authenticated by Professor Mrs. Kate Nnamani, a plant taxonomist in the Department of Applied Biology of Ebonyi State University, Abakaliki, Nigeria. Contaminants in the plant samples were washed off under flowing tap and air dried under a shade. The laboratory milling machine was used to grind the plant stem bark and were sifted using 0.25 mm sieve. Crude extract was obtained by maceration of 200 g of powder in 1.5 l of ethanol for 72hours. Filtration (Whatman filter paper) of the mixture followed the concentration of the filtrate (rotary evaporator, 65°C) afforded 18.81 g (28.08% yields) of crude extract.

Phytochemical Determination

Phytochemical determinations were conducted using standardized methods of the Association of Official Analytical Chemists [20) for the nine compounds. Tannins were analyzed using the Folin-Denis colorimetric method, where extracts were treated with ferric chloride and potassium ferricyanide, with absorbance measured at 720 nm. Flavonoids were quantified following extraction with ethyl acetate and reaction with ammonia, with absorbance at 490 nm. Alkaloids were determined by maceration with ethanol-sulphuric acid and subsequent absorbance reading at 490 nm. Phenols are commonly determined using the Folin-Ciocalteu method, where the extract is reacted with Folin-Ciocalteu reagent and sodium carbonate, then incubated to allow color development. Absorbance is measured at 765 nm, and phenol concentration is calculated using a standard curve, typically with gallic acid. Saponins involved petroleum ether extraction, ethanol dissolution, and chromogen reaction, measured at 550 nm. Hydrogen cyanide (HCN) content was assessed using alkaline picrate, boiled, cooled, and measured at 490 nm. Terpenoids were identified using ethanol extraction, phosphomolybdic acid, and sulfuric acid, with absorbance at 700 nm. Steroids were determined by ethanol extraction and reaction with a color reagent, with absorbance at 550 nm. Lastly, glycosides were extracted with water, treated with lead acetate and chloroform, evaporated, and reacted with ferric chloride and sulfuric acid, measured at 530 nm. For all determinations, the phytochemical concentration was calculated using absorbance differences

ISSN 0795 - 22066

(sample and blank), solvent volume, slope of the calibration curve, and sample weight.

Proximate Determination

Proximate composition by methods described by [21]. Crude protein determination was done by the microkjedhal method and nitrogen content was multiplied by 6.25. Ash content was done by the muffle furnace ignition method at 550°C, fat was determined by gravimetric solvent extraction method, crude fiber was determined by the Weende method, moisture determination was done by drying in an oven at 65°C to a constant weight while carbohydrate was calculated by the difference of the sum of all the proximate composition from 100%.

Mineral and Vitamin Determination

Mineral was done by dry ash extraction described by [21] using 2M hydrochloric acid. Calcium and magnesium were determined by EDTAcomplexiometric titration sodium and potassium were analyzed using a flame photometer (FP-640 model, Korea), phosphorus was determined spectrophotometrically by the vanadium phosphomolybdate method. Zinc and copper were analyzed colorimetrically while iron was analyzed by the Ophenanthroline red ferrous complex method both described by [22]. Vitamins B_1, B_2 and B_3 were determined spectrophotometrically by methods described by [23] while vitamins B_6, B_{12}, A and C were determined using the official methods of the Association of Official Analytical Chemists [20]

Statistical Analysis

All the results were expressed as Mean ± Standard deviation [SD]. Data were analyzed using SPSS. Value of $P<0.05$ were considered to be statistically significant.

RESULTS AND DISCUSSION

1. Phytochemical composition of crude extract of *Zanthoxylum zanthoxyloides* stem bark

The Phytochemical constituent of *Zanthoxylum zanthoxyloides* stem bark in a crude extract showed that the extract had alkaloids 517.79 ± 1.56 mg /100g of extract, phenol 853.49 ± 2.86 mg /100g of extract, Tannin 729.36 ± 1.89 mg /100g of extract, Flavonoid 748.95 ± 0.32 mg /100g of extract, HCN 0.46 ± 0.03 mg /100g of extract, saponins 0.65 ± 0.01 mg /100g of extract, glycosides 332.37 ± 1.64 mg /100g of extract, Terpenoids 320.22 ± 1.33 mg /100g of extract and steroids 0.59 mg /100g of extract.

ISSN 0795 - 22066

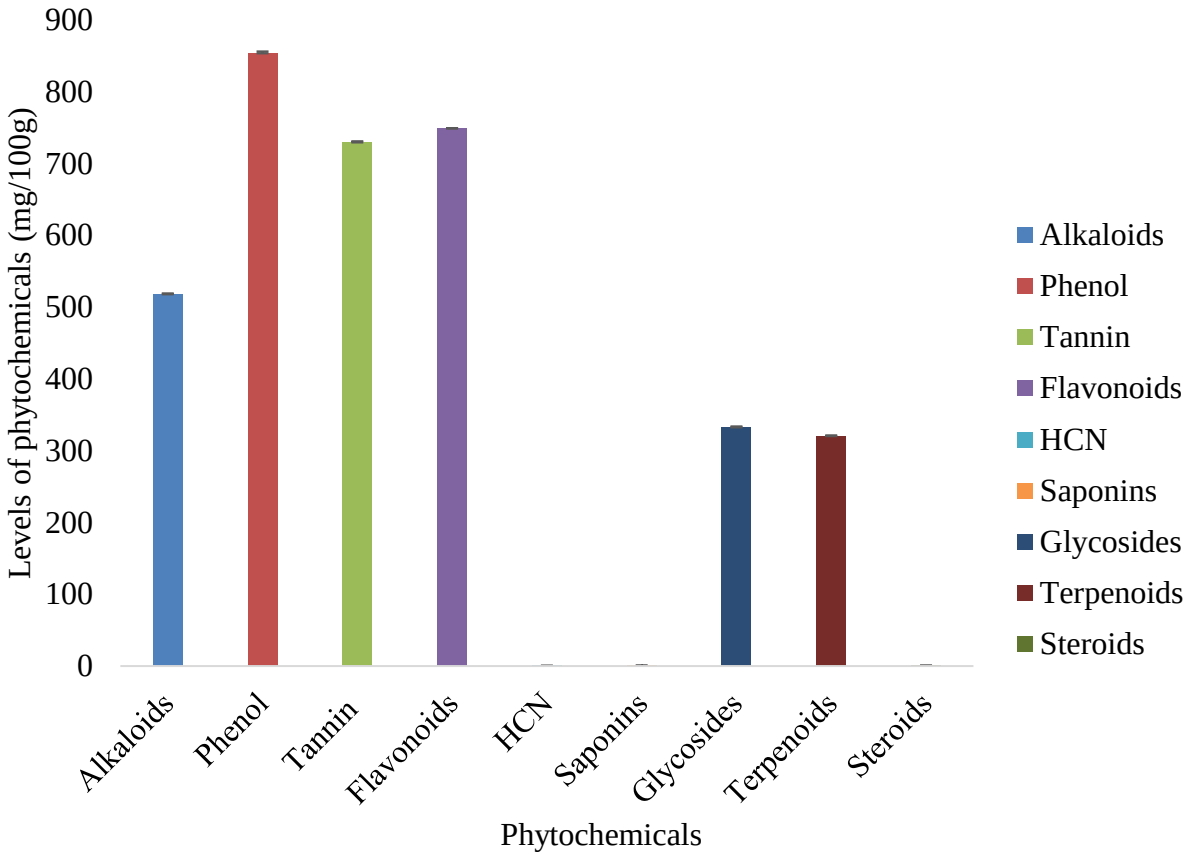

Figure 1: Phytochemical composition of crude extract of *Zanthoxylum zanthoxyloides* stem bark. (Results are present as mean ± standard deviation [n=3]).

The phytochemical analysis demonstrated the presence of significant bioactive compounds, validating its traditional applications and offering promising insights for modern utilization. The results showed that phenols were the most abundant phytochemical in the extract, followed by flavonoids, tannins, alkaloids and glycosides. This observation is consistent with the assertion made by [24]. These findings are consistent with prior studies on medicinal plants [3, 2], which often demonstrate high phenolic content due to their antioxidant properties. Phenols are known to scavenge free radicals, reduce oxidative stress, and prevent lipid peroxidation, thereby protecting

ISSN 0795 - 22066

cells from damage. This suggests that *Zanthoxylum zanthoxyloides* could be a valuable natural source of antioxidants for managing conditions linked to oxidative stress, such as cardiovascular diseases, neurodegenerative disorders, and cancer. This is in line with the research work of [25, 26, 27]. Glycosides (332.37 ± 1.64 mg/100 g) and terpenoids (320.22 ± 1.33 mg/100 g) are known for their cardioprotective and immune-boosting roles [28]. Although saponins (0.65 ± 0.01 mg/100 g) and steroids (0.59 mg/100 g) were found in relatively low concentrations, their presence adds to the plant's potential anti-inflammatory and cholesterol-lowering effects [18]. Notably, the minimal hydrogen cyanide content (0.46 ± 0.03 mg/100 g) highlights the safety of the plant for consumption within studied limits. This aligns with findings by [29] that demonstrate the safety and therapeutic efficacy of *Zanthoxylum* species. The study is also in tandem with that of [30, 19, 31, 32, 29, 17, 18].

2. Proximate composition of crude extract of *Zanthoxylum zanthoxyloides* stem bark

The proximate constituent of *Zanthoxylum zanthoxyloides* stem bark in a crude extract showed that the extract had Moisture 6.33 mg /100g of extract, Fibre 2.22 mg /100g of extract, Fats 1.03 mg /100g of extract, Ash 2.91 ± 0.01 mg /100g of extract, Protein 5.70 mg /100g of extract, and Carbohydrate 81.81 ± 0.01 mg /100g of extract.

ISSN 0795 - 22066

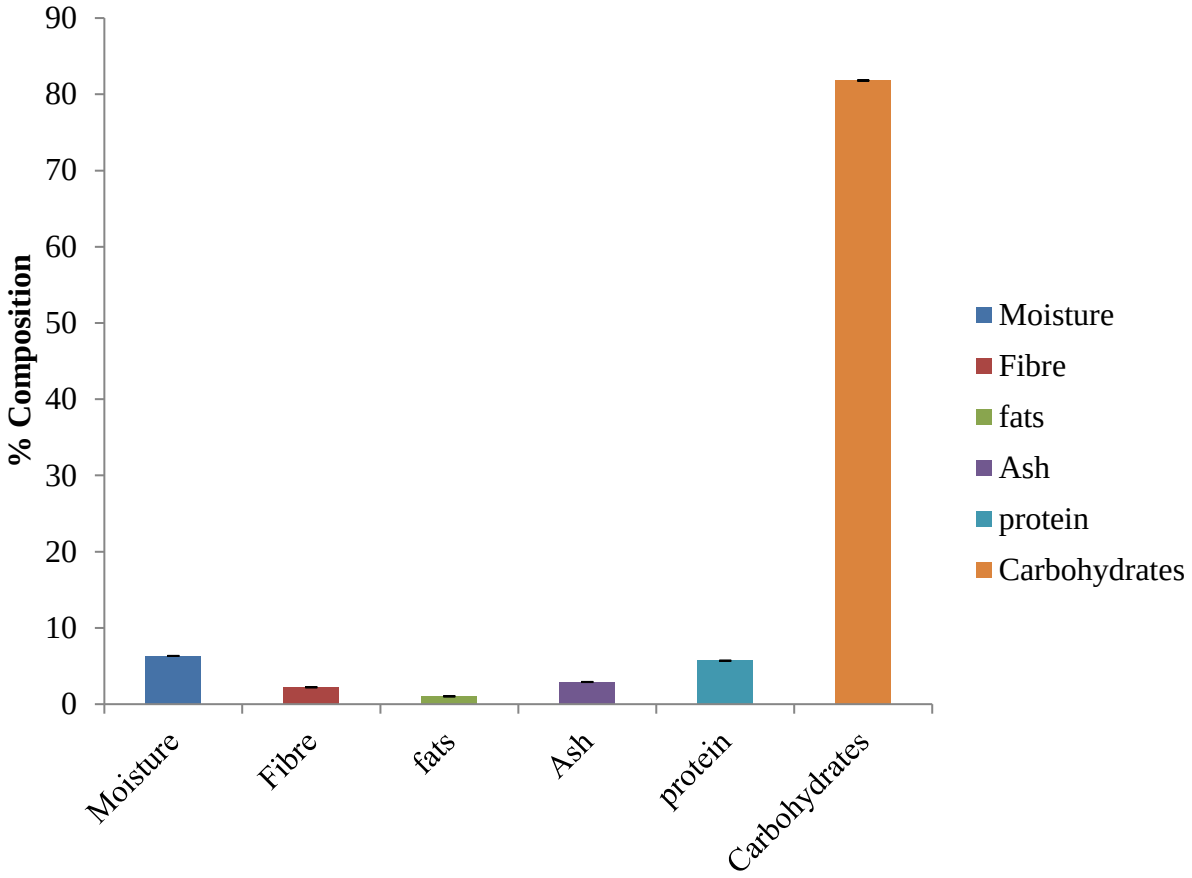

Figure 2: Proximate composition of crude extract of *Zanthoxylum zanthoxyloides* stem bark. (Results are present as mean ± standard deviation [n=3]).

The proximate composition emphasizes the nutritional value of the crude extract. The high carbohydrate content (81.81 ± 0.01 mg/100 g) positions it as a potential energy source, particularly in regions facing food insecurity. The moderate protein level (5.70 mg/100 g) suggests its suitability as a supplementary protein source, while the low-fat content (1.03 mg/100 g) makes it an ideal choice for low-fat diets. Dietary fiber (2.22 mg/100 g) supports digestive health, and the ash content (2.91 ± 0.01 mg/100 g) reflects its mineral richness. These findings align with previous studies, such as that of [30, 19, 31, 32,

ISSN 0795 - 22066

29, 17, 18] which confirmed the dietary significance of *Zanthoxylum* species.

3. Vitamins composition of the crude extract of *Zanthoxylum zanthoxyloides* stem bark

The Vitamins constituent of *Zanthoxylum zanthoxyloides* stem bark in a crude extract showed that the extract had Vitamin A 0.69 mg /100g of extract, Vitamin C 0.34 mg /100g of extract, Vitamin B_1 0.47 mg /100g of extract, Vitamin B_2 0.32 mg /100g of extract, Vitamin B_3 0.01 mg /100g of extract, Vitamin B_6 0.42 mg /100g of extract, and Vitamin B_{12} 0.24 mg /100g of extract.

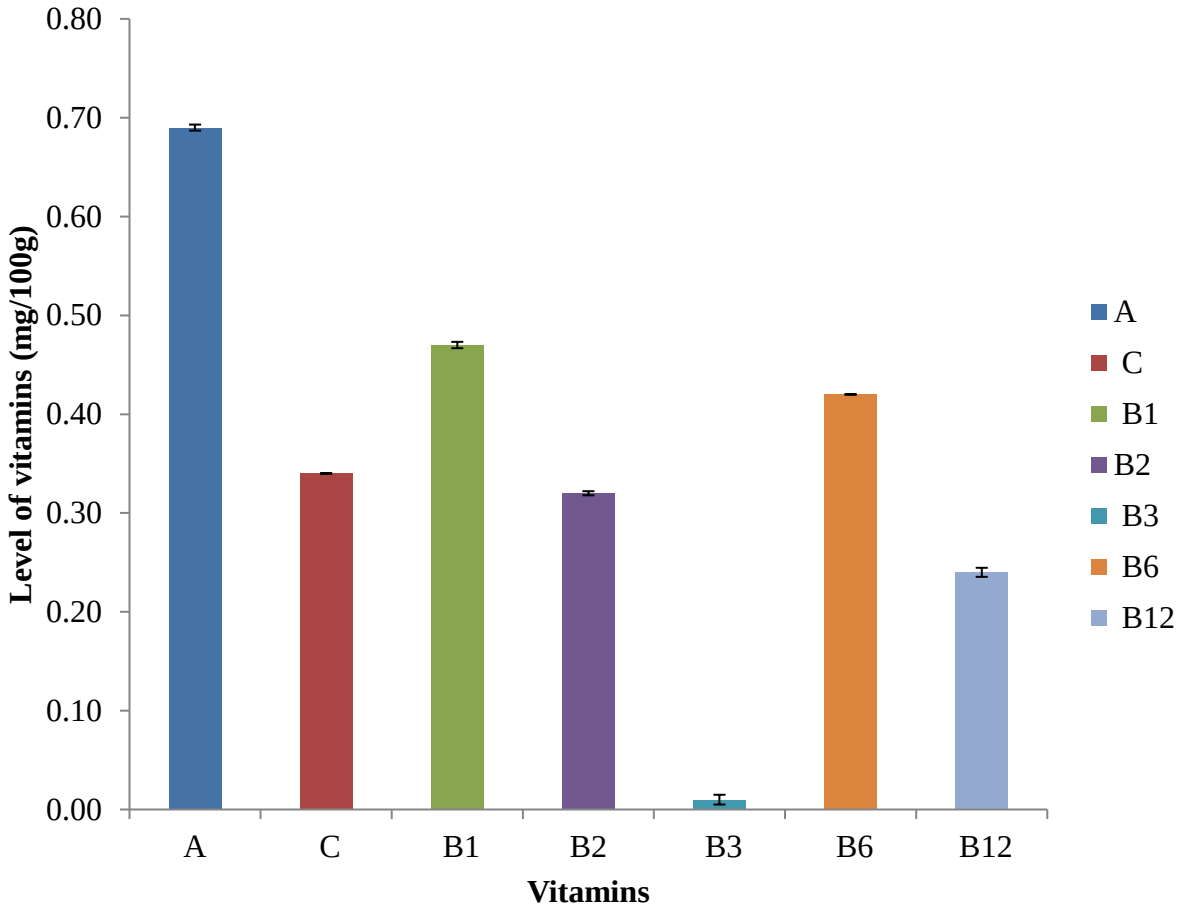

Figure 3: Vitamins composition of the crude extract of *Zanthoxylum zanthoxyloides* stem bark. (Results are present as mean ± standard deviation [n=3]).

ISSN 0795 - 22066

The vitamin composition underscores its role in supporting overall health. Vitamin A (0.69 mg/100 g) aids in maintaining healthy vision and immunity, while vitamin C (0.34 mg/100 g) supports collagen synthesis and antioxidant defense. The B-complex vitamins—B_1 (0.47 mg/100 g), B_2 (0.32 mg/100 g), B_3 (0.01 mg/100 g), B_6 (0.42 mg/100 g), and B_{12} (0.24 mg/100 g)—highlight the plant's role in energy metabolism, red blood cell formation, and nervous system health. These moderate vitamin levels collectively contribute to maintaining overall health, similar to the report of [30, 19, 31, 32, 29, 17, 18].

4. Mineral composition of crude extract of *Zanthoxylum zanthoxyloides* stem bark

The Mineral constituent of *Zanthoxylum zanthoxyloides* stem bark in a crude extract showed that the extract had sodium 190.46 mg /100g of extract, potassium 142.13 ± 1.01 mg /100g of extract, Calcium 181.49 mg /100g of extract, Magnesium 183.06 ± 0.01 mg /100g of extract, Phosphorus 0.77 mg /100g of extract, Zinc 2.48 ± 0.04 mg /100g of extract, Iron 3.12 mg /100g of extract, and Copper 0.52 mg /100g of extract.

ISSN 0795 - 22066

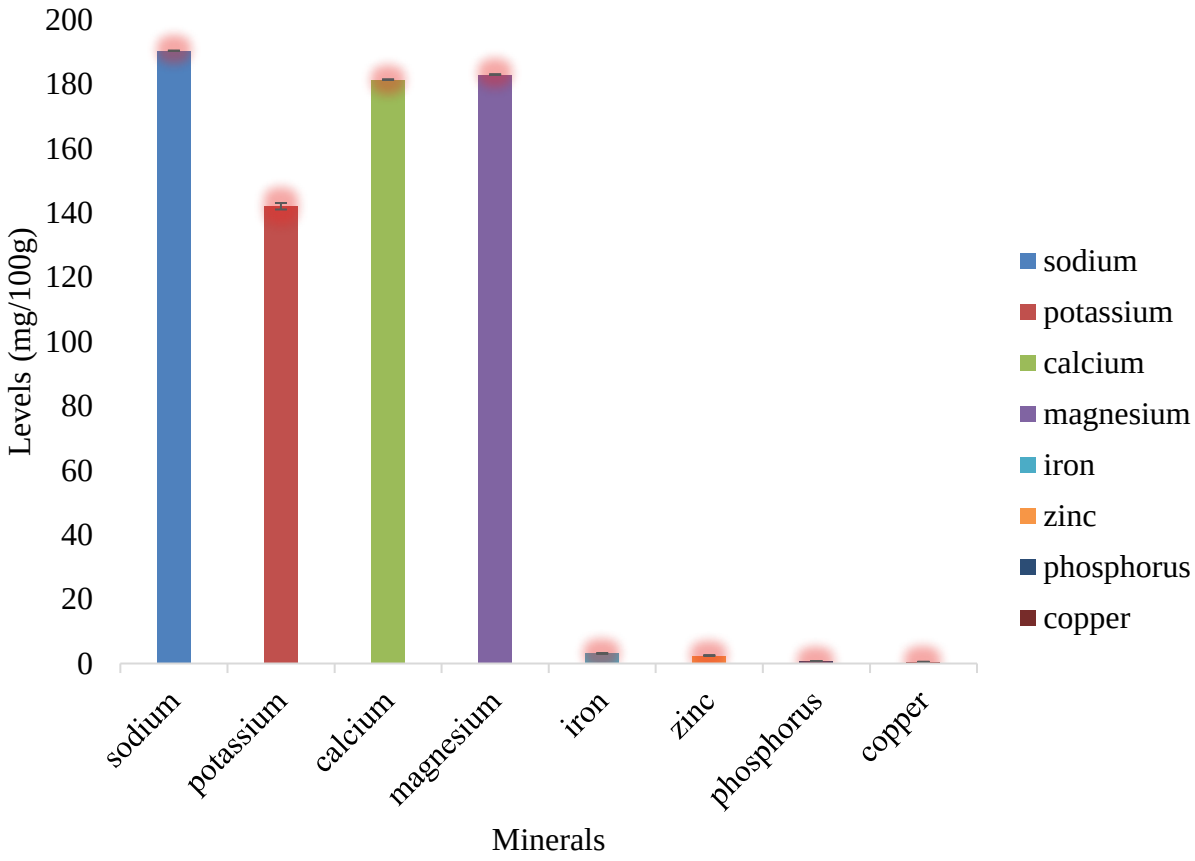

Figure 4: Mineral composition of crude extract of *Zanthoxylum zanthoxyloides* stem bark. (Results are present as mean ± standard deviation [n=3]).

Mineral constituents in plants, particularly in crude extracts, are crucial in evaluating the nutritional and therapeutic value of medicinal plants. Minerals play essential roles in numerous physiological processes, including enzymatic activities, immune response, oxygen transport, and maintaining the structural integrity of bones and tissues. The mineral content of *Zanthoxylum zanthoxyloides* stem bark extract, which includes Sodium (190.46 mg/100 g) and potassium (142.13 ± 1.01 mg/100 g) are vital for electrolyte balance and nerve function. Calcium (181.49 mg/100 g) and magnesium

ISSN 0795 - 22066

(183.06 ± 0.01 mg/100 g) support bone health and enzymatic activities. Iron (3.12 mg/100 g) aids in oxygen transport and preventing anemia, while zinc (2.48 ± 0.04 mg/100 g) and copper (0.52 mg/100 g) enhance immune function and enzymatic reactions. Phosphorus (0.77 mg/100 g) further supports cellular processes. This highlights the plant's potential as a nutritionally and medicinal valuable source of essential minerals. This concides with the study of [30, 19, 31, 32, 29, 17, 18] on the nutritional and medicinal properties of *Zanthoxylum zanthoxyloides* and the mineral richness of *Zanthoxylum* species. The plant's mineral content could contribute to the development of functional foods or dietary supplements aimed at addressing specific deficiencies, such as iron or zinc deficiency, and supporting the immune system, skin health, and metabolic functions.

The study on the crude extract of *Zanthoxylum zanthoxyloides* stem bark revealed a detailed phytochemical, proximate, vitamin, and mineral profile, emphasizing its medicinal and nutritional potential. The study demonstrates that *Zanthoxylum zanthoxyloides* stem bark is a valuable source of bioactive compounds, essential nutrients, and therapeutic agents. The significant presence of phytochemicals like phenols and flavonoids validates its traditional use in addressing oxidative stress and inflammation. Its nutritional components, including carbohydrates, proteins, vitamins, and minerals, suggest its potential as a dietary supplement to combat malnutrition and promote overall health. The relatively low levels of anti-nutritional factors, such as hydrogen cyanide, affirm its safety for human consumption. These findings provide a scientific foundation for the traditional applications of *Zanthoxylum zanthoxyloides*, paving the way for its incorporation into functional foods, nutraceuticals, and pharmaceutical formulations. Further research on its bioavailability, toxicity, and pharmacological properties is recommended to maximize its potential in modern healthcare solutions.

CONCLUSION

Zanthoxylum zanthoxyloides stem bark is a rich source of bioactive compounds, essential nutrients, vitamins, and minerals, underscoring its potential as both a medicinal and nutritional resource. The phytochemical

ISSN 0795 - 22066

analysis highlighted significant levels of phenols, flavonoids, tannins, alkaloids, and other compounds known for their antioxidant, anti-inflammatory, antimicrobial, and antidiabetic properties. The proximate analysis demonstrated its nutritional value, particularly its high carbohydrate content, making it a potential energy source. The vitamin and mineral compositions further emphasized its role in supporting immunity, metabolism, and overall health. These findings validate the traditional use of *Zanthoxylum zanthoxyloides* in addressing various health conditions and provide a scientific basis for its potential applications in modern medicine and nutrition.

REFERENCES

(1) Muscolo, A., Mariateresa, O., Giulio, T., and Mariateresa, R. (2024). Oxidative stress: the role of antioxidant phytochemicals in the prevention and treatment of diseases. *International Journal of Molecular Sciences*, **25**(6): 3264.

(2) Ezeani, N. N., Ibiam, U. A., Orji, O. U., Igwenyi, I. O., Aloke, C., Alum, E., Aja, P. M., and Ugwu, O. P. C. (2019). Effects of aqueous and ethanol root extracts of Olax subscorpioidea on inflammatory parameters in complete Freund's adjuvant-collagen type II induced arthritic albino rats. *Pharmacognosy Journal*, **11**(1): 1–10.

(3) Ezeani, N. N. (2024). Effects of Rauwolfa vomitoria (Akata) and Olax subscorpioidea (Asaja) roots on hematology of chicken type II collagen-Freund's adjuvant-induced rheumatoid arthritis in albino rats. *NEWPORT International Journal of Research in Medical Sciences (NIJRMS)*, **5**(2): 57–71.

(4) Sharma, N., Yeasmen, N., Dube, L., Orsat, V. (2024). Rise of Plant-Based Beverages: A Consumer-Driven Perspective. *Food Reviews International*, 1-27.

(5) Aderinola, T., Ajayeoba, T., Akanni, G., Uzomah, A., Onyeaka, H., and Adeboye, A. (2024). Legume-based functional foods in West Africa for managing non-communicable diseases: a comprehensive review of dietary strategies. *Nutrire*, **49**(2): 1-17.

(6) Elendu, C. (2024). The evolution of ancient healing practices: From shamanism to Hippocratic medicine: A review. *Medicine*, **103**(28): e39005.

(7) Abubakar, I. B., Kankara, S. S., Malami, I., Danjuma, J. B., Muhammad, Y. Z., Yahaya, H., Singh, D., Usman, U. J., Ukwuani-Kwaja, A. N., Muhammad, A., Ahmed, S. J., Folami, S. O., Falana, M. B., and Nurudeen, Q. O. (2022). Traditional medicinal plants used for treating emerging and re-emerging viral diseases in northern Nigeria.

ISSN 0795 - 22066

European Journal of Integrative Medicine, **49**: 102094.

(8) Dobe, M. (2024). Nutrition, Diet, and Health: role of macronutrients, micronutrients, and Nutraceuticals. *Micronutrients and Macronutrients as Nutraceuticals*, 321-357.

(9) Shahid, M., Singh, R. K., Molecules, S. T. (2023). Proximate composition and nutritional values of selected wild plants of the United Arab Emirates. *Molecules*, **28**(3): 1504.

(10) Wibawa, C., Huang, Y., Patterson, D. H., Feng, Z., and Serventi, L. (2023). Carbohydrates for Energy. *Sustainable Food Innovation*, 13-28.

(11) Ahmed, H. G. M., Naeem, M., Faisal, A., Fatima, N., Tariq, S., and Owais, M. (2023). Enriching the Content of Proteins and Essential Amino Acids in Legumes. *Legumes Biofortification*, 417-447.

(12) Alemu, T. T. (2024). Nutritional Contribution of Fruit and Vegetable for Human Health: A Review. *International Journal for Health Policy Planning*, **3**(1): 1-9.

(13) Roy, S., Sarkar, T., Upadhye, V. J., Chakraborty, R. (2024). Comprehensive review on fruit seeds: nutritional, phytochemical, nanotechnology, toxicity, food biochemistry, and biotechnology perspective. *Applied Biochemistry and Biotechnology*, **196**(7): 4472-4643.

(14) Agidew, M. G. (2022). Phytochemical analysis of some selected traditional medicinal plants in Ethiopia. *Bulletin of the National Research Centre*, **46**(1): 87.

(15) Vanja, S., Olja, S., Vesna, T. S., Jelena, V., Gordana, C., Sinisa, M. and Jasna, C. (2022). Horned Melon (*Cucumis metuliferus E*. Meyer Ex. Naudin)—Current Knowledge on Its Phytochemicals, Biological Benefits, and Potential Applications. *Processes*, **10**(1): 94.

(16) Nwozo, O. S., Effiong, E. M., Aja, P. M. and Awuchi, C. G. (2023). Antioxidant, phytochemical, and therapeutic properties of medicinal plants: A review. *International Journal of Food Properties*, **26**(1): 359-388.

(17) Fatai, M. A. (2023). Characterisation, antioxidant properties and cytoprotective investigation of *Zanthoxylum zanthoxyloides* root-bark in oxidative stressed promyelocytic leukaemia cells. *University of Chester*.

(18) Ba, A., Roumy, V., Al Ibrahim, M., Hughes, K., Hennebelle, T., Samaillie, J., Sahpaz, S., Beniddir, M. A., Hérent, M. F., Séron, K., Quetin-Leclercq, J. (2024). Antileishmanial, antitrypanosomal and anti-coronavirus activities of benzophenanthridine alkaloids and other specialized metabolites isolated from the root bark of *Zanthoxylum*

ISSN 0795 - 22066

zanthoxyloides. *Fitoterapia*, **179**: 106232.

(19) Ozigis, H. O., Olaifa, K. A., Agbeja, A. O., Asabia, L. O., Akindolu, D. R., Majolagbe, M. O. (2023). Qualitative phytochemical analysis of leave and stem bark of *Zanthoxylum zanthoxyloides* and *Zanthoxylum gilletti*. *Journal of Chemical Society of Nigeria*, **48**(3).

(20) AOAC (1990). Official methods of food analysis (15th edition). Williams, S. (Ed.). Association of Official Analytical Chemists, Washington D.C., pp. 152-164.

(21) James, C. S. (1995). The analytical chemistry of foods. *Chapman and Hall*, New York.

(22) Jackson, M. L. (1969). Soil chemical analysis advanced course: Selected methods for soil and plant analysis. IITA, Ibadan Manual Series No. 1. *Department of Soil Science, University of Wisconsin, Madison-Wisconsin*.

(23) Okwu, D. E. and Josiah, C. (2006). Evaluation of chemical composition of two Nigerian medicinal plants. *African Journal of Biotechnology*, **5**(4): 357-361.

(24) Okagu, I. U., Ndefo, J. C., Aham, E. C. and Udenigwe, C. C. (2021). Zanthoxylum species: A comprehensive review of traditional uses, phytochemistry, pharmacological and nutraceutical applications. *Molecules*, **26**(13): 4023.

(25) Otieno, K. Y. (2024). Inhibition of α-amylase and α-glucosidase by alkaloids and phenolics from stem bark of *Zanthoxylum chalybeum* and *Zanthoxylum gilletii*. *Maseno University*.

(26) Olusola, A. O., Elekan, A. O., Ogidan, T. O., Ekun, O. E., Onoagbe, I. O. (2023). Antioxidant and Antimicrobial Potentials of Alkaloid-Rich Fraction of *Zanthoxylum Zanthoxyloides*' Leaf. *Biomedical Journal of Scientific and Technical Research*, **52**(5): 44182-44200.

(27) Okagu, I. U., Okeke, E. S., Ezeorba, W. C. F., Ndefo, J. C. and Ezeorba, T. P. C. (2023). Overhauling the ecotoxicological impact of synthetic pesticides using plants' natural products: A focus on Zanthoxylum metabolites. *Environmental Science and Pollution Research*, **30**(26): 67997-68021.

(28) Gaur, R., Chauhan, A. and Kanta, C. (2024). A critical review of antioxidant potential and pharmacological applications of important Ficus species. *Journal of Herbmed Pharmacology*, **13**(4): 537-549.

(29) Correa-Barbosa, J., Sodré, D. F., Nascimento, P. H. C., Dolabela, M. F. (2023). Activity of the genus *Zanthoxylum* against diseases caused by protozoa: A systematic review.

ISSN 0795 - 22066

Frontiers in Pharmacology, **13:** 873208.

(30) Mutinda, E. S., Kimutai, F., Mkala, E. M., Waswa, E. N., Odago, W. O., Nanjala, C., Njambi Ndungu, C., Gichua, M. K., Njire, M. M., Gituru, R. W. (2023). Ethnobotanical uses, phytochemistry and pharmacology of pantropical genus *Zanthoxylum L.*(Rutaceae): An update. *Journal of Ethnopharmacology*, **303**: 115895.

(31) Mawthoh, A. B., Seram, D., Singh, K. A., Watt, H. J. (2023). Applications of Prickly Ash (*Zanthoxylum spp.*): Potential in Traditional Science. Modern Science, and Agriculture. *Journal of Food Chemistry and Nanotechnology*, **9**(S1): S117-S131.

(32) Boye, A., Barku, V. A., Addo, J. K., Martey, O., Asiamah, E. A., Essuman, M. A., Doe, D. (2024). *Zanthoxylum zanthoxyloides (Lam.)* B. Zepernick & Timler alkaloidal extract exerts hepatoprotective effects in rats with a CCl4/olive oil-induced hepatocellular carcinoma-like. *Journal of Taibah University Medical Sciences*, **19**(4): 753-765.

ISSN 0795 - 22066