Lesser-known leafy vegetables of Southeastern Nigeria (*Vitex doniana* and *Zanthoxylum zanthoxyloides*)

Thecla O. AYOKA1*, Charles O. NNADI2

1University of Nigeria, Nsukka, Faculty of Physical Sciences, Department of Science Laboratory Technology (Biochemistry Unit), 410001, Enugu State, Nigeria; thecla.ayoka@unn.edu.ng (corresponding author)

2University of Nigeria, Nsukka, Faculty of Pharmaceutical Sciences, Department of Pharmaceutical and Medicinal Chemistry, 410001, Enugu State, Nigeria; charles.nnadi@unn.edu.ng

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**Abstract**

*Vitex doniana* and *Zanthoxylum zanthoxyloides* are plants grown in the Southeastern part of Nigeria. They have been used traditionally as food and in medicine, also in teeth cleaning and as a mouth wash to reduce pain. The availability of these plants has sparked a surge in interest in knowledge about their supplements and contents, including nutrients, mineral components, and bioactive chemicals, which are critical for drug discovery and development. Compounds derived from them have been used as effective pharmaceuticals throughout human history. This review is aimed at providing a comprehensive report on the chemical constituents, traditional uses, biological and pharmacological activities of *Vitex doniana* and *Zanthoxylum zanthoxyloides*. Information was sourced from literatures using search engines such as Google, Google Scholar, Microsoft Academic, ResearchGate, and Semantic Scholar. The plants were found to contain natural products such as alkaloids, phenolics, tannins, saponins, glycosides, steroids, proteins, carbohydrates, anthraquinones, resins, lignans, lipids, allicins, balsams, hydroxycinnamic acid, oleoanolic acid, esters, norisoprenoids, anethracene, essential oils and terpenes, which seem to correlate with their antioxidant potentials. They have gained interest recently due to the presence in them of varieties of their bioactive compounds. Biological and pharmacological studies revealed that they possess antioxidant, anti-cancer, antimalarial, anti-inflammatory, antimicrobial activities and hepatoprotective properties. In addition, the alkaloidal content of *V. doniana* and *Z. zanthoxyloides* can enhance serum biochemical parameters, repair cellular damage and fibrosis in the liver, and control hepatocyte activity.

**Keywords:** antioxidant; hepatoprotective; vegetables; *Vitex doniana; Zanthoxylum zanthoxyloides*

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**Introduction**

Southeastern Nigeria is an area that has cultural diversity and traditions. The basic food habits and medical practices of the area are observed. There are a number of traditional medical methods such as folk/tribal medicine practiced in Southeastern Nigeria, and medicinal sources are taken from medicinal plants in these practices (Elekwe et al., 2017; Chinwe, 2018). Nevertheless, the majority of edible foods and their components, such as fruits, seeds, roots and leaves are also found to have substances of medicinal value, such as flavonoids,
tannins and other phenolic compounds (Orabueze et al., 2017; Iheanacho et al., 2019). About 2000 plants are estimated to be used in local health traditions in Southeast’s mostly rural and tribal villages (Nnamani et al., 2009). Of these, the actual therapeutic value of a small fraction is either little known or unknown to the plant’s population mainstream (Ikeyi et al., 2014; Enechi, 2019).

The use of all parts of medicinal plants in the treatment of diseases has been described, and this serves as the basis for the search for and development of novel drugs (Tougoma et al., 2021a). Over the years, man has used many leafy vegetables to fight and control disease and pain. The plant materials that are mostly used for these purposes are leaves, barks and seeds (Wanzala et al., 2012). They are used in the form of concoctions, decoction, or infusions. The use of medicinal plants is found in almost all cultures, in some, many types of plants are used (Osum et al., 2013). Some are efficacious while others are not.

Southeastern Nigeria has different climatic variations, favoring region-specific vegetables and their use (Orabueze et al., 2017; Iheanacho and Ogunwa, 2021). Different studies on fruit and leaf vegetables of Vitex doniana and Zanthoxylum zanthoxyloides especially consumed in southeastern Nigeria, and their chemical and biological activities by different researchers are reviewed in this study.

This review is aimed at exploring the bioactivity, biological and chemical activities of the two leafy vegetables eaten in southeastern Nigeria and to outline the practical reasons why they are being encouraged to consume these vegetables.

Materials and Methods

Electronic search engines (Google, Google Scholar, Microsoft Academic, ResearchGate, and Semantic Scholar) were used to collect literature using the terms Vitex doniana, Zanthoxylum zanthoxyloides, Fagara zanthoxyloides, bioactivity, toxicity, phytochemistry, proximate composition, hepatocurative and hepatoprotective of the two plants. After being found to be specifically relevant to the main theme of this paper, the details provided in this analysis was chosen.

Results

Vitex doniana

A. Plant profile

Synonyms

Vitex cuneata, Vitex cienkowskii, Vitex pachyphylla.

Vitex comprises of over 270 species, which are mainly shrubs and trees (Orwa et al., 2009).

B. Taxonomic classification


C. Common names

D. Distribution

_Vitex doniana_ is distributed widely in tropical Africa (Aiyeloja, 2014) Nigeria inclusive, especially South-eastern Nigeria (Lasekan, 2017).

E. Description

A tree 15-20 m high, or to 25 m in good conditions, girth 1-20 m, of the dense forest, wooded savanna, coastal savanna and riverine thickets (Bangou _et al._, 2019). The bark is light grey. Leaves are made up of 5-7 leaflets, which are wide at the tip, they are also hairless. The fruits are shaped like earth, with a size of 2-5 cm long. They are green in colour, but black when ripe. Flowers are white and numerous (Orwa _et al._, 2009). The photograph of the plant is represented as shown in Figure 1.

![Vitex doniana](image)

**Figure 1. Vitex doniana**

F. Traditional uses

_V. doniana_ fruits are taken to suppress appetite by farmers and hunters. It is also used to promote soil fertility as a mulch, as food, as medicine and as timber to make dyes and charcoal (Orwa _et al._, 2009; Dadjo _et al._, 2012). Leaves are employed to treat oedema, diabetes, ulcer and in diuresis. The twig of _V. doniana_ is employed in cleaning teeth (Chinwe, 2018). The leaves’ decoction is given to induce labour during child birth. _V. doniana_ is used in making smoke. Its extracts are employed to manage infestation by worm in poultry. The leaves can also serve as fodder for cattle (Wanzala _et al._, 2012). The leaf extract is taken as a therapy for eye and liver problems, releases pain during child birth and enhances milk production in lactating mothers. It serves as a supplement for deficiency of vitamins A and B, and also as a remedy for kidney diseases (Burkill, 2000).
G. Phytochemical studies and chemical constituents

Various phytochemical studies have been carried out over the years on different parts of *V. doniana* (Table 1). According to Sanniet *et al.* (2019), forty three (43) different bioactive compounds were found in the methanol extract of *V. doniana* leaves. They are β- Bisabolene, linalool, erucic acid, α-Farnesene, D-Nerolidol, α-Caryophyllene, α-Copaene and Calarene. They also identified some trace elements namely Fe, Mn, Se, Cu and Zn in the leaf extract. Sonibare *et al.* (2009) investigated the chemical composition of *V. doniana* using GC-MS. In their report, they identified twelve compounds including phytol, β-phellandrene, β-caryophyllene, caryophyllene oxide, caryophyllene, bicyclogermacrene and α-pinene. Thirty-five (35) aroma constituents were identified in the free fractions of *V. doniana* sweet while Twenty-eight (28) aroma constituents were found in the bound fraction. Those detected in the free fraction are alcohols, esters, and terpenes, while those identified in the bound fraction are ketones, alcohols, terpenes and norisoprenoids (Lasekan, 2017). Ifeanacho *et al.* (2019) carried out characterization of phytoconstituents using Gas chromatography.

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<tr>
<th>Table 1. Phytochemicals present in various parts of <em>V. doniana</em></th>
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A total of nine (9) saponins, eleven (11) flavonoids, sixty-one (61) terpenoids, three (3) allicins and hydroxycinnamic acid were identified in their study. Several putative compounds were identified in the soluble butanol of *V. doniana* by peak dereplication of LC-MS chromatograms (Ayoka et al., 2020a). Seven alkaloids, four flavonoids, two lignans, four terpenoids and one lipid were identified. Among the compounds tentatively characterized are vitedoin B, quercetin, myricetin, casticin and vitexilactone. According to their report, there was a 10.33%, 0.69%, 0.45%, 0.49% and 0.39% extractive yield of methanol extract, dichloromethane, hexane, ethylacetate and butanol fractions respectively. Olajide et al. (2018) reported an 8.25% yield of methanol extract in a similar work. Three compounds 20-hydroxyecdysone, turkesterone and ajugasterone were isolated from the stem bark of *V. doniana* using nuclear magnetic resonance (NMR) spectroscopy (Bunuet et al., 2021).

H. **Proximate composition**

The proximate composition and iron content of *V. doniana* leaves were determined. There was a high mineral content due to high ash, low moisture and high iron contents in the leaves of *V. doniana* (Yangora and Bello, 2017). The moisture, protein and carbohydrate contents of *V. doniana* leaf were set to be 10.8%, 8.74% and 58.94% respectively (Nnannamiet al., 2009). The fruits were found to contain good concentrations of useful macro-mineral elements as well as sugars, phytin and tannins, with lower vitamin C levels as compared with other common plants (Agbede and Ibitoye, 2007). Their proximate compositions were determined to be ash (52.7 ± 0.1), moisture (487.7 ± 0.5), fat (30.0 ± 0.4), protein (72.8 ± 0.1), fibre (67.3 ± 0.7), and carbohydrates (289.5 ± 0.8) g/kg. The level of sugar ranged between 474 and 40000 mg/kg. Osum et al. (2013) investigated the proximate parameters of the leaves. Protein, fibre, ash, moisture, fat and carbohydrate contents were found to be 0.07 − 17.29%, 1.85 − 6.33%, 0.47 − 6.55%, 10.86 − 95.67%, 0.05 − 1.24% and 3.61 − 58.08% respectively. Micronutrients such as Ca, Fe, Na, vitamin A, vitamin E and vitamin B2 were recorded as 13.38 − 59.50 mg 100g⁻¹, 3.0− 18.00 mg 100g⁻¹, 0.37 – 1.29 mg 100g⁻¹, 1.5 – 32.98 mg 100g⁻¹, 54.6 – 3583.26 IU, 3.11 – 53.36 mg 100g⁻¹ and 0.01 – 9.63 mg 100g⁻¹ respectively. The nutritional values of black plum were determined to be ash (11.50%), moisture (16.66%), crude proteins (8.24%), crude fat (34.62%), crude fibre (0.58%), and carbohydrate (28.40%). Other parameters measured included vitamin A (0.27), vitamin B1 (18.33), vitamin B2 (4.80) and vitamin C (35.58) mg 100g⁻¹. K, Na, Ca, Fe, Cu, Mg and P levels were 16.5, 10.40, 30.27, 5.20, 2.70, 20.10 and 16.50 (mg 100g⁻¹) respectively (Vunchiet al., 2011). According to the report of Aiwonegba et al. (2018), the proximate composition of moisture, crude fibre, ash, crude protein, carbohydrates and crude lipids were as follows 10.00%, 18.00%, 4.50%, 0.60%, 43.20% and 23.70% respectively. Similarly, the result of Bello et al. (2014) showed that the moisture, crude protein, crude fibre, crude fat, ash and carbohydrate contents were 8.04%, 8.75%, 15.58%, 11.75%, 5.10%, 7.92% and 70.20% respectively. Also, ascorbic acid, Ca, K, and Fe contents were 24.0 mg 100g⁻¹, 3.36 g 100g⁻¹, 1.13 g 100g⁻¹ and 0.12 mg kg⁻¹ respectively. Abdulsalam et al. (2019) in their work, processed *V. doniana* fruit into juice, and then estimated their nutritional value. The proximate composition of carbohydrate, crude fat, crude protein, moisture, ash, crude fibre was determined to be 5.22%, 0.30%, 1.93%, 96.36%, 0.94% and 0.60% respectively. *V. doniana* plums was demonstrated to be highly nutritious with moisture, ash, fat, fibre, protein and carbohydrate contents as 77.03%, 1.65%, 2.9%, 2.75%, 8.10% and 7.57% respectively, while Imosis et al. (2021b) in their work determined the moisture, ash content, fat, fibre, protein and carbohydrate to be 9.90%, 21.5%, 0.75%, 0.006% and 67.84% respectively. The bioactive and nutritional effects of *V. doniana* leaves were investigated. A high fibre and protein content (14.67-35.39) and (15.46 − 37.30) mg 100g⁻¹ respectively were reported, while the lipid and carbohydrate contents (0.80 – 1.93) and (4.02 – 9.70) g 100g⁻¹ respectively were moderate (Iheanacho and Ogunwa, 2021). The edible pulp of *V. doniana* were found to be have a pH of 5.20, moisture content of 67.9%, 12.5 % sucrose and 7.3 % reducing sugar, while its syrup contains 51.7% reducing sugar, 25% moisture and 12.9% sucrose contents (Abu, 2007). Fats, proteins, fatty acids, and amino acids were found in the seeds after phytochemical analysis (Amah and Okogeri, 2019).
I. Pharmacological effect

Antioxidant activity

Ayoka TO and Nnadi CO (2022), Not Sci Biol 14(2):11177

Agbafor and Nzuchukwu (2011) disclosed that the stem bark, leaves and root extracts of *V. doniana* have antioxidant properties that can be compared to standard antioxidant drugs. Its antioxidant property was associated to its phenolic contents. The methanol leaf extract exhibits good DPPH radical scavenging effect compared with quercetin (Sanni et al., 2019; Ani et al., 2020). Lagnika et al. (2012) reported the antioxidant properties of *V. doniana* on hydroethanol and methanol extracts. Their result was similar with that of Agbafor and Nzuchukwu (2011). Ayoka et al. (2020a) attributed the antioxidant potentials of *V. doniana* leaves to the presence of phenolics and alkaloids (Njoku et al., 2019). According to them, dichloromethane fraction which contains the bulk alkaloid fraction showed the highest antioxidant activity. They demonstrated its antioxidant properties on the methanol extracts, dichloromethane and butanol fractions of the leaves. The antioxidant activity of aqueous, ethanol and n-hexane fractions of *V. doniana* was evaluated (Yakubu et al., 2014). They demonstrated that the DPPH scavenging activity of *V. doniana* followed the order: ethanol extract > aqueous extract > n-Hexane extract. Sanni et al. (2019) in their work identified some trace elements and forty-three phytochemicals in the extract, which they claimed may be accountable for its significant antioxidant activity. Adjei and Fosu-Mensah (2021) in their work determined the antioxidant effects of *V. doniana* fruits using the DPPH model, with the ethyl acetate fraction having an IC₅₀ 99.35 ± 0.77 µg ml⁻¹. However, its antioxidant activity using DPPH model ranges from 71.0 ± 0.4 to 48.3 ± 0.1 (Charles and Mgina, 2021), while the IC₅₀ was found to be 245.8 µg ml⁻¹ (Imoisi et al., 2021a).

Antimicrobial activity

*V. doniana* contains alkaloids, tannins, and flavonoids which accounts for its properties as antifungal and antibacterial agents (Agbafor and Nzuchukwu, 2011). Lagnika et al. (2012) carried out similar work on the leaves using the hydroethanol and methanol extracts. Kuta et al. (2015) looked at the antibacterial effect of the bulk extract and fractions of the leaves and stem bark using *in vitro* methods. They demonstrated that extract of ethanol produced the highest antibacterial potential. The anti-microbial studies on the leaf and stem bark extracts of *V. doniana* were demonstrated by Egharevba et al. (2010). Their analysis was carried out using ethylacetate, methanol and hexane extracts of the leaf and stem bark. The extracts impaired *P. aeruginosa*. Anti-microbial potential against *E. coli* and *S. typhi* followed the order: acetone extract > methanol extract > ethanol extract (Nzuchukwu and Uzuo, 2010). Aiwonegbe et al. (2018) reported that *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Klebsiella pneumonia* were impaired by acetone and methanol extracts. The zone of inhibition was found to be between 10.50 – 21.00 mm for all concentrations. Sonibare et al. (2009) had earlier reported that the essential oils have antibacterial properties against *Proteus mirabilis*, *Bacillus subtilis* and *Candida albicans*. Meanwhile, the bark extract and the three compounds isolated in the work of Bunu et al. (2021) were investigated for anti-microbial and anti-protozoan activities. They all inhibited strains of bacterial with less activity (MIC values of 500-1000 µg ml⁻¹) exhibited by the three compounds isolated, with greater activity exhibited by the crude extract (MIC values of 125-250 µg ml⁻¹). They further added that at a concentration of 4.8 g ml⁻¹, it has no action against *P. falciparum*.

Anti-inflammatory activity

Bioactive constituents found in the plant may be accountable for its analgesic and anti-inflammatory roles. Saponins and alkaloids have anti-inflammatory properties, which was reported by Iweke et al. (2006). They demonstrated that the formation of paw edema in rats induced by agar were prevented when the rats were administered the extracts of the leaves (Adjei and Fosu-Mensah, 2021).
Hepatoprotective effect

Hepatoprotective study on the dichloromethane fraction (DCM-F) of *V. doniana* leaves was demonstrated. The study measured the activity of enzymic and non-enzymic markers in carbon tetrachloride-induced hepatocellular damage. In CCL4-induced rats, dichloromethane fractions triggered a substantial elevation (p < 0.05) in catalase, superoxide dismutase, glutathione peroxidase, and vitamins C and E relative to usual (Ayoka et al., 2020a). A similar work had earlier reported the ameliorating effect of its ethanol extract following aluminum-induced liver damage, (Yakubu et al., 2016) and kidney (Abdulrahman et al., 2007). The authors indicated that the serum activities of these biochemical markers were remarkably decreased following the intake of the ethanolic extract of *V. doniana*. Yakubu et al. (2016) also reported that *V. doniana* administration did not invoke any change in the concentration of serum bilirubin of animal models. Olajide et al. (2018) suggested that the hepatoprotective effect of *V. doniana* may be due to its anti-inflammatory and antioxidant activities. Similar work by Olajide et al. (2018) reported that *V. doniana* decreased serum concentrations of blood urea nitrogen (BUN) and creatinine in cadmium-induced toxicity in rats.

Toxicology

Acute toxicity studies were done on the extracts as well as fractions of *V. doniana* (Ayoka et al., 2020a; Onwukwe et al., 2020). During the duration of the study, the treated mice did not produce lethality (mortality). The mice did not experience any significant weight loss or changes in their food patterns. Skin dryness, hair loss, or general weakening were not observed in the mice. Their results were similar to Sha’a et al. (2011), which looked at the toxicity of *V. doniana* extracts. Adjei and Fosu-Mensah (2021) estimated LD₅₀ to be greater than 3000mg kg⁻¹, while there is an increased lymphocyte and red blood cell counts in their subacute studies. Imosis et al. (2021b) also determined LD₅₀ to be above 5000 mg kg⁻¹.

Zanthoxylum zanthoxyloides

A. **Plant Profile**

**Synonyms**


B. **Taxonomic Classification**


C. **Common names**


D. **Distribution**

*Z. zanthoxyloides* is abundant in West African savannah and dry forest vegetation, coastal areas from Senegal to Nigeria and Cameroon. It occurs abundantly in coastal areas and at low altitudes and well drained soils (Anne et al., 2013).
E. Description
It’s a 6-12 m tall tree. The bark is grey and rough, with prickles. The leaves are alternate, garnished with prickles. Flowers are 5-6 cm in diameter, white or green. The fruits contain a black shiny single seed (Ouedraogo et al., 2019). Its photograph is represented in Figure 2.

Figure 2. Zanthoxylum zanthoxyloides

F. Traditional uses
In traditional medicine, Z. zanthoxyloides is employed extensively in the management of disease (Table 2). Because of the presence of thorns, they are planted as hedges. It has antimicrobial properties and positive effect on oral pathogens (Douro et al., 2019). Sheep also browse the leaves. It is a fetish plant with magico-religious uses, such as protection against spirit (Matu, 2011).

G. Phytochemical studies and chemical constituents
Reports on the phytochemicals of Z. zanthoxyloides have revealed several compounds with pharmacological potentials. Benzo[C] phenanthridine alkaloid, fagaronine, an active compound isolated from Z. zanthoxyloides, has strong antileukemic activity against both L 1210 and P-388 leukemia. Other compounds isolated from its root such as chelerythrine, aporphine (N-methyl-corydine), berberine and canthine-6-one are found to have antimicrobial activity (Anne et al., 2013). Others are dihydrokavain, oxychelerythin, skimmianine, magnoflorine, tembaterin and 8-methoxydictamine (furoquinolines). It also contains arotiamamide, fagaramide, piperlonguminine, ruberamidine and N-isopentyl cinnamamide (Nantongo et al., 2018). Pellitorine is the component that is responsible for the hot peppery taste of Z. zanthoxyloides it is regarded as the local anaesthetic component of the roots. Its main component N-isobutyldeca-trans-4-
dieanamide, is very active against house fly, *Musca domestica* L. It also has antibacterial and antimalarial properties (Anne et al., 2013).

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<tr>
<th>Table 2. Traditional uses of various parts of <em>Z. zanthoxyloides</em></th>
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<td><strong>Plant parts</strong></td>
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<td>Stem and root decoctions</td>
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<td>Root extracts</td>
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<td>Pulped stem bark and root bark</td>
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<td>Crushed bark</td>
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<td>Bark macerated in wine</td>
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<td>Shoots, roots and twigs</td>
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<td>Leaves</td>
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<td>Leaf, bark and root extracts</td>
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Coumarins such as aesculetin dimethylether (scoparone), 6,7,8-trimethoxy coumarin, scopoletin, umbelliferone, xanthotoxin, imperatorin, bergaptenin, marmesin, pimpinellin and furocoumarins were all detected in the stem bark of *Z. zanthoxyloides*. Sesamin and asarinin which are lignans have also been isolated from the root, fruits and stem bark. Other compounds such as zanthoxylol, diosmin, fagaron and hesperidin have been detected and characterized. Lupeol, β-sitosterol and β-amyrin were isolated from different parts of plants (Nantongo et al., 2018). An anti-sickling agent, 2-hydroxymethyl benzoic acid has been isolated from the root. Alkaloids such as chelerythrine dihydroavicine and oxchelerythrine were also isolated from the root and bark. Others are skimmianine, 8-methoxydictamine, 3-dimethallyl-4-methoxy-2-quinolone, tembatarine, berberine, magnoflorine, 6-canthinone and N-methyl-corydine isolated from the roots (Nantongo et al., 2018). *Z. zanthoxyloides* leaves contain essential oils such as α-pinene, myrcene and trans-β-cimene. Its fruit has monoterprenoids, linalool, geraniol and fairly high proportion of oxygenates. (Adekunle et al., 2012) identified and quantified three flavonoids (quercetin, kaempferol and rutin) from the ethanol extract of the stem using HPLC-DAD. Hesperidin, neohesperidin and eriocitrin (flavonones) and quercetin, quercetin-3-O-glucopyranoside, datiscin, quercitrin, hyperoside (flavanols) and neodiosmin (flavones) were all identified in all plant extracts. As well as rutin and kaempferol. Other compounds identified from the fruits of the plant are geraniol, citronellol, citronellyl acetate, citronellal, limonene, (E)-β-cimene, myrcene, and α-pinene. Burkinabines A, B and C were detected in the root bark of the plant (Anne et al., 2013). Thirty (30) important compounds were tentatively characterized in the butanol fractions of *Z. zanthoxyloides* leaves using HPLC-MS dereplication. They detected for the first-time good number of phenolic compounds and alkaloids whose roles are unknown in radical scavenging activity (RSA) (Ayoka et al., 2020b). They reported the extractive yield of the extracts and fractions as methanol extract (12.4%), dichloromethane fraction (0.7%), hexane fraction (0.43%), ethylacetate fraction (0.47%) and butanol fraction (0.41%). Olushola-Sudoks et al. (2020) identified forty-six chemical constituents grouped into phytochemicals such as phytosterols, coumarins,
terpenes and fatty aldehydes. Misra et al. (2013) in their own work identified citronellol and geraniol as the major compositions of the essential oils of *Z. zanthoxyloides*. They also maintained that the fruits exhibited moderate antimicrobial and anticancer activities. Phytochemical results of the aqueous bark of *Z. zanthoxyloides* showed that alkaloids and flavonoids are present (Tougoma et al., 2021). Structures of some compounds isolated from the plants are represented in Figure 3.

![Chemical structures of compounds](image)

**Figure 3.** Some compounds isolated from *V. doniana* and *Z. zanthoxyloides*

F. **Proximate composition**

Proximate composition of the ethanolic stem bark extract was analysed (Olushola-Sudoks et al., 2020). They determined the proximate analysis parameters for moisture 9.47%, crude fat 6.36%, crude protein 11.00%, crude fibre 18.75%, ash 4.29% and total carbohydrates 50.13%. Other parameters determined were Na 12946.7760 ppm, K 1012.9924 ppm, Ca 6055.5591 ppm, Fe 1093.8837 ppm, Mg 1478.5064 ppm and Zn 216.8516 ppm.

G. **Pharmacological Effect**

**Antioxidant Activity**

The methanolic extract of *Z. zanthoxyloides* was showed to possess both antioxidant and acetylcholinesterase inhibitory effect. Tine et al. (2017) in his work tested the antioxidant properties of all the extracts using the ABTS model. The activity reduced in the order leaf > stem > root > fruit extracts. The methanol extracts of the fruits, leaves, stems, barks, trunks, and roots of the plant have also been investigated. The extracts from other parts were found to have less antioxidant activities than the leaf and trunk bark extracts (Tine et al., 2017). Different extracts from *Z. zanthoxyloides* stem bark showed considerable reduction of free radicals (Negi et al., 2011). Similar work on antioxidant properties was carried out using the ethanol extract of
its stem by Adekunle et al. (2012), where they reported that its good antioxidant activity may be due to the presence of the flavonoids quantified. Chaaib et al. (2003), investigated the antiradical, antioxidant and antifungal properties of Z. zanthoxyloides root bark. It was claimed that they do this by reducing the formation of free radicals, suggesting a function for them in the treatment of disorders as a supporting and supplemental treatment. The methanolic extracts of Z. zanthoxyloides have shown both antioxidant (Chaaib et al., 2003) and acetylcholinesterase inhibitory activity (Queiroz et al., 2006). Ayoka et al. (2020b) demonstrated the antioxidant effects of the butanol sub-fractions. In DPPH assay, the activity decreased in the order BF2 > BF5 > BF1 > BF3 > BF4. While in the TAC and FRAP models, the antioxidant activity followed the order BF3 > BF5 > BF1 > BF4 > BF2.

Antimicrobial activity
The anti-bacterial potential of the root of Z. zanthoxyloides has been demonstrated. It was reported that the toothpaste formulated from the root bark and whole root have remarkable activity against organisms that cause dental illness (Orafidiya et al., 2010). This is in agreement to its ethno-medicinal use as a chewing stick. Similar anti-microbial work was done on the aqueous and ethanol extracts of its root, in which the aqueous extracts showed better anti-microbial effect than the ethanol extract (Anne et al., 2013). The activity of light irradiation on the antimicrobial activity of the methanol extract of Z. zanthoxyloides was demonstrated by Adegbolagun and Olukemi (2010). According to them, there was a reduction or loss of activity when different sources of radiation were used to cause irradiation on the methanol extracts of Z. zanthoxyloides. Ynalvez et al. (2012) also evaluated the antimicrobial properties of Z. zanthoxyloides on various extracts of the root bark. They measured antimicrobial activities against E. coli, Staphylococcus aureus. There was no discernible variation in inhibition zone among microorganisms exposed to the extracts.

Anti-inflammatory properties
The anti-inflammatory and antipyretic activities of Z. zanthoxyloides were investigated using the hydroethanolic extracts of the roots, leaves and aqueous stem bark. Both extracts significantly inhibited appearance of pain in Wistar rats induced using egg albumin and formalin (Diatta et al., 2014; Tougoma et al., 2021a).

Bioactivity
The biological potentials of the extracts and fractions of Z. zanthoxyloides are summarized in Figure 4. The gastroduodenal effect of Z. zanthoxyloides was investigated by Boye et al. (2012). They demonstrated that the ethanol root bark extract significantly decreased in a dose-dependent way, the number of ulcers per stomach, and increased the ulcerative index and the curative ratio. Zahouli et al. (2010) demonstrated that the active constituents present in the different extracts of Z. zanthoxyloides roots reduced blood pressure. This report demonstrated its anti-hypertensive effects. The anti-malarial effect of the extracts of Z. zanthoxyloides bark was demonstrated by Gansane et al. (2010), the antimicrobial activity was investigated by Tine et al. (2017a). They showed that the extracts inhibited the development of the Plasmodium parasite. Similarly, Enechi et al. (2019) worked on methanol extracts as antimalarial agents. They maintained that the ethanol extract modified the biochemical status of the infected mice. Dofouor et al. (2019) in their work demonstrated that different fractions (methanol, butanol and dichloromethane) of Z. zanthoxyloides root inhibited T. brucei cell cycle, with dichloromethane and methanol fractions showing higher activity. In addition, the ameliorative effect of Z. zanthoxyloides on alloxan-induced diabetic rats was demonstrated by Aloe et al. (2012). They noted increase in the activity of the liver enzymes at higher concentrations of Z. zanthoxyloides and also demonstrated that serum albumin and total protein concentrations were increased in diabetic rats treated with feed formulated with Z. zanthoxyloides. Alkaloidal extracts of Z. zanthoxyloides leaves improved the insulin
level of diabetic rats and also restored the histoarchitecture of liver and kidney (Kyei-Barffour and Adokoh, 2021). They also demonstrated anti-tumour and hepatoprotective effects on CCl₄/olive oil induced toxicity on rats. They were also found to improve hepatoprotective damage and body weight/liver ratio (Acheampong et al., 2021). The analgesic effects of the aqueous extract of its bark were also investigated by Tougoma et al. (2021b). They maintained that writhing pain was significantly reduced in albino Wistar rats administered the extract.

**Figure 4. Biological potentials of Z. zanthoxyloides**

**Toxicology.**
The methanol and aqueous extracts of its root bark were found to be slightly toxic at higher concentrations. Their LD₅₀ concentrations were reported to be 4148 ± 467 mg kg⁻¹ and 5500 ± 875 mg kg⁻¹ body weight respectively (Guendehou et al., 2018). Similarly, Ogwai-Okeng et al (2003) measured LD₅₀ to be 5.0 g kg⁻¹ body weight. Cerebral irritation was observed in the mice before death. Enechi et al. (2019) also reported LD₅₀ of 5000 mg kg⁻¹ in their work. Gbeta et al. (2021) demonstrated that the root bark extract of Z. zanthoxyloides are relatively safe. There was no damage on the liver and kidney function after its administration on albino rats.

**Prospects of V. doniana and Z. zanthoxyloides in phytomedicine and nutrition**
Phytomedicine includes the combination of native medicine practices and numerous therapeutic experiences from many past ages. It provides helpful guidance on the choice, concocting and application of herbal preparations in the management and treatment of diseases (Bhardwaj et al., 2018). The growing demand and suitability of herbal medicine is believed to be healthy, cheaper and readily available for all natural products. However, phytomedicine is often concerned with some questions over its pharmacognosy and optimization relative to prescription medicines. *V. doniana* and *Z. zanthoxyloides* are reported to be effectively used to cure skin problems, malaria, liver disease, conjunctivitis, hypertension, cancer and other infectious diseases (Yakubu et al., 2016; Dofiuor et al., 2019; Bunet et al., 2021; Imosise et al., 2021a; Tougoma et al., 2021a; Tougoma et al.,
2021b). Their prospects in phytotherapy and nutrition are shown in Figure 5. In the treatment of acute and chronic diseases, constituents of *V. doniana* and *Z. zanthoxyloides* have produced many clinically beneficial products, and search for newer therapeutic agents from them is also ongoing (Adesina, 2005; Chinwe, 2018; Olajide *et al.*, 2018; Imosis *et al.*, 2021b; Charles and Mgin, 2021; Iheanacho and Ogunwa, 2021; Achempong *et al.*, 2021). The study of both plants has increased over the years, to clinically examine their use and to authenticate their herbal products. As a result, we set out to investigate the current state of their use in the treatment of various ailments and associated pharmacological problems, while also considering the increased future potential for herbal medicines.

![Figure 5. Prospects of *V. doniana* and *Z. zanthoxyloides* in phytotherapy and nutrition](image)

**Conclusions**

There is an array of secondary metabolites in the leaves of *V. doniana* and *Z. zanthoxyloides*. Such secondary metabolites are alkaloids, flavonoids, tannins, coumarins, terpenes and saponins. It is possible to relate the antioxidant activity found in *V. doniana* and *Z. zanthoxyloides* to the significant number of secondary metabolites they produce. Some studies attributed this to the presence of alkaloids and phenolics. Based on the history and context of the publications and research papers used as the basis for this analysis, it can be proposed that *V. doniana* and *Z. zanthoxyloides* are of great importance for the developments in safety and efficacy medicine, bringing to the fore, chemotherapeutic actions of antioxidant, anti-inflammatory, anti-cancer and anti-microbial activities.

These plants can provide new opportunities for limited diagnostic tools to be considered for future studies in the treatment of diseases or their symptoms. However, there should be further research on the mechanisms of action of these phytochemicals responsible for the biological activities. Studies to isolate and characterize these bioactive alkaloids should be carried out. Meanwhile, the rich antioxidant potentials of the plant's fractions need to be investigated in detail to enable the formulation of liver treating drugs. These
additional studies would give an intuition into the mechanisms that lead to the specific bioactivities of *V. doniana* and *Z. zanthoxyloides*.

**Authors’ Contributions**

Conceptualization (TOA and CON); Data curation (TOA); Formal analysis (CON); Methodology (TOA); Resources (TOA and CON); Software (TOA); Supervision (CON); Validation (TOA and CON); Visualization (TOA and CON); Writing - original draft (TOA); Writing - review and editing (CON). All authors read and approved the final manuscript.

**Ethical approval** (for research involving animals or humans)

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**Conflict of Interests**

The authors declare that there are no conflicts of interest related to this article.

**References**


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