Pro-life
Jurnal Pendidikan Biologi, Biologi, dan Ilmu Serumpun
https://ejournal.uki.ac.id/index.php/prolife

Tithonia diversifolia (Hemsl.) A. Gray: Botany, Bioactivity, and Secondary Metabolites

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Article History

Received:07April 2026
Approved:20 July 2026
Published:22 July 2026

DOI: https://doi.org/10.33541/pro-life.v13i2.8077

Keywords
Tithonia diversifolia, antimicrobial, epicatechin, botany, bioactivity.

ABSTRACT

Tithonia diversifolia is widely found across various landscapes in Indonesia, from roadsides and neglected areas, and information on its use remains limited. This study aims to explain the botany, bioactivity, and secondary metabolites of T. diversifolia. This research is based on a review of online literature using the keywords T. diversifolia, uses T. diversifolia, and secondary metabolites of T. diversifolia. Tithonia diversifolia is a perennial shrub-like plant, growing to 1.2 – 3 m, easily recognized by its cup-shaped yellow ribbon flowers. The bioactivities of T. diversifolia include antimicrobial, antioxidant, anti-inflammatory, anticancer, antidiabetic, and Alzheimer's disease treatment. Various researchers have reported that T. diversifolia inhibits the growth of Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Proteus mirabilis, Salmonella typhi, Shigella dysenteriae, Corynebacterium diptheriae, Streptococcus pneumoniae, Saccharomyces cerevisiae, Microbacterium foliorum, and Rhodococcus equi. Epicatechin and quercetin are promising antibacterial agents. The bioactivity of T. diversifolia as a microbial agent is more pronounced than that of other species, making it highly promising for development as an alternative antibiotic.

INTRODUCTION

Tithonia diversifolia is a high-density invasive plant (Kato-Noguchi & Kato, 2025) native to North and Central America (Ajao & Moteetee, 2017). Empirically, this plant is easy to find in various landscapes in Indonesia, ranging from roadsides to neglected land. This plant is easily recognized by its yellow ribbon-like flowers, which resemble sunflowers. This plant has high genetic variation, making it easily adaptable to various environmental conditions and exhibiting a high reproductive rate (Kato-Noguchi & Kato, 2025). In various countries such as Costa Rica, Democratic Republic of Congo, Kenya, Nigeria, Mexico, the Philippines, São Tomé and Príncipe, Taiwan, Uganda,

and Venezuela, the traditional use of this treatment for various diseases has been reported (Ajao & Moteetee, 2017). However, its use in Indonesia has not been widely reported.

T. diversifolia has traditionally been used to treat hepatitis and liver cancer (Wang et al., 2025). Traditionally, in various countries, *T. diversifolia* is used to treat a variety of diseases, including diabetes, malaria, snakebite, measles, ulcers, menstrual pain, and wounds (Ajao & Moteetee, 2017). The bioactivity of *T. diversifolia* as an antimicrobial has been reported by Bouberte et al. (2006), Obafemi et al. (2006), Ogundare (2007), John-Dewole & Oni (2013), and Tran et al. (2013). The antimicrobial activity of *T. diversifolia* compares well with that of standard antibiotics (Ogundare, 2007). Sesquiterpene lactones from non-polar *T. diversifolia* leaf extract are promising phytotherapeutic agents against bacterial infections (Obafemi et al., 2006).

The use of plants as traditional medicine is related to their bioactivity. The leaves of *T. diversifolia* contain essential oils in the form of β-pinene, α-pinene, and limonene (da Silva Júnior et al., 2025). Ethyl acetate extracts from leaves, stems, and roots contain sesquiterpene lactone compounds including 8β-O-(2-methylbutyroyl) thyrotundin; 8β-O-(isovaleroyl) thyrotundin; 1β-methoxydifolin, tagitinin A, and tagitinin C (Miranda et al., 2015). Tithonia diversifolia contains the compounds Tithoniamarin, tithoniamide, β-sitosterol, and β-sitosterol glucopyranoside, which have anti-fungal and antiviral properties (Bouberte et al., 2006). Tagitinin C sesquiterpene exhibits a significant antifibrotic effect on TGFβ1-induced HSC-T6 activation by inducing cell apoptosis and regulating the TGF-β1/Smad pathway (Wang et al 2025). The results of the in vitro evaluation showed that compounds extracted from the TD nerve section, in the form of germacrane sesquiterpenes 1β-hydroxydifolin-3-O-methyl ether and 1β-hydroxythyrotundin-3-O-methyl ether, could significantly increase glucose uptake without significant toxic effects (Zhao et al., 2012a; Zhao et al., 2012b).

Empirically, in Indonesia, *T. diversifolia* has not been widely used, despite various studies showing its great potential for development as animal feed, bioinsecticides, and traditional medicine. The use of plants as traditional medicine is related to their bioactivity and secondary metabolites. This study aims to explain the botany, bioactivity, and secondary metabolites of *T. diversifolia*.

RESEARCH METHODS

Study Design

This research is based on a literature review of articles published in various

scientific journals on Google Scholar using the keywords *T. diversifolia* and uses *T. diversifolia*. Scientific journals are obtained and analyzed to determine whether they are compatible with the research objectives.

Data Collection and Analysis

The information obtained was grouped into botany, bioactivity, and secondary metabolite content. To complete the botanical data, including habitus, leaf structure, and flowers, photos were taken from the surrounding environment. Data analysis was carried out qualitatively. From the various scientific articles that have been obtained, as many as 30 scientific articles have been further studied. The information obtained is synthesized to explain its botany, bioactivity, and secondary metabolites. This makes this study more comprehensive.

RESULTS AND DISCUSSION

Botanic *Tithonia diversifolia* (Hemsl.) A. Gray

Asteraceae is a family within Magnoliopsida with a relatively large number of species. This family is easily recognized by its floral characteristics, including cup, tube, and ribbon flowers. *T. diversifolia* is one of the species of Asteraceae that is easily found in Indonesia.

Description: *T. diversifolia* is a shrub-like perennial plant with a height of 1.2–3 m. The stems are green when young and turn brown with age. Branches are tight and dense. The leaves are intermittent, lobed (sometimes the upper leaves are not lobed), with tapered or descending bases, pointed or tapered tips, and serrated edges, measuring 5–17 × 3.5–12 cm, densely hairy at the bottom; with palm venation. Single flower heads on flower stalks 6–13 cm long; florets yellow, petals measuring 3–6 cm × 5–18 mm (Ajao & Moteetee, 2017).

T. diversifolia is a perennial invasive plant, native to North and Central America (Ajao & Moteetee, 2017). *Tithonia diversifolia*, a shrub in the family Asteraceae, is widely distributed along agricultural land boundaries in humid and subhumid tropical regions of Africa (Jama et al, 2000). *T. diversifolia* is an invasive weed commonly found in tropical ecosystems (Sampaio et al, 2016).

Benefits and Bioactivity *Tithonia diversifolia* (Hemsl.) A. Gray

In different countries such as Costa Rica, Democratic Republic of Congo, Kenya, Nigeria, Mexico, Philippines, São Tomé and Príncipe, Taiwan, Uganda, and Venezuela, people traditionally treat various diseases, including diabetes, malaria, snakebites, measles, ulcers, menstrual pain, and wounds (Ajao & Moteetee, 2017). *T. diversifolia* has anti-inflammatory, analgesic, antimalarial, antiviral, antidiabetic, antidiarrheal, antimicrobial, antispasmodic, vasorelaxant, chemopreventive cancer, cytotoxic, toxicology, bioinsecticide,

and insect repellent activity (Chagas-Paula et al, 2012). The following will further study the bioactivity of *T. diversifolia* as antimicrobial, antioxidant, anti-inflammatory, anti-cancer, anti-diabetes mellitus, and anti-Alzheimer's. Figure 1 shows the morphology of *T. diversifolia*.

Antimicrobial

Pathogenic microbes are the main cause of various infections in humans. Antimicrobial compounds are substances that inhibit the growth of microorganisms, including pathogenic microbes. The clinical usefulness of antibiotics is increasingly threatened by increasing bacterial resistance to various drugs (Oluyele et al, 2025). Ethyl acetate extract was the most active, showing inhibitory activity against Gram+ and Gram– bacteria, followed by hexane extract and then methanol (Obafemi et al., 2006).

Figure 1. *Tithonia diversifolia* (Hemsl.) A. Gray. A. Habitus; B. Arrangement of leaves on stems; C. Compound flowers; D. Flower buds.

The bioactivity of *T. diversifolia* as an antimicrobial has been reported by Bouberte et al. (2006), Obafemi et al. (2006), Ogundare (2007), John-Dewole & Oni (2013), and Tran et al. (2013). The antimicrobial activity of *T. diversifolia* compares well with that of standard antibiotics (Ogundare, 2007). Lactone sesquiterpene compounds from non-polar *T. diversifolia* leaf extract are good candidates as phytotherapeutic agents against some bacterial infections (Obafemi et al., 2006).

Various extracts of *T. diversifolia* inhibit the growth of bacteria such as *Pseudomonas aeroginosa* (John-Dewole & Oni, 2013; Ogundare, 2007; Tran et al., 2013), *Staphylococcus aureus, Escherichia coli* (John-Dewole & Oni, 2013; Ogundare, 2007), *Bacillus subtilis* (Ogundare, 2007; Tran et al., 2013), *Proteus mirabilis, Salmonella typhi, Shigella dysenteriae, Corynebacterium diptheriae, Streptococcus pneumoniae, Candida albicans* (Ogundare, 2007), *Saccharomyces cerevisiae* (John-Dewole & Oni, 2013), *Microbacterium foliorum,* and *Rhodococcus equi* (Tran et al, 2013).

The antimicrobial activity of plant extracts is greatly influenced by concentration, extract polarity, the type of microbes, and the organs used. Hexane, ethyl acetate, and methanol extracts of *T. diversifolia* leaves have antimicrobial activity in vitro (Obafemi et al., 2006). Chloroform and methanol extracts of *T. diversifolia* leaves inhibit the growth of pathogenic human microbes, namely *Proteus mirabilis, Salmonella typhi, Bacillus subtilis, Shigella dysenteriae, Corynebacterium diphtheriae, Pseudomonas aeruginosa, Streptococcus pneumoniae,* and *Candida albicans* (Ogundare, 2007).

Extracts of water (John-Dewole & Oni, 2013), chloroform, and methanol (Ogundare, 2007) from the leaves exhibit growth-inhibitory effects on *Staphylococcus aureus and Escherichia coli*. The synthesis of silver nanoparticles (AgNPs) using water leaf extract *T. diversifolia* has antimicrobial activity against *Pseudomonas aeruginosa, Microbacterium foliorum, Bacillus subtilis,* and *Rhodococcus equi* (Tran et al., 2013). The molecular docking approach of *T. diversifolia* extract inhibits the growth of *E. coli* and *P. aeruginosa* (Oluyele et al., 2025).

The phytochemical *T. diversifolia* is a candidate for managing infections resistant to various drugs (Oluyele et al, 2025). The bioactivity of *T. diversifolia* as an antimicrobial is associated with its secondary metabolite content. Compounds tithoniamarin, tithoniamide, β-sitosterol, and β-sitosterol glucopyranoside, which have anti-fungal and antiviral properties (Bouberte et al., 2006). Epicatechin and quercetin show strong inhibitory potential

against antibacterial-related gyrase-B DNA (Oluyele et al., 2025).

Antioxidants

Antioxidants are compounds that can reduce or inhibit free radicals. Water extracts, methanol, and dichloromethane extracts of *T. diversifolia* leaves contain phenolics and flavonoids with free radical-scavenging capacity and inhibit plasma lipid peroxidation in vitro (Di Giacomo et al., 2015). Some phenolic compounds exhibit antioxidant activity and inhibit tyrosinase, a key enzyme in insect metamorphosis (Pulido et al., 2017). *T. diversifolia* exhibits attractive health-promoting properties, generated by both its free radical scavenging capacity and the induction of protective cellular systems involved in cellular stress defense and mesenchymal adipogenesis (Di Giacomo et al., 2015).

Caffeic acid derivatives have antioxidant activity as a potent 2,2-diphenyl-1-pykrilhydroxyl (DPPH) radical scavenger and moderate iron-reducing antioxidant power (FRAP) (Pulido et al, 2017). The methanol extract from the dried leaves of *T. diversifolia* has anti-inflammatory and analgesic activity (Owoyele et al., 2004). The extract (50–200 mg/kg, p.o.) produced dose-related inhibition of carrageenan-induced leg edema and cotton pellet-induced granuloma in rats (Owoyele et al., 2004).

The bioactivity of *T. diversifolia* is thought to be related to its antioxidant activity. *T. diversifolia* contains sesquiterpene, phenolic, fatty acids, five phenylpropanoids, and three flavonoids (Wang et al., 2025). Phenolic compounds derived from caffeic acid from *T. diversifolia* leaves include (E)-3- ((((3-(3,4 dihydroxyphenyl)acrylic)oxy)methyl)-2methyl oxycarbonyl-2-carboxylic acid, 4,5-dicaffeoylquinic acid, 3,4-dicaffeoylquinic acid, and 3,5-dicaffeoylquinic acid (Pulido et al., 2017). Water extracts from *T. diversifolia* leaves contain phytochemicals such as gilluone B, tagitinine A, thyrotundin, tadeonal, and stigmasterol glucoside (Almayda et al., 2025). Antioxidant activity of water extract from *T. diversifolia* leaves (70.43 mg/mL) (Almayda et al, 2025).

Anti-Cancer

Hepatic fibrosis or liver fibrosis is a disorder of the liver caused by excessive accumulation of scar tissue (collagen) in the liver as a result of chronic injury or long-term inflammation, so that a healthy liver turns hard. Fibrosis can progress to cirrhosis (permanent damage) or liver failure. Plants used to treat cancer produce antifibrotic compounds with antiproliferative activity (Gu et al., 2002; Lee et al., 2011) and induce apoptosis (Wang et al., 2025). Tithonia diversifolia has traditionally been used to treat hepatitis and liver cancer (Wang et al., 2025), colon cancer (Gu et al., 2002), and leukemia (Lee et al., 2011).

Bioactivity to alleviate liver fibrosis is associated with the presence of lactone-like sesquiterpenes, such as Tagitinin C (Wang et al., 2025; Lalremruata et al., 2025). Tagitinin C sesquiterpene exhibits a significant antifibrotic effect on TGFβ1-induced HSC-T6 activation by inducing cell apoptosis and regulating the TGF-β1/Smad pathway (Wang et al., 2025). Tagitinin C, a lactone sesquiterpene, has been shown to inhibit various tumors and cancer cell lines (Lalremruata et al, 2025). The lactone-lactone sesquiterpene Tagitinin C may be developed as a precursor for future antifibrotic therapy (Wang et al., 2025).

T. diversifolia ethanol extract significantly inhibits the symptoms of carbon tetrachloride-induced liver fibrosis and collagen deposition in pathological tissues by suppressing the protein expression of various pro-fibrotic factors (Wang et al., 2025). Fractionation of the ethyl acetate extract from *T. diversifolia* showed antiproliferative activity in human colon cancer (Col2) cells (Gu et al., 2002). The compounds tagitinin C and 1β,2α-epoxytagitinin C showed significant antiproliferative activity, tithofolinolide, 3α-acetoxydiversifolol, and 4α,10α-dihydroxy-3-oxo-8β- isobutyriloxiguaia-11(13)-en-12,6α-olide induced cellular differentiation of HL-60, and 3β-acetoxy-8β-isobutyryloxyreynosine significantly inhibited lesion formation (63.0% at 10 μg/mL) in rat mammary organ culture assays (Gu et al., 2002).

Ethanol extract of 80% EtOH from *T. diversifolia* contains sesquiterpenoid compounds, and flavonoids show cytotoxic activity against HL-60 leukemia cells (IC50 ranges from 0.13 - 13.0 μM) compared to etoposids used as positive controls (IC50 of 0.43 μM) (Kuroda et al., 2007). Methanol extract of *T. diversifolia* containing tatagitinin C showed antiproliferative activity against human glioblastoma U373 cells with an IC50 value of 6.1 ± 0.1 μg/mL (Lee et al., 2011). In PARP, p-p38, ULK1, and LC3-II, tagitinin C-induced anti-glioblastoma activity is possible through autophagy. The compound tatagitinin C induces autophagy-dependent U373 cell death under certain conditions (Lee et al., 2011).

Anti-Alzheimer's

Alzheimer's disease is a chronic neurodegenerative brain dysfunction and the most common form of dementia, especially in the elderly, and is considered a serious problem for health systems worldwide. The disease is a multifactorial and progressive condition, characterized by memory loss, personality changes, and decreased cognitive function, in addition to neuropsychiatric complications such as depression, anxiety, sleep disorders, and others, which further degrade the quality of life of Alzheimer's patients (Guimarães et

al., 2025). Galantamine is an acetylcholinesterase inhibitor (cholinesterase inhibitor) that is used to relieve symptoms of mild to moderate dementia in people with Alzheimer's disease.

Since the introduction of galantamine into Alzheimer's therapy, medicinal plants and herbal remedies have been increasingly in demand as complementary and alternative interventions and as a valuable resource for developing drug candidates for Alzheimer's (Guimarães et al., 2025). Various genetic, metabolic, and environmental disorders are known to contribute to the pathogenesis of Alzheimer's dementia. Although dementia is theoretically reversible, its treatment requires multiple drugs targeting various brain cell types, including astrocytes, oligodendrocytes, neurons, endothelial cells/pericytes, and microglia (Fessel, 2023).

Ethanol extract of *T. diversifolia*, which exhibits acetylcholinesterase (AChE) inhibitory activity similar to that of rivastigmine, is a new candidate for Alzheimer's molecular targets. Ethanol extract of *T. diversifolia* induced a decrease in STZ-induced depressive and anxiety behavioral parameters, as well as reversing the memory deficit of experimental mice. Biochemical tests show that the ethanol extract of *T. diversifolia* increases antioxidant defenses and lowers levels of neuroinflammatory markers. In addition, the ethanol extract of *T. diversifolia* partially inhibits beta-amyloid (Aβ) production (Guimarães et al., 2025).

Anti-Diabetes Mellitus

Ethanol extract of *T. diversifolia* (500 mg/kg body weight) reduced blood glucose in rats 3 weeks after a single oral dose and also significantly lowered plasma insulin in experimental rats. *T. diversifolia* increases glucose metabolism by reducing insulin resistance, making it useful for the treatment of type 2 diabetes (Miura et al., 2005). The results of the in vitro evaluation showed that compounds extracted from the *T. diversifolia* part of the intestine in the form of germ sesquiterpenes, 1β-hydroxydiversifolin-3-O-methyl ether, and 1β-hydroxythyrotundin-3-O-methyl ether can significantly increase glucose uptake without significant toxic effects (Zhao et al., 2012a; Zhao et al., 2012b).

Secondary Metabolites *Tithonia diversifolia* (Hemsl.) A. Gray

Plants produce secondary metabolites to adapt to their environment and to support their development. The activity of secondary metabolites affects natural enemies such as insects and herbivorous mammals, pathogenic nematodes, fungi, and viruses, as well as allelochemical effects on surrounding competitive plant species (Kato-Noguchi & Kato, 2025). Based on the formation process, secondary metabolites are grouped into terpenoids (containing isoprene/5C compounds), phenolics

(containing aromatic rings), and alkaloids (containing Nitrogen bases). The genus *Tithonia* is an important source of a wide variety of natural products, particularly lactone sesquiterpenes, diterpenes, and flavonoids (Chagas-Paula et al, 2012). Phenolic compounds derived from caffeic acid from Tithonia diversifolia leaves include (E)-3-(((3-(3,4-dihydroxyphenyl) acrylic)oxyl)methyl)-2-methyloxyron-2-carboxylic acid, 4,5-dicaffeoylquinic acid, 3,4-dicaffeoylquinic acid, and 3,5-dicaffeoylquinic acid (Pulido et al, 2017).

T. diversifolia contains sesquiterpene, phenolic, fatty acids, phenylpropanoids, and flavonoids (Wang et. Al., 2025). Water and ethanol extracts *of T. diversifolia* contain alkaloids, saponins, tannins, flavonoid terpenoids, and phenols, and these contents are highest in the leaves, followed by roots and stems, except for the highest phenol in the root section (Olayinka et al., 2015). Alkaloids are the most abundant compounds, followed by tannins, flavonoids, saponins, terpenoids, and phenols (Olayinka et al., 2015).

However, the content and type of metabolites in plants vary greatly between organs and are also influenced by the polarity of the compounds used for extraction. Phytochemical screening of extracts from the leaves of Tithonia diversifolia shows the presence of Alkaloids, Saponins, Saponin glycosides, Tannins, Balsams, Cardiac glycosides, and Essential oils (John-Dewole & Oni, 2013).

Water extracts from *T. diversifolia* leaves contain phytochemicals such as gilluone B, tagitinine A, thyrotundin, tadeonal, and stigmasterol glucoside (Almayda et al, 2025). Variations mainly influence the distribution of metabolites in the flower and root sections in several soil nutrients, such as Ca, Mg, P, K, and Cu (Sampaio et al., 2016). The leaves of *T. diversifolia* contain essential oils in the form of β-pinene, α-pinene, and limonene (da Silva Júnior et al., 2025). Ethyl acetate extracts from leaves, stems, and roots contain sesquiterpene lactone compounds including 8β-O-(2-methylbutyroyl) thyrotundin; 8β-O-(isovaleroyl)thyrotundin; 1β-methoxydifolin, tagitinin A, and tagitinin C (Miranda et al., 2015).

The aerial part of Tithonia diversifolia contains heliangolid compounds, namely heliangolides (tagitinin F; 1,2-epoxytagitinin C), guaianolide (histitulin flavon (Pereira et al., 1997). Sesquiterpene compounds in the air part of TD include thyrotundin-3-O-methyl ether, deasetilv guiestine, 1β-hydroxydifolin-3-O-methyl ether, tabitinin C, 1β-hydroxyrotundin-3-O-methyl ether, 1β-hydroxyrotundin-1,3-O-dimethyl ether, tabithinin F-3-O-methyl ether, tagitinin F, tagitinin A, 3β-acetoxy-4α-hydroxyeduesm-11(13)-en-12-oic acid, and ilicic acid (Zhao et al., 2012). TD shoot

extract contains sesquiterpenoid compounds (2α-hydroxythyroid, tithofolinolide, 3α-acetoxydifolol), sesquiterpene lactones (3β-acetoxy-8β- isobutyryloxyreynosine, tagitinin C, 1β,2α-epoxytagitinin C, 4α,10α-dihydroxy- 3-oxo-8β-isobutyrilolocsiguaia-11(13)-en-12,6α-olide, 3α-acetoxy-4α-hydroxy-11(13)-eudesmen-12-oat acid methyl ester, 17,20-dihydroxycyngeylnerol, tagitin A, and tyrotundin) (Gu et al., 2002).

T. diversifolia leaves contain essential oil compounds such as α-pinene (32.9%), β-caryophyllene (20.8%), germacrene D (12.6%), β-pinene (10.9%), and 1,8-cineole (9.1%) (Moronkola et al., 2007). Germacrene D (20.3%), β-caryophyllene (20.1%), and biclogermacrene (8.0%) characterize flower oils (Moronkola et al., 2007). Several aliphatic fatty acids and the diterpenoid compound sandaracopimaradiene, found in flowers, are not detectable in leaf oil (Moronkola et al., 2007).

Various compounds such as Tatagitin A, takitinin C, 1β-methoxydifolin, phytol, phytol acetate, α-pinene, bicyclo [3.1.0] hexane, 4-methylene-1-(1-methylylyl), hispidulin, dihydro-p-kumaric acid, and methyl linoleic are toxic to herbivorous insects, while tatagitin C and 5-O-(E)-caffeine acid are harmful to herbivorous mammals (Kato-Noguchi & Kato, 2025). Tyrotundin compounds have nematocidal activity, whereas α-pinene, camphor, eucalyptol, and α-terpineol have fungicidal activity. Tataghinin A, tatagitin C, and 1β-methoxydifolin-3-O-methyl ether have antiviral activity. Tagitinin A, tagitinin C, 1β-methoxydifolin, and hispidulin act as allelochemicals that inhibit the growth of surrounding competing plant species (Kato-Noguchi & Kato, 2025).

CONCLUSION

Tithonia diversifolia is a shrub-like perennial plant, growing to 1.2–3 m, easily recognized by its yellow ribbon flowers. The bioactivity of *T. diversifolia* includes antimicrobial, antioxidant, anti-inflammatory, anticancer, antidiabetic, and Alzheimer's disease activities. Various researchers reported that *T. diversifolia* inhibits the growth of *Pseudomonas aeroginosa, Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Proteus mirabilis, Salmonella typhi, Shigella dysenteriae, Corynebacterium diptheriae, Streptococcus pneumoniae, Saccharomyces cerevisiae, Microbacterium foliorum,* and *Rhodococcus equi*. The compounds epicatechin and quercetin are promising antibacterial agents.

REFERENCES

Ajao, A. A., & Moteetee, A. N. (2017). *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae: Heliantheae), an invasive plant of significant ethnopharmacological importance: A review. *South African Journal of Botany, 113*, 396–403.

Almayda, N., Arraihan, N. P., Alfira, D., Masruri, M., Susanti, E., & Safitri, A. (2025). Phytochemical compositions, microencapsulation, and antioxidant activity of aqueous extract from *Tithonia diversifolia* leaves. *Trends in Sciences, 22*(9), 10306.

Bouberte, M. Y., Krohn, K., Hussain, H., Dongo, E., Schulz, B., & Hu, Q. (2006). Tithoniamarin and tithoniamide: A structurally unique isocoumarin dimer and a new ceramide from *Tithonia diversifolia*. *Natural Product Research, 20*(9), 842–849.

Chagas-Paula, D. A., Oliveira, R. B., Rocha, B. A., & da Costa, F. B. (2012). Ethnobotany, chemistry, and biological activities of the genus *Tithonia* (Asteraceae). *Chemistry & Biodiversity, 9*(2), 210–235.

da Silva Júnior, R. A., de Carvalho Fragoso, M., Paraguassu, B. A., Marcos, R. A., Scherer, R., Osório, V. M., ... & de Andrade, T. U. (2025). Chemical composition and acaricidal and insecticidal activity of the essential oil of *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae). *Neotropical Entomology, 54*(1), 50.

Di Giacomo, C., Vanella, L., Sorrenti, V., Santangelo, R., Barbagallo, I., Calabrese, G., ... & Acquaviva, R. (2015). Effects of *Tithonia diversifolia* (Hemsl.) A. Gray extract on adipocyte differentiation of human mesenchymal stem cells. *PLOS ONE, 10*(4), e0122320.

Fessel, J. (2023). Cure of Alzheimer's dementia requires addressing all of the affected brain cell types. *Journal of Clinical Medicine, 12*(5), 2049.

Gu, J. Q., Gills, J. J., Park, E. J., Mata-Greenwood, E., Hawthorne, M. E., Axelrod, F., ... & Kinghorn, A. D. (2002). Sesquiterpenoids from *Tithonia diversifolia* with potential cancer chemopreventive activity. *Journal of Natural Products, 65*(4), 532–536.

Guimarães, G. M., Cazarin, C. A., Bernadina, J. G., Eisendecker, H. I., dos Santos, A. C., Dalmagro, A. P., ... & de Souza, M. M. (2025). *Tithonia diversifolia* (Hemsl.) extract attenuates cognitive dysfunction, oxidative stress and neuroinflammation in a model of sporadic Alzheimer's disease induced by streptozotocin. *Exploration of Neuroscience, 4*, 1006109.

Jama, B., Palm, C. A., Buresh, R. J., Niang, A., Gachengo, C., Nziguheba, G., & Amadalo, B. (2000). *Tithonia diversifolia* as a green manure for soil fertility improvement in western Kenya: A review. *Agroforestry Systems, 49*, 201–221.

John-Dewole, O. O., & Oni, S. O. (2013). Phytochemical and antimicrobial studies of extracts from the leaves of *Tithonia diversifolia* for pharmaceutical importance. *International Journal of Pharmacy and Biological Sciences, 6*, 21–25.

Kato-Noguchi, H., & Kato, M. (2025). Defensive compounds involved in the invasiveness of *Tithonia diversifolia*. *Molecules, 30*(9), 1946.

Kuroda, M., Yokosuka, A., Kobayashi, R., Jitsuno, M., Kando, H., Nosaka, K., ... & Mimaki, Y. (2007). Sesquiterpenoids and flavonoids from the aerial parts of *Tithonia diversifolia* and their cytotoxic activity. *Chemical and Pharmaceutical Bulletin, 55*(8), 1240–1244.

Lalremruata, B. C., Vanlalhluna, P. C., & Singh, G. (2025). Tagitinin C: A potential anticancer agent from *Tithonia diversifolia*: A comprehensive review. *South African Journal of Botany, 177*, 472–486.

Lee, M. Y., Liao, M. H., Tsai, Y. N., Chiu, K. H., & Wen, H. C. (2011). Identification and anti-human glioblastoma activity of tagitinin C from *Tithonia diversifolia* methanolic extract. *Journal of Agricultural and Food Chemistry, 59*(6), 2347–2355.

Miranda, M. A., Varela, R. M., Torres, A., Molinillo, J. M. G., Gualtieri, S. C. J., & Macías, F. A. (2015). Phytotoxins from

Tithonia diversifolia. *Journal of Natural Products, 78*(5), 1083–1092.

Miura, T., Nosaka, K., Ishii, H., & Ishida, T. (2005). Antidiabetic effect of Nitobegiku, the herb *Tithonia diversifolia*, in KK-Ay diabetic mice. *Biological and Pharmaceutical Bulletin, 28*(11), 2152–2154.

Moronkola, D. O., Ogunwande, I. A., Walker, T. M., Setzer, W. N., & Oyewole, I. O. (2007). Identification of the main volatile compounds in the leaf and flower of *Tithonia diversifolia* (Hemsl.) Gray. *Journal of Natural Medicines, 61*, 63–66.

Obafemi, C. A., Sulaimon, T. O., Akinpelu, D. A., & Olugbade, T. A. (2006). Antimicrobial activity of extracts and a germacranolide-type sesquiterpene lactone from *Tithonia diversifolia* leaf extract. *African Journal of Biotechnology, 5*(12).

Ogundare, A. O. (2007). Antimicrobial effect of *Tithonia diversifolia* and *Jatropha gossypifolia* leaf extracts. *Trends in Applied Sciences Research, 2*(2), 145–150.

Olayinka, B. U., Raiyemo, D. A., & Etejere, E. O. (2015). Phytochemical and proximate composition of *Tithonia diversifolia* (Hemsl.) A. Gray. *Annals of Food Science and Technology, 16*(1), 195–200.

Oluyele, O., Ejigbo, G. O., & Bodun, D. S. (2025). Antibacterial efficacy and bioisosteric optimization of lead compounds from *Tithonia diversifolia* targeting DNA gyrase B in multidrug-resistant bacteria. *In Silico Research in Biomedicine*, 100073.

Owoyele, V. B., Wuraola, C. O., Soladoye, A. O., & Olaleye, S. B. (2004). Studies on the anti-inflammatory and analgesic properties of *Tithonia diversifolia* leaf extract. *Journal of Ethnopharmacology, 90*(2–3), 317–321.

Oyewole, I. O., Adeoye, G. O., Anyasor, G. N., & Obansa, J. A. (2008). Anti-malarial and repellent activities of *Tithonia diversifolia* (Hemsl.) leaf extracts. *Journal of Medicinal Plants Research, 2*(8), 171–175.

Pereira, P. S., Dias, D. A., Vichnewski, W., Nasi, A. M. T. T., & Herz, W. (1997). Sesquiterpene lactones from Brazilian *Tithonia diversifolia*. *Phytochemistry, 45*(7), 1445–1448.

Pulido, K. D. P., Dulcey, A. J. C., & Martínez, J. H. I. (2017). New caffeic acid derivative from *Tithonia diversifolia* (Hemsl.) A. Gray butanolic extract and its antioxidant activity. *Food and Chemical Toxicology, 109*, 1079–1085.

Sampaio, B. L., Edrada-Ebel, R., & da Costa, F. B. (2016). Effect of the environment on the secondary metabolic profile of *Tithonia diversifolia*: A model for environmental metabolomics of plants. *Scientific Reports, 6*(1), 29265.

Tran, T. T. T., Vu, T. T. H., & Nguyen, T. H. (2013). Biosynthesis of silver nanoparticles using *Tithonia diversifolia* leaf extract and their antimicrobial activity. *Materials Letters, 105*, 220–223.

Wang, J., Li, H., Wang, T., Xie, H., Ruan, Y., & Zhang, C. (2025). Research on the anti-hepatic fibrosis effects and active components of the medicinal plant *Tithonia diversifolia*. *Fitoterapia, 180*, 106317.

Zhao, G., Li, X., Chen, W., Xi, Z., & Sun, L. (2012a). Three new sesquiterpenes from *Tithonia diversifolia* and their anti-hyperglycemic activity. *Fitoterapia, 83*(8), 1590–1597.

Zhao, G. J., Xi, Z. X., Chen, W. S., Li, X., Sun, L., & Sun, L. N. (2012b). Chemical constituents from *Tithonia diversifolia* and their chemotaxonomic significance. *Biochemical Systematics and Ecology, 44*, 250–254.