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Review article

Galinsoga parviflora (Cav.): A comprehensive review on ethnomedicinal, phytochemical and pharmacological studies

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ABSTRACT

Galinsoga parviflora (Cav.) is a member of the Asteraceae family traditionally used for treatment of various ailments such as malaria, flu, cold, colorectal cancer, liver problems and inflammation. The medicinal properties of *G. parviflora* are due to the presence of various secondary metabolites including flavonoids, saponins, terpenoids and tannins. The literature survey revealed that *G. parviflora* possesses several pharmacological properties such as antibacterial, antifungal, antioxidant and antidiabetic. This review systematically discusses the potential of *G. parviflora* for managing medical conditions. The information is collected from various online databases such as Google Scholar, ScienceDirect, Springer, Web of Science, Plant of the World Online and PubMed. Among other information provided in this review, ethnomedicinal uses, phytochemistry and pharmacological activities are discussed extensively. Additonally, the potential benefits, challenges and future opportunities are presented.

1. Introduction

Natural products have been a prominent area of research, and this interest continues today [1]. As alternative medicines, they offer fewer side effects, among the advantages. People in developing nations rely entirely on natural products from medicinal plants for their basic healthcare requirements [2,3]. Underutilized plants and vegetables are among the potential medicinal plants with remarkable quality for medicinal purposes [4]. These plants are found in threatened or extreme environmental situations as life-supporting species, have the genetic capacity to thrive under difficult conditions, and have phytochemicals with medicinal and dietary benefits. Understanding these underutilized plants can attribute to the improvement of nutrition, food security [5], health and economics for people [6,7]. *Galinsonga parviflora* (Cav.) is one of underutilized vegetables possessing medicinal and dietary benefits. It is commonly known as Gallant soldier in Britain, Quickweed,Waterweed, and Piphe in Central America [8–11], due to its ability to grow and mature within a short time and to spread widely and rapidly like water [12]. It is a member of the Asteraceae family distributed in subtropical and temperate regions of the world, including South and North America, Asia, Africa and Australia [12,13].

G. parviflora has many promises for managing medical disorders in various countries worldwide. It is commonly employed for the management of both infectious and non-infectious diseases. Phytochemicals such as quercetin, beta sitosterol, gallic acid, kaempferol and hydrobenzoic acid have been identified from *G. parviflora* [14]. It has potential pharmacological properties including antibacterial

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Table 1
Summary of the **s**elected studies conducted on *G. parviflora* indicating its potential for managing medical conditions.

Study	Year	Type of Study/Modal	Specie(s) studied	Findings	Implication	References
Phytochemical screening and bioactivity testing of ethyl acetate soluble fraction of *G. parviflora.*	2009	Experimental (*In-vitro*) using DPPH antioxidant assay, alfa glucosidase and urease inhibition assay.	*G. parviflora*	Results indicated the presence of new flavanone glucosides, galinsosides A and B with two known flavanones, 7,3′,4′-trihydroxyflavanone and 3,5,7,3′,4′-pentahydroxyflavanone in ethyl acetate, a soluble fraction of *G. parviflora* with antioxidant activity, urease and α-glucosidase inhibitory activities.	Possibility to use a plant to manage inflammatory diseases, diabetics and infections caused by ureolytic bacteria.	[15]
Investigation of biological activities of selected medicinal plants traditionally used in South Brazilian medicine.	2009	Experimental (*In-vitro*) using mosquitoes 3rd instar larvae, and gravid adult females.	*G. parviflora*	The hydrophilic extracts from *G. parviflora* among other investigated plant species turned out to be the most active.	Results prove medical uses, particularly for wound healing.	[19]
Phytochemical screening of leaves of *G. parviflora.*	2010	Experimental *L. monocytogenes S. aureus, B. cereus, L. innocua, E. coli, Salmonella* sp., and *E. sakazakii.*	*G. parviflora*	(Z)-3-hexen-1-ol (21.7%), β-caryophyllene (12.4%) and 6-demethoxy-ageratochrome (14%) were among the major bioactive compounds with antibacterial activity. The remaining per cent of the major bioactive compounds had little to no antibacterial activity.	Potential use of leaf extract for management of diseases caused by bacteria.	[20, 21]
Investigation of potentials of selected medicinal plants.	2010	Experimental (*In-vitro*) using DPPH antioxidant assay and Folin-Ciocalteu phenolic assay	*G. parviflora.*	Major components potentially reduce Type 2 diabetes-related hyperglycemia and hypertension include chlorogenic acid and hydroxycinnamic acid derivatives.	Potential use for the management of blood sugar for people with diabetic disorders.	[22]
Investigation of the presence of caffeic acid derivatives and flavonoids from selected *Galinsoga* species.	2011	Experimental; identification of bioactive compounds using HPTLC and HPLC-DAD-MS methods	*G. parviflora*	The results indicated that caffeoylglucaric acids were the dominant bioactive compounds in the tested extracts.	Promising to utilize the plant for the management of inflammation.	[23]
Investigation of nematicidal potential of the *G. parviflora.*	2011	Experimental using meloidogyne incognita (root-knot) and Cephalobus litoralis.	*G. parviflora*	Results indicated that four pure compounds (β-sitosterol, ursolic acid, 4-hydroxybenzoic acid, and β-sitosterol' 3-O-, β-D glucopyranoside) possess significant nematicidal activity, whereas three pure compounds (octacosanoic acid, 3,4-dihydroxybenzoic acid and gallic acid) showed nematicidal lower activity.	Possibility to use plant extracts to manage diseases caused by nematodes.	[24]
Examining and contrasting the antioxidant properties of various *G. parviflora* extracts and fractions.	2012	Experimental (*In-vitro*) using DPPH• and superoxide radicals, and linoleic acid peroxidation assay.	*G. parviflora*	Results indicated that the extract possesses dose-dependent free radical-scavenging ability, superoxide radicals, and inhibitory effects on linoleic acid peroxidation in a manner comparable to gallic acid. Most active fractions contained flavonoids, patulitrin, quercimeritrin, quercitagetrin and caffeoyl derivatives.	Potential use for the management of inflammatory diseases.	[25]
Investigation of chemical constituents and bioactivity of *G. parviflora.*	2013	Experimental *(In-vivo, clinical) using* cirrhotic rats; *B. subtilis, P. aeruginosa, E. coli, A. niger, and C. Albicans,* cancer cell (MCF-7)	*G. parviflora*	Eleven chemical constituents were identified from fractions of aqueous ethanolic extract and more than 40 volatile constituents in the hydrodistilled oil.	Possibility to be employed for the management of infectious and non-infectious diseases.	[26]

(*continued on next page*)

Table 1 (*continued*)

Study	Year	Type of Study/Modal	Specie(s) studied	Findings	Implication	References
				The ethanolic extract showed a significant reduction in the alanine aminotransferase enzyme and blood glucose levels, antimicrobial activity, antioxidant, and weak cytotoxicity.		
Investigation of n-butanol soluble sub-fraction of plant extract.	2014	Experimental; using spectroscopic and chromatographic methods.	*G. parviflora*	New glucosides, parvisides A and B, were identified and correlated to their use in wound treatment.	The plant can be used to manage microbial-infected wounds and diseases.	[27]
Determination of antioxidant potential from selected *Galinsoga* species.	2014	Experimental (*In-vitro*), using chromatographic methods.	*G. parviflora*	The extracts demonstrated potential antioxidant activity in a dose-dependent manner.	Applicability of plant extracts for management of inflammatory diseases.	[28]
Evaluation of performance of *Bemisia tabaci* (Genn.) Biotype B (Hemiptera: Aleyrodidae) on Weeds.	2014	Experimental (*In-vitro*); by using *Bemisia tabaci* (Genn.) Biotype B (*Hemiptera: Aleyrodidae*).	*G. parviflora,*	Among other weeds, G. parviflora allowed *B. tabaci* biotype B reproduction.	Possibility to be utilized as insecticidal to prevent crop infection in places where whitefly is present during cropping and the intercrop period.	[29]
Determination of *in-vitro* antioxidant of aqueous and ethanolic extracts from selected *Galinsoga* species.	2015	Experimental (*In-vitro*); using optimized enzymatic calorimetric assay.	*G. parviflora*	Results revealed that while the aqueous extracts of the *G. parviflora* herb have protective action, the ethanolic extracts of the herb have cytotoxic effects.	A plant can be used to manage inflammatory diseases and accelerate wound healing.	[30]
Determination of antioxidant ability of ethanolic and aqueous extracts of *Galinsoga*.	2015	Experimental); using optimized enzymatic calorimetric assay	*G. parviflora*	Results indicated a correlation between the plant extracts and the concentration of caffeic acid and flavonoids, and their derivatives.	Use medicinal plants, particularly Galinsoga herb extracts to manage skin diseases.	[31]
Evaluation of the anti-inflammatory activity of *G. parviflora* and phytochemistry.	2018	Experimental (In-vitro); LAL Folin-Ciocalteu's Assay; and chromatographic method.,	*G. parviflora*	Results indicated that the main compound was chlorogenic acid. *G. parviflora* herb extract has potential antioxidant, anti-inflammatory and hyaluronidase-inhibiting activities.	Possibility of its use to manage tissue damage, wounds and inflammation.	[32]
Evaluation of a hydroalcoholic extract from *G. parviflora* herb anti-inflammatory activity and phytochemical profile.	2018	Experimental; LAL,viability and proliferation assay, mosquitoes vector.	*G. parviflora*	The antioxidant, anti-inflammatory, and hyaluronidase-inhibiting activities of *G. parviflora* herb extract were responsible for healing.	Potential use for the management of wounds.	[32]
Investigation of the potential of new thiophene-derived aminophosphonic derivatives for their herbicidal activity.	2018	Experimental (*In-vitro*) using selected bacteria.	*G. parviflora*	Results among other showed among other species, *G. parviflora* had remarkable herbicidal activity on *Aliivibrio fischeri* with no toxicity.	Potential as herbicidal and can be applied in soil for agriculture activities to control harmful microbes affecting plants that may also affect human.	[33]
Evaluation of the potential of *G. parviflora* essential oil (GPEO) on larvicidal activity and oviposition deterrent against mosquito vectors.	2018	Experimental; mosquito species (*Anopheles Stephensi, Aedes Aegypti, Culex Quinquefasciatus, Aedes Albopictus, Culex Tritaeniorhynchus, Anopheles subpictus*).	*G. parviflora*	The major constituent (Z)-γ-bisabolene showed acute toxicity for all tested mosquito species.	With innovative and efficient larvicides and oviposition deterrents, *G parviflora* extract has the potential to be environmentally beneficial for the mitigation of malaria by controlling mosquitoes.	[16]
Isolation of biomolecules from *G. parviflora* and bioactivity testing.	2019	Experimental (cell line) using selected microorganisms.	*G. parviflora*	Results indicated potential antimicrobial activity and inhibitors of filamentous temperature-sensitive protein Z.	Potential future use to manage microbial-related diseases such as furuncles, abscesses	[34]

(*continued on next page*)

Table 1 (*continued*)

Study	Year	Type of Study/Modal	Specie(s) studied	Findings	Implication	References
					(boils), cellulitis and skin rash.	
Asteraceae plants were investigated as the source of antiageing and antioxidant agents.	2021	Experimental, Yeast *Schizosaccharomyces pombe cells*	*G. parviflora*	The results indicated that among other fractions of Asteraceae plants, *G. parviflora* have potential antioxidant and antiaging activities.	Potential use in cosmetology and management of inflammatory diseases.	[35]

DPPH - 1,1- diphenyl-2-picryl-hydrazil; LAL - Limulus amebocyte lysate; HPLC-DAD-MS - High-performance liquid chromatography-diode-array detection-mass spectrometry; HPTLC - High performance thin layer chromatography.

[15], antimalarial [16], anti-oxidant [17], antidiabetic [14] and anti-inflammatory [18]. However, the general audience needs to be explored by the information on its medical utilization as so far the availability of the collective information is limited regardless that it is widely studied.

In this review, a comprehensive discussion on the ethnomedicinal uses, phytochemistry and pharmacological properties of *G. parviflora* has been conducted. The potential future outlook of *G. parviflora is* highlighted. This review will advance knowledge and awareness of medicinal plants, particularly *G. parviflora*. Additionally, it will shed light on how *G. parviflora* can sustainably be utilized to manage a range of health complications such as colorectal cancer, painful joints, fever, hepatic pain, internal inflammation, analgesia and skin diseases that plague communities all over the world.

2. Methodology

G. parviflora has been extensively investigated over the past two decades, and this review was done to describe its potential for managing medical disorders by gathering data on its ethnomedicinal uses, phytochemistry and pharmacological activities. The pertinent information on *G. parviflora* was obtained by using search terms like *G. parviflora*, medicinal plants, ethnomedicinal applications, phytochemistry, and pharmacological properties in online databases like Google Scholar, Web of Science, PubMed, Springer, Plant of the World Online and ScienceDirect. The study plan includes well-explained and useful results based on the selected topic. Personal correspondence and unpublished findings are not included in this review. Studies on the topic are listed and reviewed in-depth.

The outcome and quality of the publications included in this study were inconsistent, making comparisons challenging. The Grading of Recommendation, Assessment, Development and Evaluation (GRADE) approach was used to analyze and evaluate the quality of the collected studies. The outcomes of the included studies were analyzed and explained depending on the type of evidence.

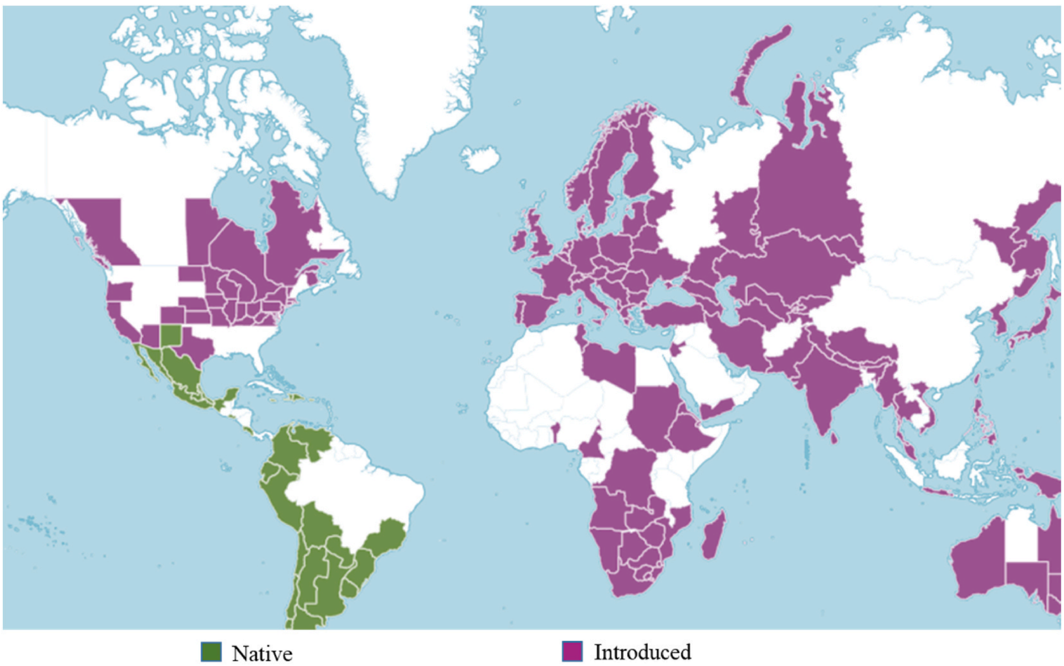


Fig. 1. Global distribution of G. parviflora [38].

After thorough screening, this review accomplished by citing 89 studies to address the potential of G. parviflora. The summary of the **s**elected studies on the potential of *G. parviflora* for managing medical conditions are presented in Table 1**.**

3. Global distribution of *Galinsoga parviflora*

G. parviflora is distributed globally as presented in both native and introduced ways [36,37]. It is native in South and North America, while introduced in various countries in Asia, Africa and Australia as shown in Fig. 1. *G. parviflora* has environmental benefits for long-term sustainable health as a medicine, poison, and food for humans and animals [38].

4. Taxonomic classification

G. parviflora, like other medicinal plants, belongs to the kingdom Plantae. It can be taxonomically classified as follows [39,40].
Domain: Eukaryota.
Kingdom: Plantae.
Phylum: Spermatophyte.
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Asterales
Family: Asteraceae.
Genus: *Galinsoga*.
Species: *Galinsoga parviflora* (Cav.)

5. Vernacular names

According to the regions and language, *G. parviflora* is known locally by various vernacular names**.** Traditionally, societies from various regions are easily accessing this medicinal plant by referring to its vernacular names as shown in Table 2.

6. Morphological description

G. parviflora (Fig. 2) consists of leaves, which are lanceolate to ovate, opposite, pale green and petiolate with a leaf stalk erect, branched, slender and striate stems (parallel ridged) [24,57]. They are 1–6 cm in length and 0.5–4 cm in width. The stems can have hairs or not (glabrous). On the other hand, the leaf margins are fringed with short hairs that look like eyelashes. Upper leaves are often smaller, narrower and sessile (without a stalk) [57]. The flower heads are small, with yellow disk/tubular florets in the center, surrounded by several (usually 5) small white ray florets. The inflorescence stalk is slender and hairy. The flower head measures 4–7 mm in diameter and has two or three rows of involucral bracts [24,57]. Each of the five inner bracts houses a ray floret small and distinct from one another.

Its fruit is an achene (a dry indehiscent 1-seeded fruit) that is 2 mm long, slightly hairy and has or does not have a pappus of short bristles. The fruit associated with the disc florets is also achene, but it is 1.8 mm long, slightly hairy, has a 1.5 mm long pappus of hairy-edged scales, and most blooms in the summer. Unlike other family members, ray florets are three-lobed [24].

7. Phytochemistry of G. parviflora

Various studies on *G. parviflora* showed the presence of several phytochemicals such as flavonoids, terpenoids and tannins [15,58,

Table 2
Vernacular names of G. parviflora.

Language/Region	Vernacular name	Reference
Australia	Yellow weed, Potato weed	[12]
Indonesia	Batakacut, bribil, mondreng and jukut saminggu	[42]
Central Java, Indonesia	Loseh, Gletang	[43,44]
Oaxaca, Mexico	Piojito, Hierba de Piojito	[45]
Pindari Valley (India), North western Himalaya	Banmara	[46,47]
Japan	Khavu	[48]
India	Potato weed	[49]
Tripura, India	Gangaful, Garingburani sam	[50]
Uttarakhand, india	Soch	[41]
Zulu-Natal, South Africa	Ushukeyana, Isishukelana	[51,52]
Kumaun Himalaya	Khusari	[53]
Southern Ethiopia	Ematiya/Bizdiya	[54]
Northern Ethiopia	Dka-Nequel	[55]
Rajouri, Jammu and Kashmir, India	Piploo	[56]
Brazil	Picão-branco	[19]

Fig. 2. *G. parviflora* [57].

59]. The investigation of the aqueous extract of *G. parviflora* showed the presence of phytosterols, alkaloids, saponins, glycosides, tannins and flavonoids [58]. The chemical strucutres of the selected isolated bioactive compounds are presented in Fig. 3.

Similar studies on *G. parviflora* reported that leaves contains a significant amount of flavonoids, quinines, and cellulose, while

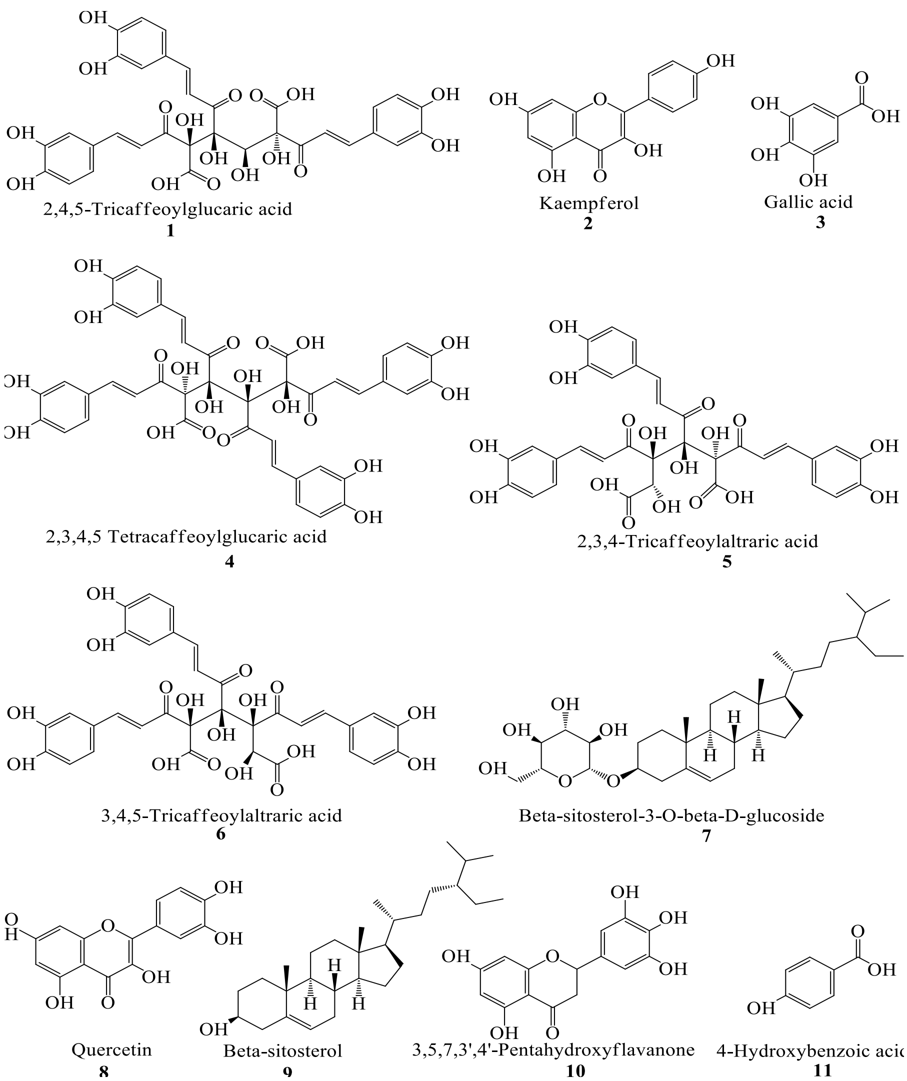


Fig. 3. Structures of selected bioactive compounds identified from *G. parviflora*.

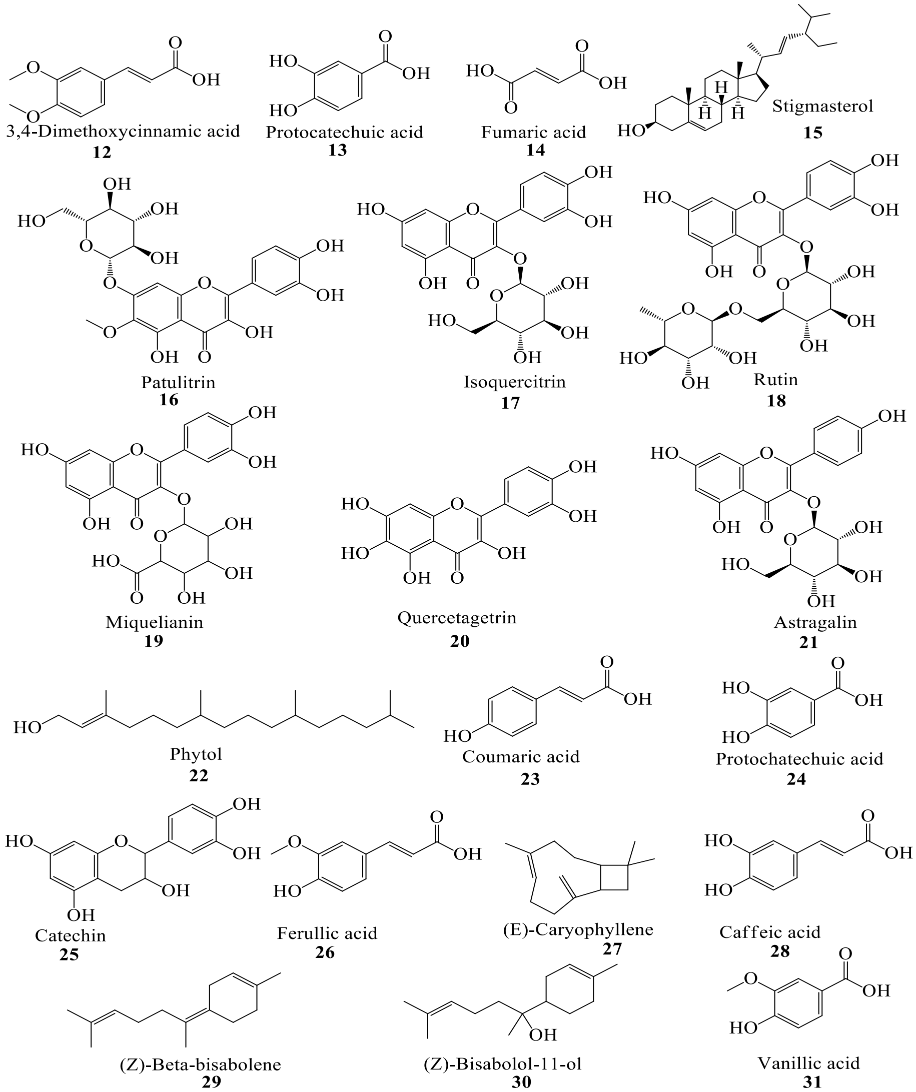
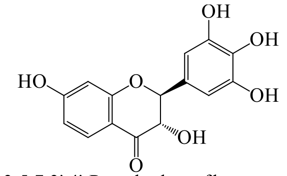


Fig. 3. (*continued*).

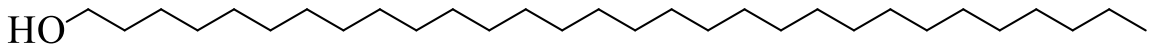
flowers contain flavonoids, tannins, glycosides, celluloses, carbohydrates, quinines, steroids [59] and flavanone glucosides [15]. Several bioactive compounds have been isolated and identified from different parts of the plant using various experimental approaches.

Most of the identified bioactive compounds possess remarkable medicinal qualities for the management of medical conditions such as malaria, flu, cold, colorectal cancer, liver ailments and skin diseases. The investigation of plant extracts revealed the presence eleven bioactive compounds including compounds 7, 9,12, 13, 14, 15, and 22 [14]. Similar study identified 48 bioactive compounds from hydrodistilled oil of the aerial parts of *G. parviflora*, where compound 29 being the most abundant component (45.66%), followed by compounds 27 (4.99%), 30 (4.95%), and 22 (4.39%) [14]. Furthermore, 37 bioactive compounds were identified from the essential oils of *G. parviflora*, where compound 29 was the major phytoconstituent [16].

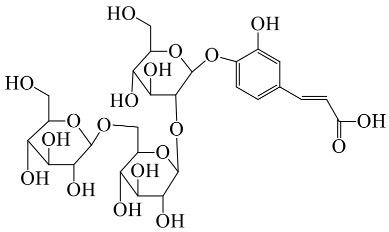
Study of phytochemical profile of *G. parviflora* extract showed the presence of compounds 16, 17, 18 and 20 from fractions of ethyl acetate, and 19 and 21 from aqueous extract as major flavonoid components [32]. The aqueous methanolic extract contains compounds 23, 24, 25,26, 28 and 31 [17], which attribute to the remarkable antioxidant activity of the plant extracts. Other identified bioactive compounds from *G. parviflora* are compounds 1, 2, 4, 5, 34, 35, 37 and 38 [21,60–62]. Further investigations of *G. parviflora* identified the presence of bioactive compounds 3, 7, 9,10,11, 39 and 40 [15,25,63]. Recently, two glycosides (compounds 34 and 35) from *G. parviflora* were identified from n-butanol soluble sub-fraction of the alcoholic extract [62]. These findings suggest that *G. parviflora* has a broad spectrum of bioactive compounds promising for medical uses.



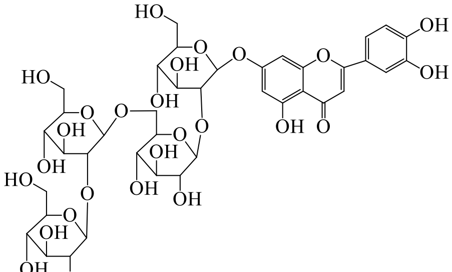
3,5,7,3',4'-Pentahydroxyflavanone
32



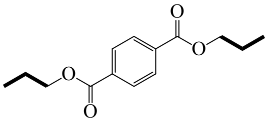
Triacontanol
33



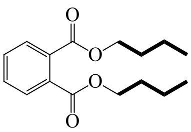
Parviside A
34



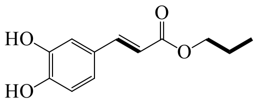
Parviside B
35



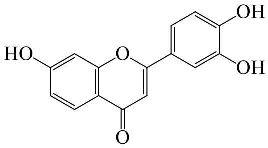
Galinosoate A
36



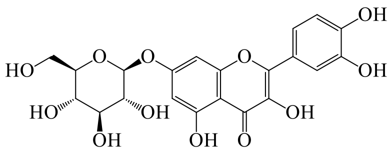
Galinosoate B
37



Galinosoate C
38



7,3',4'-Trihydroxyflavanone
39



Quercimeritrin
40

Fig. 3. (*continued*).

8. Pharmacological properties of *G. parviflora*

Natural products have been utilized to mitigate medical conditions since pre-historic periods. The studies were conducted based on scientific proof of the possibility of improvement and future use in clinical settings. Bioactive compounds identified from *G. parviflora* demonstrated potential biological activities [9,10,45,46,49,51,53,54,61,64,65,75,76,78] that proved its traditional uses. The observed biological activities of *G. parviflora* may be contributed by the presence of various bioactive compounds such as compounds 9, 12,13, 14, 22 and 24 [14,22,66]. Due to genetic variances, ecological changes and environmental variables, there are great chemical variety [67], which contributes to the diversity in pharmacological properties.

8.1. Antibacterial activity

G. parviflora, possess remarkable antibacterial activity against various bacteria. Mostafa and Colleagues [14] reported a weak antibacterial effect of *G. parviflora* extracts against all tested Gram-positive bacteria, except *B. subtilis* and weak antibacterial potential against all tested Gram-negative bacteria, including *K. pneumoniae* and *S. typhimurium*. A significant effect against *E. coli* and *P. aeruginosa*, relative to the standard cefotaxime was observed [14].

8.2. Antioxidant activity

A study by Bazylko and Colleagues [68] showed that extracts and fractions from *G. parviflora* possess dose-dependent free radical-scavenging agents against DPPH and superoxide radicals, as well as inhibitory effects on linoleic acid peroxidation comparable to gallic acid. The observed effect might be contributed by the presence of bioactive compounds such as 16, 20 and 40 as well as significant contents of flavonoids and caffeoyl derivatives [25,68]. Similarly, the ether, alcoholic and petroleum ether extracts of *G. parviflora* at 150 mg/mL demonstrated strong moderate and weak antioxidant activity respectively as compared to standard 0.1 M ascorbic acid [14]. These findings revealed that the plant extracts are interesting sources of bioactives compounds with significant antioxidant activity. The use of both raw materials in inflammatory diseases, among others, is due to their ability to prevent free radical-induced deleterious effects. *G. parviflora* extract has strong antioxidant properties by using the ferric reducing ability of plasma (FRAP) assay, with an estimated inhibitory concentration ($IC_{0.5}$) of 498.2 μg/mL for the dry herb as opposed to $IC_{0.5}$ of 44.40 μg/mL for L-ascorbic acid [32]. The extracts of these plants may be improved and utilized to manage ailments in clinical settings for a healthier community.

8.3. Anti-arthritic and antiplatelet activities

The methanolic leaf extract *G. parviflora* was tested for anti-arthritic and antiplatelet activities utilizing an *in-vitro* model of protein denaturation [69]. Results showed that in comparison to aspirin, which was used as a reference drug, the methanolic extract of *G. parviflora* had considerable anti-arthritic and anti-platelet properties [69]. These results indicate that the extracts may be improved and used in clinical settings to manage malaria, flu, cold, colorectal cancer and liver ailments.

8.4. Anti-inflammatory activity

G. parviflora plant extract was studied to assess its anti-inlfamatory potential, which revealed to be promising. The findings revealed that *G. parviflora* extract had a significantly potent anti-inflammatory effect than the positive control, kaempferol, with half-maximal inhibitory concentration (IC_{50}) = 0.78 mg/mL [32]. This suggest that *G. parviflora* plant extract may be used to manage inflammatory disorders.

8.5. Diabetic activity

Mostafa and Colleagues [14] reported that *G. parviflora* alcoholic extract at a content of 400 mg/kg body weight was nearly equivalent to that of glibenclamide (5 mg/kg) in reducing the blood glucose levels of diabetic rats, indicating a potential hypoglycemic effect of extracts [14]. The results revealed that adding *G. parviflora* vegetables to a daily meal may potentially aid in managing diabetes. The plant extracts may be used for the management of diabetes.

8.6. Antifungal activity

A study of *G. parviflora* extracts demonstrated strong antifungal potential against *A. niger* and *C. albicans* relative to the standard nystatin [14]. This report shows the potential of utilizing *G. parviflora* extract to manage fungal diseases.

9. Uses of *G. parviflora*

G. parviflora is traditionally used as a food and medicine for managing various ailments as shown in Table 3.

9.1. Ethnomedicinal uses

The whole plant treats yellow fever, painful joints and hepatic pain. Its leaves, when infused are used to treat colorectal cancer, anaemia-with jaundice, malaria and to detach the fetal placenta in veterinary medicines [16,64,69]. One can drink a flower decoction to enhance memory [16]. An extract from the leaves of *G. parviflora* speeds up wound healing [31], treats diarrhoeal disorders [70]. When combined, treats snake bites [59]. Flu and common colds are treated through oral administration [30]. Futhermore, prevents scurvy due to a significant amount of vitamin C [25]. The tender shoots and leaves of *G. parviflora* are consumed as a vegetable in South Africa, Zimbabwe and Tanzania [66]. The plant treats nettle stings when applied to the body [49].

Table 3
Summary of ethnomedicinal use of *G. parviflora*.

Plant part	Country	Uses	Reference
Whole plant	India, Java, America, Equador	Treatment of wounds, cold, flu, cold sores, halt bleeding, as fodder for cattle, body injuries, yellow fever, hepatic pain, painful joints, fever and internal inflammation, potherb, earache, skin diseases, and scorpion bite.	[16,42,49,53,66,71]
Leaves	India, South Brazil, Java, Africa	Treatment of diarrhoea, fever, snake bite, haemorrhages, eaten as a vegetable, malaria, anaemia-with jaundice, to detach fetal placenta, colorectal cancer, analgesic, liver problem, toothache, inflammation, colds and sores.	[16,50,64,69,72]
Stem	Africa	Treatment of colds and sores	[72]
Roots	Pakistan	Treatment of beetle bites,	[66]
Flowers	Africa	Treatment of toothache, and enhanced memory,	[16,66]
Aerial part	America, Java, Asia	Mitigation of lichens, acne, wounds, eye problems, eczema, and rosacea, protect against UV irradiation-induced damage, fever, toothache, inflammation, liver problem, and insect bite.	[30,42,50,68]

9.2. Medicinal uses of *G. parviflora*

Reports of medicinal use of *G. parviflora* plant extract are available [17,32,58,73–81]. It was further reported that applying *G. parviflora* extract effectively treated skin lesions, allowing wound healing based on the antioxidant, anti-inflammatory and hyaluronidase-inhibiting activities of *G. parviflora* herb extract [77]. This may be due to the presence of flavonoids in *G. parviflora*. Furthermore, it can be used for management of malaria, as *G. parviflora* extracts have potential larvicidal activity due to the substantial amount of (Z)-γ-bisabolene present, with highly potent larvicide and preventive oviposition activities against mosquitoes. The (Z)-γ-bisabolene obtained from *G. parviflora* essential oil was tested for its ability to prevent oviposition on six mosquito vectors [16]. Results showed that 25 g/ml of (Z)- γ-bisabolene decreased the oviposition activity index in all tested mosquito vectors, indicating its capability for management of malaria parasite. The extracts from *G. parviflora* plant and its essential oil demonstrated potential bioactivities for management of various ailments including inflammation of the liver, jaundice, mucous membranes and malaria [13,19,32,33,70,82,83]. With the rise in antibiotic resistance, there is an urgent need for novel lead compound classes and novel mechanisms to combat the antibiotic crisis.

One of the most serious challenges is the rise of antibiotic-resistant pathogenic species [84]. Infections caused by multidrug-resistant (MDR) bacteria are becoming more common and pose a serious threat to global public health [84–86]. It significantly reduces the likelihood of successfully treating infections and increases morbidity and mortality associated with common bacterial diseases. Future studies need to consider the antimicrobial activity of *G. parviflora*, either alone or in combination with conventional antibiotics and other plant species to improve activity. Furthermore, newly developed tools such as prebiotics, probiotics, synbiotics, bacteriophages, nanoparticles and bacteriocins should be reviewed to aid in the development of effective antibiotics to combat the emergence of antibiotic-resistant infectious bacteria. Search of drug candidates from *G. parviflora* extracts that can be used in future drug discovery is highly promising.

9.3. Use of *G. parviflora* as vegetable

Studies have demonstrated the significance of *G. parviflora* as an indigenous vegetable in human nutrition and health [59,83]. A significant amount of proteins, fat acids, minerals [83] and carbohydrates [59] have been reported in *G. parviflora*.

10. Other applications of *G. parviflora*

Beam walking tests were performed on the test animals throughout the experiment to determine the effects of aqueous leaf extract of *G. parviflora* on $HgCl_2$-induced cerebellar toxicity in adult male mice [87]. In mice with $HgCl_2$ poisoning, treatment with the *G. parviflora* extract led to significant changes, which improved balance and posture. Although treatment with *G. parviflora* was beneficial therapeutically, cerebellar $HgCl_2$ exposure was neurotoxic [87]. *G. parviflora* can be utilized to synthesize nanoparticles for dye remediation when combined with other plant species. By employing aqueous leaf extracts of *G. parviflora, C. bonariensis*, and *B. pilosa* for the breakdown of methylene blue dye, iron nanoparticles from $FeCl_3$ solution were produced [67]. The results demonstrated that the synthesized nanoparticles were economical and ecologically secure in revealing information about the environmental elimination of dyes. Additionally, it can act as a corrosion inhibitor [88]. These results indicate the potential future use of *G. parviflora* for managing poisoning, soil pollution and corrosion.

11. *G. parviflora* as a potential weed

Plants from the genus *Galinsoga* are very troublesome weeds in many organic vegetable crops [74,89], including *G. parviflora.* Among the measures to keep *G. parviflora* invasions under control is targeting the seedbank. Cauwer and Colleagues [74] investigated the relationships between the seedbank size of *Galinsoga* species such as *G. parviflora* and prevailing management practices and pedo-hydrological conditions. Results indicated that the genus *G. parviflora* was presented in 90% of the soil weed seedbanks of organic vegetable fields with wide variation in abundance. Therefore, to reduce *G. parviflora* invasions, fields should preferably be tilled without soil inversion, fertilized with organic amendments with low content of readily plant-available phosphorus and cropped with competitive crops all season long [74]. Reports indicate that *Galinsoga* spp. Considered as common weeds in several major crops such as tomato, pepper, potato, bean, onion, cabbage, garlic, wheat, corn, cotton, tobacco, sugar beet, coffee, citrus, banana and strawberry; it is frequently found in gardens and uncultivated areas [12]. The classification of *Galinsoga* spp. *as* weeds from potential medicinal properties hinders its utilization as researchers concentrate on investigating how to control rather than utilize the plant.

12. Toxicological study

No toxicological response or death was reported on any dosages during the acute toxicity test performed on male and female rats by giving them a single dose of aqueous extract. As there was little evidence of treatment-related toxicity or mortality, the oral dose of aqueous extract up to 5000 mg/kg was considered relatively safe [58,58]. Mostafa and Colleagues [14] reported that ethanolic extract of *G. parviflora* at concentrations of 0.1, 1, 10, and 100 μg/mL exerted a weak cytotoxic activity against the MCF-7 cell line [14]. The cell viability percentages were 99.23, 98.21, 92.58, and 91.53, respectively. However, at higher concentrations (1000 μg/mL), the extract caused the death of all cells [14].

13. Conclusion and prospects

G. parviflora is underutilized vegetable categorized as a weed, which has potential medicinal and nutritional values that can be utilized to attain a healthier community. It is employed by various societies globally to manage both communicable and non-communicable diseases. This is revealed by its phytochemical profile and pharmacological studies, which to a broad spectrum support traditional uses of the plant. Apart from these benefits, more effort is required to overcome the barrier toward the clinical applications of the plant. Therefore, future study should continue to isolate and identify bioactive compounds, evaluating mechanisms of action and their effectiveness against various diseases. The toxicity study is highly recommended for clinical settings to enable sustainable utilization of this potential medicinal plant.

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